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CONTENTS

On cover: Assembly line for relays at the Broadmeadows Factory, Australia.

Push-Button Dialling from Subscribers' Telephones

C. JACOBÆUS, TELEFONAKTIEBOLAGET LM ERICSSON, STOCKHOLM

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This article presents a general survey of push-button dialling, viewed chiefly from the users' aspect. Investigations of subscriber attitudes are reported, and also the results obtained in field tests as regards dialling speed and fault frequency. Finally the financial gains to subscribers through the change to push-button dialling are discussed.

In later articles the signalling system will be described, as also the forms of keyset designed for the Dialog and Ericofon instruments.

The usual device for indicating to the exchange the number of a called subscriber is the dial. The first dials were introduced at the end of last century. The form of the dial was governed primarily by the decimal selectors of Strowger type. Since then the principle of the dial has remained unchanged, but in the course of the years it has been constantly improved in order to increase its length of life. This has been made possible by improvements in design and by the use of modern materials and new production methods.

In the twenties and thirties, when the semiautomatic trunk service started, it was soon realized that the trunk operators' positions should be equipped with keysets. The idea presumably came from the adding machines. It was quite clear that this type of dialling would be much quicker with a suitably devised keyset than with an ordinary dial. When the switches in the local telephone system were not of step-by-step type, the connection was also set up more quickly.

Push-button subscriber dialling has been discussed since the forties. A number of systems were designed during the forties and fifties, but they were used on a fairly small scale. There were many reasons for this. The most important was presumably that administrations wished to allot available capital primarily to the extension of plant so as to provide waiting subscribers with telephones and to cater for the traffic requirements. In many quarters it has also been questioned whether push-button dialling is really something that subscribers wish for and whether it can offer them any advantages.

Laboratory and Field Tests of Push-Button Dialling

A large number of laboratory and field tests have been made with push-button telephones in different parts of the world. Reports on these trials were given in particular at the symposia on "Human factors in telephony" held in 1963 at Copenhagen and in 1966 at the Hague. The chief points of investigation were:

1. the speed of dialling
2. the fault rate
3. the attitude of the public to push-button dialling

Investigations have also been made concerning the layout and form of the buttons.

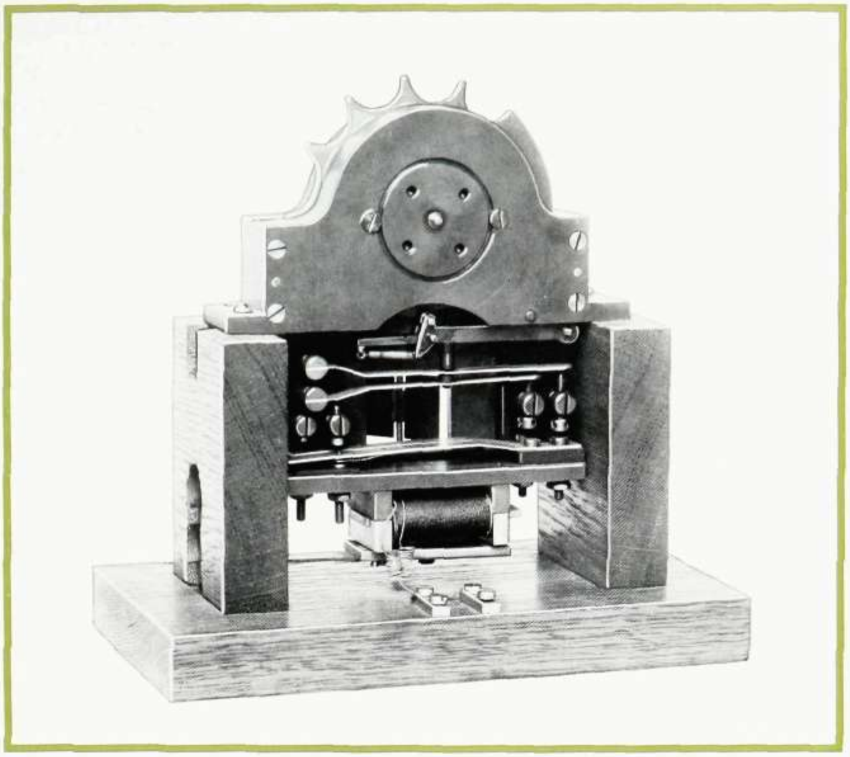

Fig. 1
Dial from 1895

As regards *dialling speed* all trials show the same result. A number can be keyed considerably more quickly than it can be dialled. The reason is obvious. With an ordinary dial the time for dialling a digit is composed of the time for transmission of the pulses, i.e. with a normally adjusted dial 100 ms/pulse or an average of 550 ms per digit, the lost motion time of the dial, 200—300 ms, and the time for rotating the dial, which depends on the quickness of the subscriber. The time for push-button dialling is composed of the time taken to press the button and to move the finger to another button. These times are almost exclusively dependent on the speed of the subscriber, since the keyset itself operates far quicker than the quickest subscriber. The observations made in field trials and in laboratories indicate a mean time per digit of 1.2—1.6 s for a dial and 0.4—0.8 s for a keyset. The lower figures apply to persons who make a large number of calls, and in the case of keysets to persons who have had some practice in this form of dialling. On an average the saving of time per digit may be put at 0.8 s.

The measurements of *fault rate* show throughout higher figures for the keyset than for the dial. In the various investigations the fault rate is reported as 2—3 times greater for the keyset, though the rate is considerably reduced after some practice. Typical figures are 0.25—0.35 per cent per digit for the dial and 0.35—0.75 per cent per digit for the keyset. These figures do not change in the case of multidigit numbers.

The higher fault rate for the keyset is presumably due to the fact that the return movement for the dial gives the subscriber time to plan for the next digit, which he does not have with a keyset. With a keyset there is a certain tendency to carelessness. With some forms of keyset, furthermore, the buttons are placed rather close together, so that the wrong button may be pressed unintentionally.

The higher fault rate with a keyset is an argument against it which has the greatest force for multidigit numbers, as for example on international calls. One must remember, however, that such calls are made chiefly by persons who are very used to telephoning and who therefore may be expected to make less faults than other people.

The *attitude of the public* to push-button dialling was investigated chiefly by the Swedish Telecommunications Administration in its Nynäshamn network for some 3000 subscribers. Investigations have presumably been made also in the U.S.A., but have not been published. In minor field trials, finally, the subscribers have been questioned as to their opinion on push-button dialling. In all cases there has been a general preference for the keyset instead of dial. The arguments have been that the keyset is more convenient to use and is quicker. People have not reacted against having to wait longer before the called subscriber is rung, although in certain automatic systems this may be very noticeable. The subscribers have no feeling that the fault rate is higher with push-button dialling; their opinion is rather that it is lower. The fault rate is obviously so low that a doubling of the rate is not noticed by the subscriber.

Investigations show that persons who make a large number of calls have a particular preference for push-button dialling. The latter naturally also have a greater reason for increasing their speed of dialling.

In the Swedish investigation it was found that elderly people have been more guarded in their opinion of the keyset and in some cases have preferred an ordinary dial. This may naturally be attributed to a general negative attitude to innovations, but also to the dislike of having to learn a new procedure. In Nynäshamn it was found that the reserved attitude of these persons persisted only in exceptional cases after they had received personal instruction and some time of practice.

A weakness of the investigations has been that they could not be planned so as to find out what a person with a positive attitude to push-button dialling would have been willing to pay for it. To use a marketing term, one does not know what the price elasticity is. Is the average subscriber in favour of the keyset, but not so much that he is willing to pay extra for it? The answer to this question will come when administrations start to provide keyset subscriptions on a wider basis.

Other Arguments for Push-Button Dialling

The development of switching technique in the stored-programme-controlled exchanges has necessitated additional numerical signals from the subscriber's station over and above the ten signals now used. For prefixes for special services two extra buttons have been introduced. In Sweden these are denoted A and B, in the U.S.A. the symbols * and # are used. The introduction of two additional signals, corresponding to 11 and 12 pulses, necessitates a total redesign of the dial, which furthermore, would hardly be possible in many cases on grounds of space.

In the push-button dialling experiments it has been found that people with limited mobility of hands and fingers find it very much easier to use a keyset. For persons with severe handicap as regards the use of their fingers, the keyset has even made it possible for them to use the telephone at all.

Through the introduction of push-button dialling one may except that a world standard will be established as regards the layout and numbering of the buttons, in contradistinction to the present practice with the dial, for which different countries have different arrangements of the digits. For a traveller in a foreign country there will be no difficulty in dialling, as the keyset will be the same as in his own country.

Economic Significance of the Gain of Time for the Subscriber

The increased convenience of push-button dialling to the subscriber is difficult to evaluate in monetary terms. In our daily life, however, we are accustomed to the use of many things which from a strictly practical point of view must be regarded as unnecessary or as luxuries. Their value lies more in the fact that they give us a general sense of comfort, of convenience—in fact of status—rather than a direct saving in money or in one's own or others' work. Many people would undoubtedly consider push-button dialling in this light.

But it is undeniable that for people who use the telephone in their work the gain of time achievable through push-button dialling has a specific value. A person who makes 10 calls per day with 6-digit numbers saves per annum (200 working days)

$$\frac{200 \cdot 6 \cdot 0.8 \cdot 10}{3600} \text{ hours} = 2.67 \text{ hours}$$

which he can thus use for other work.

His employer probable pays him no less than \$ 2 per hour. Including other charges of an indirect and social nature he undoubtedly costs his employer \$ 4 per hour. The introduction of push-button dialling thus brings a saving for an employer of about \$ 10 per annum for this low-salary employee. For higher-salaried employees the saving is correspondingly greater.

Fig. 2 shows the relation between cost per working hour and the number of calls per day for two arbitrarily chosen extra annual charges for push-button dialling, \$ 4 and \$ 8, where the saving on working time directly corresponds to the extra charge made by the administration. In the area above the curves *it pays to introduce push-button dialling.* The diagram takes no account of the indirect advantages of push-button dialling in the form of increased convenience, which is probably of particular importance for those who make large numbers of calls.

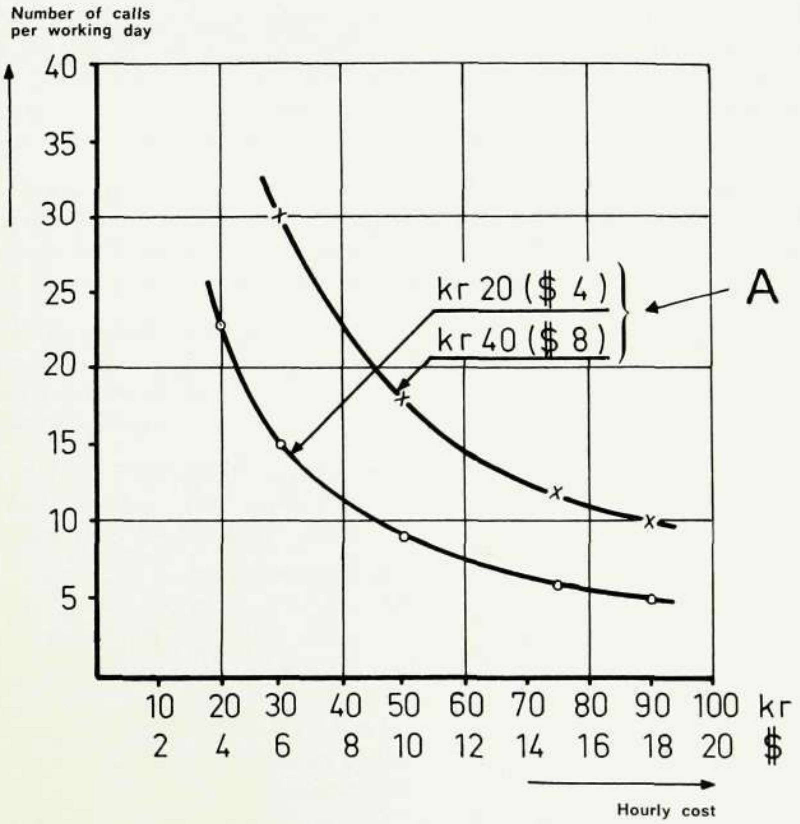

Fig. 2
Relation between hourly cost and number of calls per working day to cover the extra annual charge

A Extra annual charge for push-button dialling

The saving of time per call with 6-digit numbers is 4.8 s or about 5 % of the average conversation time. The direct saving that can be made over and above the gain in employees' working time is particularly clear in the case of PABX subscribers. Obviously some reduction can be made in internal switching equipment. But of greater significance is the reduction of outgoing exchange lines, for which a saving of some 5 % would be possible.

The Tariff Question—Some Reflexions

As regards the tariffs to be applied by administrations, it appears natural to divide them into an installation charge covering primarily the replacement of dial by keyset (not the telephone set in its entirely) and a monthly or quarterly charge. Administrations should consider, however, whether the latter charge should not be replaced by a general addition to the charge per call of, for example, 10 %, subject to a certain maximum. In this way the natural effect would be gained that the subscriber pays for push-button dialling to the extent that he makes use of it.

The proper setting of tariffs will promote the expansion of push-button dialling at the same time as it will be good business for the administration.

To sum up, one may say that push-button dialling is a more convenient and quicker method of dialling and is therefore preferable to ordinary dialling for the majority of subscribers. By suitably adjusted tariffs the administration can obtain an increased income from push-button dialling. It should therefore be of interest both for subscribers and administrations that push-button dialling is not only furnished as an alternative to ordinary dialling but also that administrations adopt a positive attitude to its introduction on a wider scale.

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Applications of Push-Button Selection in Conventional Telephone Systems

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The transmission of digits between a telephone set and an automatic telephone exchange has been in most cases, and still is to a large extent, based on the dial and decimal pulsing. Developments have shown, however, that the time taken to dial can be greatly reduced through the use of push-buttons and rapid signalling systems. The holding time for the expensive common equipment in the automatic exchange is also reduced, which to a great extent compensates for the expense of the additional equipment necessary for push-button selection.

Motives for Introduction of Push-Button Selection

The introduction of push-button selection must be viewed as a natural consequence of the development that has taken place in switching technique. The oldest telephone systems, the step-by-step systems, were based on the fact that each selector stage in the switching path was regarded as an independent unit which received the decimal signals direct from subscriber's dial and advanced the selector a corresponding number of steps. The stepping speed of the selector was directly adapted to the dial speed.

The next stage of development in switching technique was the register-controlled systems. Typical of these systems is the signal translation in the register. The digital transmission is again effected by means of dial pulses, but in this case the digits are received in the register, where they are also stored. A suitable signal code can then be chosen for the signalling to the various selector stages. The switching equipment is thereby rendered independent of the decimal signalling from the subscriber's dial.

Subsequent developments have shown that the time for operation of the various switching units could be greatly reduced by placing the switching stages under the control of markers, which employ rapid signalling systems for the transmission of information to and from the register.

In the register-controlled systems, accordingly, the time spent on setting up a connection can be divided into two phases. The first phase consists of dialling and transmission of digits to the register, the second phase of setting up the switching stages.

In rapid telephone systems the times for these two phases can be directly added together. Their ratio is approximately 11:3. These figures may be explained by the following example:

Subscriber reaction time = 2 s
Dialling time 6×1.5 = 9 s
Total 11 s

Setting up of I-GV = 0.7 s
Setting up of II-GV = 0.7 s
Setting up of SL = 1.1 s
Through-connection = 0.6 s
Total 3.1 s

The tendency is, moreover, to further shortening of the times for setting up of the switching stages.

Most of the time spent on setting up a connection thus consists of the dialling time. During the dialling time expensive common equipment in the exchange is connected to the individual subscriber's line, e.g. subscriber's stage, register finder and register, and there are thus economic motives for reducing this time as far as possible.

For reduction of the dialling time the subscriber's dialling behaviour must be altered, and the most obvious measure is to make dialling more convenient for the subscriber. In a previous article in this issue push-button selection was presented from the point of view of the user/subscriber, and it was stated that dialling time can be reduced by 0.8 s per digit through the use of a keyset.

Even if the resulting gain in time is not fully sufficient to justify the introduction of push-button selection on economic grounds, modernization considerations suggest that push-button selection should be offered as alternative to, and in the long run should replace, ordinary dialling.

Speed of Digit Transmission

The introduction of push-button selection places great requirements on the rapidity of digital transmission between the telephone set and the receiving equipment in the exchange. Although the normal speed of digit transmission is fairly low, about 1.3 digit/s, it may happen, with a suitably designed keyset, that subscribers can attain a speed of 10 digits/s and above.

Field tests have shown that a sender and receiver equipment which allows keying at a speed of up to 10 digits/s can cope with 99.95 % of all digits.

Fig. 1
DIALOG telephone with keyset

Signalling Code

In the first field test of push-button dialling made by L M Ericsson, d.c. signalling and resistance measurement were used in the digital transmission. Every digit could be identified at the exchange by measuring the resistance between the two legs of the subscriber's line and determining the direction of the current. In another field test the push-button dialling was based on v.f. code signalling. In this test each digit was represented by a specific frequency in the range 525—2100 Hz. A limited number of subscribers were selected for the test, and after more than 15 years they still declare that they are entirely satisfied with the keying equipment.

After MFC had been successfully introduced as register signalling system, a push-button selection system was developed which was based on eight of the usual MFC frequencies. In this case each digit was sent in the form of a signal consisting of two simultaneous v.f. frequencies selected from two groups of four frequencies.

With this equipment, which was completed and put into operation in 1964, the foundations were established for connection of push-button telephones to exchanges.

The frequencies has since been altered in order to comply with the recommendations issued at the plenary meeting of CCITT at Mar del Plata in 1968 (see table below).

Signalling system for digit transmission between subscriber and REG by push-button selection

Digit	Push-button selection set → KMK							KMK → REG				
	V.f. signalling on 2 wires							D.c. signalling on 5 wires				
	Digit frequencies in Hz							Wire number 1	2	3	4	5
	Group I				Group II			Wire notation				
	697	770	852	941	1209	1336	1477	0	1	2	4	7
1	×				×			×	×			
2	×					×		×		×		
3	×						×		×	×		
4		×			×			×			×	
5		×				×			×		×	
6		×					×			×	×	
7			×		×			×				×
8			×			×			×			×
9			×				×			×		×
X				×	×							
O				×		×					×	×
Y				×			×					

This signalling system is designed for normal use of 12 combinations of signals, but additional combinations can be obtained if required. In such case an additional frequency can be added to group II.

Signals *X* and *Y* can be used for future facilities, e.g. as first digit code for abbreviated dialling.

Equipment and Method of Operation

The principle of the push-button equipment and its adaptation to a local exchange of type *ARF 102* will be seen from the block diagram in fig. 2.

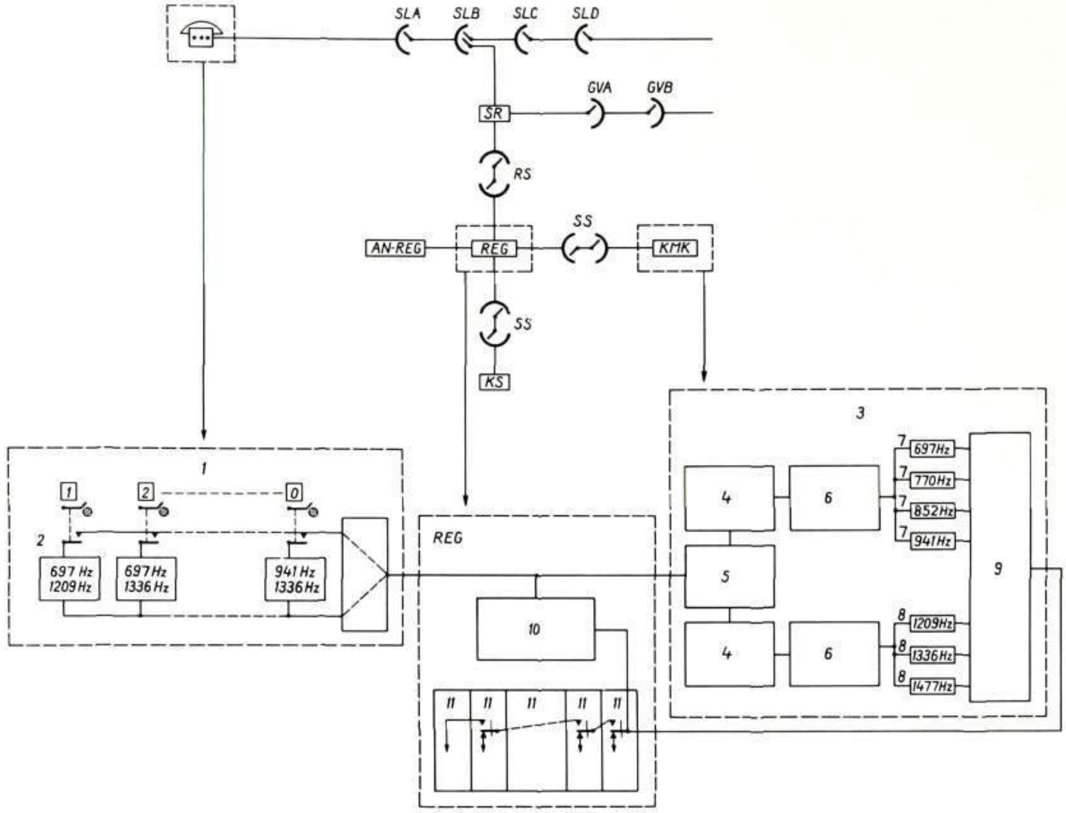

Fig. 2
Block diagram for connection of push-button telephones to a system of type ARF 102

1	Push-button telephone
$\boxed{1}$ $\boxed{2}$–$\boxed{0}$	Push-buttons
2	Oscillator
3	Code receiver, push-button selection
4	Band-stop filter
5	Input amplifier
6	Group limiter
7	Channel receiver for group I
8	Channel receiver for group II
9	Recoding unit
10	Receiver for dial pulses
11	Digit store

From the functional aspect the equipment may be divided into a sending unit in the telephone set and a receiving unit connected to the exchange equipment. This article is concerned solely with the receiving unit and its adaptation to the telephone system. In a subsequent issue of this journal the push-button telephone itself will be presented.

The push-button code receiver *KMK* constitutes a subsystem which, by means of cabling, can be connected to the telephone system without any alterations of relay sets of the like. For certain telephone systems, which are not prepared for connection of *KMK* and cannot receive digital information at the rapid rate required by push-button selection, L M Ericsson will develop special *KMK* units taking this factor into account. The function of *KMK* is to receive the v.f. signals from the subscriber's push-button telephone, convert them into d.c. signals and send them on to the register, where they are stored. The signal receiving equipment must also be able to prevent signal imitations entering the subscriber's microphone and being interpreted as digital signals. The evaluation is based on frequency combination, signal level and duration of signal.

Connection of KMK

KMK is connected to *REG* via a 10-pole finder. The number of *KMK* is determined on the basis of the number of push-button subscribers connected to the exchange.

A call to *KMK* may be made either on every occupation of *REG* or on a call from a subscriber who is classified as a push-button subscriber. The latter alternative is used when less than some 50 % of the total number of subscribers connected to the exchange are push-button subscribers.

In parallel with *KMK*, however, there is always a dial pulse receiver connected to *REG*, so that both push-button and dial telephones can be connected to the exchange without indication of class of subscriber.

KMK Functions

Input Amplification

The digital signal from the push-button telephone first passes through an input amplifier with high input and low output impedance.

Limitation

Apart from digital signals, signal imitations may also enter *KMK* which may derive from, for example, different audio frequencies reaching *KMK* via the subscriber's microphone. To prevent *KMK* from interpreting these signal imitations as digit signals, certain conditions have been laid down which must be fulfilled for a digital signal to be accepted.

The digital signal must consist of two frequencies, one of which belonging to group I and the other to group II.

The digital signal must be correctly interpreted if the frequencies do not reviate by more than ± (1.5 % + 4 Hz) from the nominal value.

The digital signal must be correctly interpreted if its length exceeds 40 ms. Signals shorter than 25 ms must not be interpreted as digital signals.

An interval between two digital signals must be correctly interpreted if its length exceeds 70 ms. A silent interval of less than 45 ms must not be interpreted as an interval between two digital signals.

The digital signal must be correctly interpreted if the difference of level between two frequencies is less than 8 db.

If *KMK* receives signal imitations and interference frequencies simultaneously, and if they are of the same level, this must not be interpreted as a digital signal. To prevent this from occurring during push-button dialling, the microphone circuit is shorted when a button is pressed.

Reception of the first digital signal can take place simultaneously with the transmission of dial tone to the subscriber.

Frequency Division in Groups

Two parallel band-stop filters are connected in the signal receiving circuit. One of them suppresses frequencies from group I, the other from group II. These filters, on the other hand, do not suppress other frequencies within the speech band. By means of this division the abovementioned limitation conditions can be fulfilled as regards signal imitations. Two or more signal frequencies within the same group, or within one group of frequencies plus the remainder of the speech band, constitute an indication of signal imitation and must therefore result in a not digital signal.

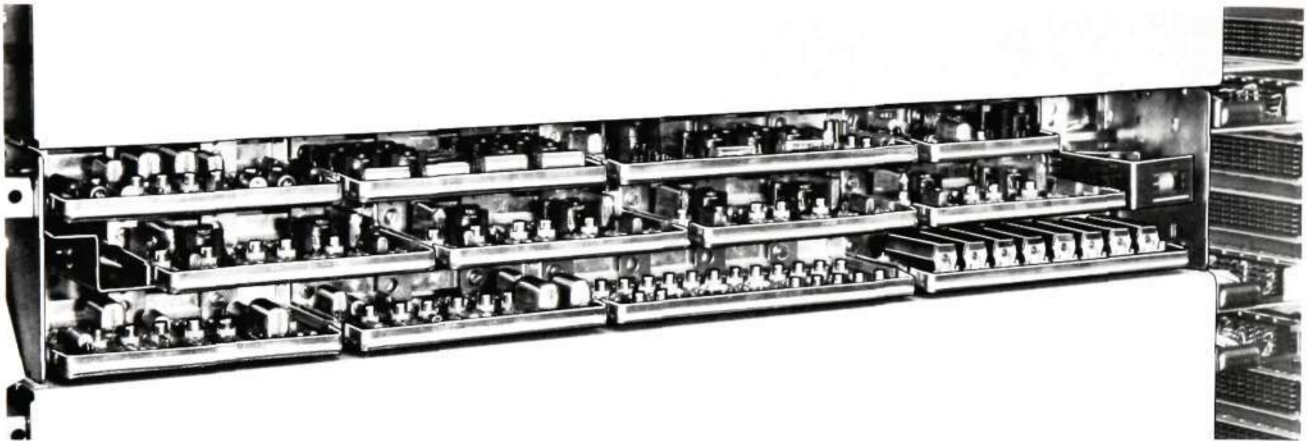

Fig. 3
Push-button code receiver on rack
(with cover removed)

Frequency Division in Individual Frequencies

In the signal-receiving circuit for grups I and II there are, respectively, four and three (extendable to four) channel receivers which are tuned to the frequencies listed in the table on page 9. Connected to the channel receivers there is a supervisory circuit which accepts the digital signal if it contains a frequency from each group.

Recoding and Transmission of Digital Signals between KMK and the Digit Store in REG

In the recoding unit of *KMK* the digital signal is recoded into a signal system directly adapted to the digit store in the register. The signalling is based on the d.c. system, a.d.c. code being sent on two out of five wires for every digital signal (see table on page 9).

For older types of *REG* which are not adapted for push-button signalling, decimal digit transmission is used at 20 pulses per second. The rapidity of transmission and the length of the number may in this case also require the addition of a buffer store in *KMK*.

Dial Tone

Dial tone is sent to the subscriber from KMK and disconnected after reception of the first digit.

Mechanical Design

The additional equipment required at the exchange for the introduction of push-button selection consists of two units: a code receiver finder *SS* and a code receiver *KMK*. For older types of exchange it may also be necessary to install matching equipment and a buffer store. *SS* is made up of units for 10 or 20 inlets and 12 outlets with 10-pole through-connection.

The 20-inlet form of *SS* is used for exchanges where the number of push-button subscribers is less than about 50 %, the 10-inlet form where the number of push-button subscribers is more than about 50 %.

For exchanges where the number of push-button subscribers is 100 %, *SS* can be entirely eliminated and a permanent connection is used between *KMK* and *REG*.

The *SS* unit consists of one or two relay sets, and four units can be placed on one rack.

KMK consists of two units: a push-button receiver for v.f. code *KMKT* (fig. 3) and test, supervisory and holding functions *KMKR*. Fifteen *KMK* units can be placed on one rack.

The units are of plug-in type and can therefore be added at the rate at which push-button dialling is introduced.

New Member of the DIALOG Family

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The DIALOG was introduced by L M Ericsson in 1962 and, due to the flexibility of its design, has proved to be adaptable for many different applications and varying customer requirements in the past years.

A great need has been found, however, for a simple high-class standard telephone set. As a complement to the DIALOG, therefore, L M Ericsson has designed a new telephone set which, while less flexible, has a simplified mechanical structure. Particular attention has nevertheless been paid to greatly varying customer requirements. This further development of the DIALOG has been made possible by new advances in technique and technology.

Thanks to the farsightedness in the design of the original DIALOG (see Ericsson Review No. 4/64) L M Ericsson has been able to base its subsequent development of telephone sets on well-tried and reliable principles of engineering and functional design.

The basic characteristics and components of the new telephone set are briefly presented in this article. Detailed accounts will appear in a later number of Ericsson Review.

Basic Characteristics

Strict requirements in respect of transmission characteristics, length of life and ease of maintenance were the guiding principles in the design of the new DIALOG. Subscribers' desires have also been taken into account.

☐ The *transmission characteristics* of the telephone set are satisfactory and stable, which is a decisive factor in economic network planning on the basis of CCITT recommendations.

☐ *Long life* is ensured by the well tested cradle switch construction, the new robust dial, the general ruggedness of the instrument—which stands up well also to tropical environments—and the high dielectric and mechanical strength.

☐ *Maintenance* is facilitated and reduced by the simple mechanical structure in separate functional units. No extra parts are required for provision of a fully adequate seal against insects. No lubrication is needed.

☐ *Subscriber desires* are met through the generous range of colours, portability, modern design, the light handset which lies conveniently in the hand, easily extendable spiralized handset cord, and easy adjustment of the sound level of the bell.

Functional Units

The telephone set contains separate functional units consisting of

- Dial
- Cradle switch springset
- Printed circuit board
- Bell
- Handset
- Cords
- Wall terminal

Fig. 1
Functional design

The division into separate units facilitates maintenance and the adaptation of the components to future techniques.

The dial and cradle switch springset are mounted in the case, which reduces the building-in tolerances and ensures high functional reliability.

The printed circuit board is also placed in the case, while the bell is mounted on the base, which provides a simple mechanical structure of high strength. Between bell and case only a two-wire cable is required, which is plug-terminated. The case can thus easily be removed from the bell and base, which greatly simplifies maintenance.

To ensure satisfactory operation of the telephone set in severe environmental conditions the material and finish have been selected with care. Good ventilation and inlets for light have also been achieved. Insects are prevented from entering the instrument by the fact that no slots are larger than 0.5 mm.

The *external form of the telephone set* resembles that of the previous DIALOG, the new set being available in seven standard colours:
Red, beige, blue, light-grey, green, white, ivory.

Fig. 2
Hand-grip and recess for admission of light

The *case* is made of ABS (Acryl-Butadiene-Styrene) thermoplastic which has admirable strength properties and a high surface gloss.

The *feet* provide high friction against the underlying surface. They do not leave marks on polished surfaces and the material has good aging properties.

Termination of the various functional units is done with screw-terminals. Screw terminations, which from experience provide a more reliable contact, were chosen in preference to plug and jack connection, which is simpler from the servicing aspect, in view of the low voltage levels which occur in some parts of the telephone instrument circuit.

Since the ringing voltage level is high, the bell can be provided with plug and jack.

The *thumb-wheel for adjustment of the sound volume of the bell* is placed on the underside of the instrument in order to prevent involuntary alteration of its adjustment. Experience from various markets shows that the sound level of the bell is almost without exception set once and for all to the position desired by the subscriber and is thereafter seldom changed.

The *cord outlets* are placed on the left-hand side of the instrument for convenience of handling. At the same time the placing of the cords does not prevent the use of different forms of keybase.

Relief from strain on the cords is provided by a moulded-in grip in the case in the form of a zig-zag channel, which ensures a simple but extremely reliable anchorage of the cord.

The Dial

The *dial* is of new type and is the outcome of a very thorough analysis and calculation of the properties of materials, and of pulsing and governor systems.

The dial has plastic gears and plastic-to-steel bearings, as a result of which it requires practically no maintenance. The tension spring is well protected under the central gear-wheel.

The *finger wheel* is resiliently mounted on its hub and is thus not subjected to constant strain.

Fig. 3
Simple mechanical design facilitates servicing

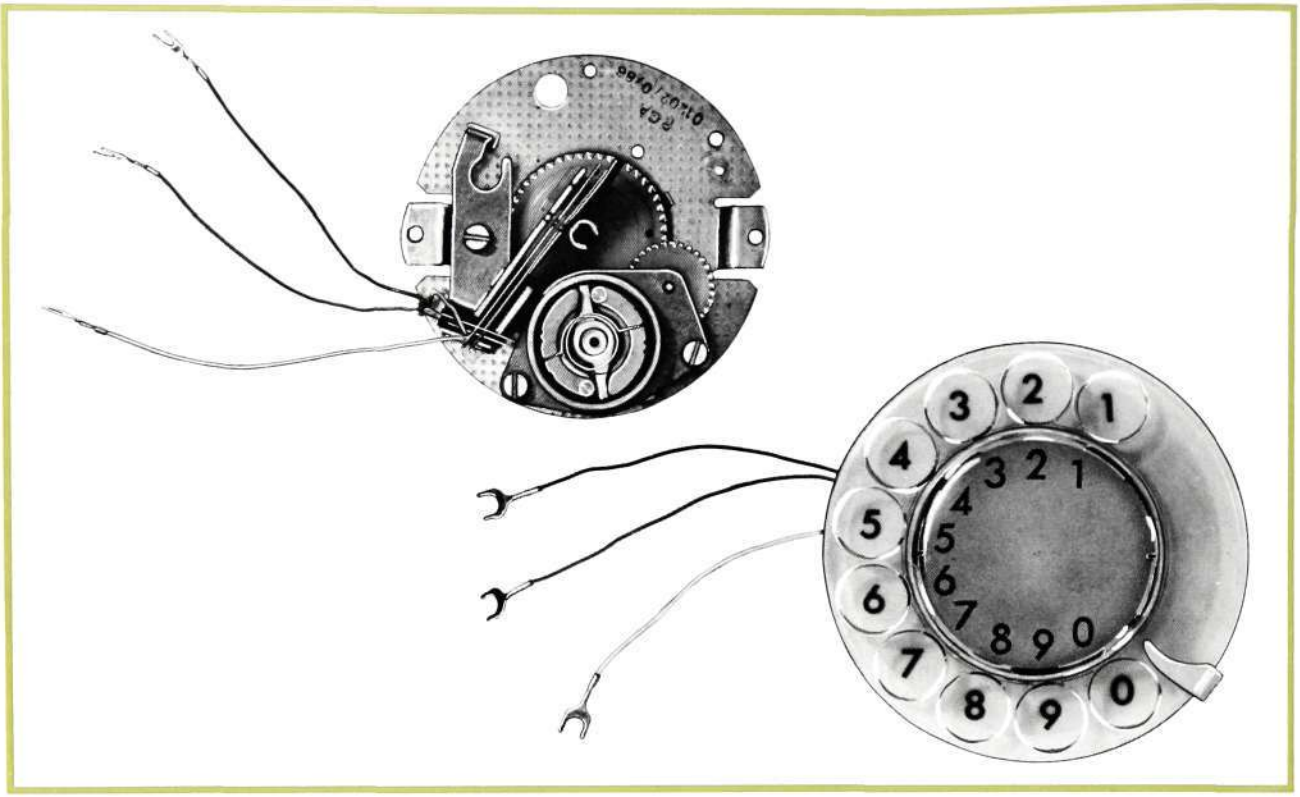


Fig. 4
New maintenance-free long-life dial

The *pulsing system* is an one-cam system with double eccentric which ensures accurate pulses without contact bounce. The pulsing system delivers exclusively the selected number of pulses. The pulsing springs have twin contacts with adequate sliding action, which ensures good contact performance.

The *governor* is of the drive-bar type and ensures accurate speed of pulsing even at a changed torque (forcing of the dial).

There is a choice of two *pulse speeds*, 10 ± 1 Hz and 20 ± 2 Hz up to 2×10^6 operations with small variations within the same pulse train.

The *pulse ratio*, defined as the ratio of the break pulse to the entire pulse period, is maintained with an accuracy of ± 3 % up to 2×10^6 operations. The dial can be delivered with different pulse ratios: 50 %, 60 % and 67 %.

The *inter-digit pause*, determined by the mechanical design, is greater than 300 ms (not including the time of rotation to the finger-stop). Including the time of rotation the inter-digit pause may be estimated to definitely exceed 500 ms.

Cradle Switch Springset

Reliable operation of the cradle switch springset is ensured during the entire life of the telephone set. This is due to the following factors:

☐ *The effective weight of the handset in relation to the force requirement of the cradle switch springset*

The effective weight of the handset is its real weight minus the frictional losses to case and cradle switch discs on replacement of the handset.

The form and material for the case and cradle switch discs have been chosen with care in order to keep the friction losses at a low level during the entire life of the telephone set.

The effective weight of the handset during the cradle switch movement will be seen from fig. 6.

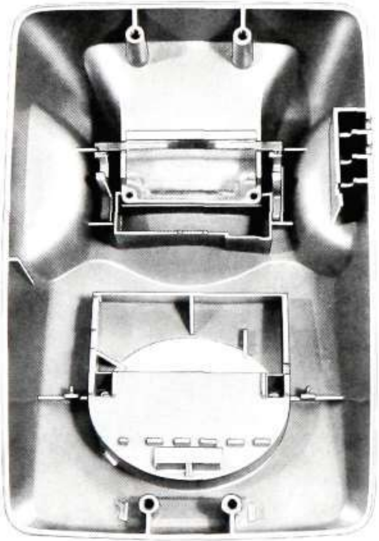


Fig. 5
The case protects the cradle switch springset and dial

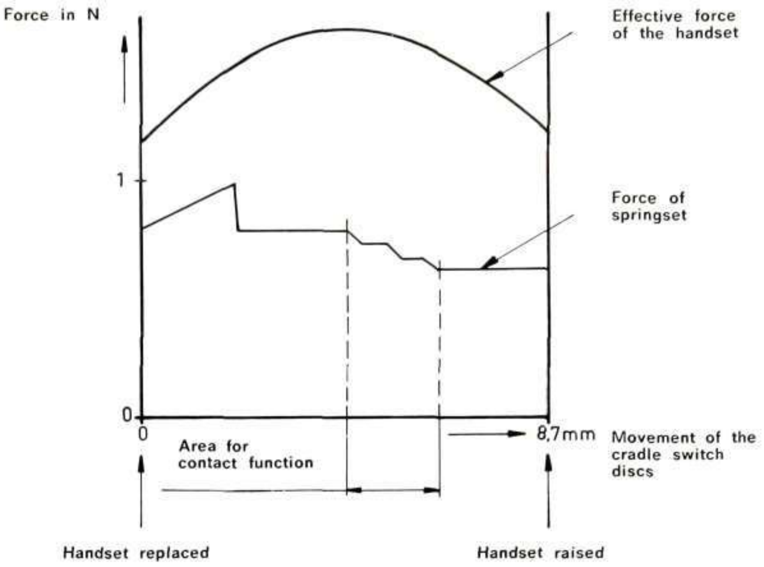


Fig. 6
The cradle switch has large margins of force and movement

The force-travel characteristic of the cradle switch springset has been adapted to the effective weight of the handset for reliable operation during the entire life of the telephone set, corresponding to 300,000 replacements of the handset.

☐ *Contact performance*

The contact performance of the cradle switch springset is ensured by

- Dusttight placement in the case
- Contact force exceeding 300 mN (30 g)
- Twin contacts
- Contact material of well tested silver-copper alloy
- Large contact slide (100 μm)
- Large contact clearance (min. 0.3 mm)
- Injection-moulded phenolic spacers (not to be confused with paper-based laminate)

The contact functions are provided by *a single* springset in which time sequences, contact force and contact clearance are controlled by lifting and supporting cards built into the springset. The functions of the cradle switch springsets are thus unaffected by dimensional deviations in the case or external devices.

Only a small part of the total movement of the cradle switch discs is used for reliable electrical function of the springset (see fig. 6).

Printed Circuit Board

The placing of the printed circuit board in the case with the foil side facing the dial protects the wiring against damage during fitting and removal of the case.

The angle at which the board is placed in the case prevents any condensation from remaining on the surface and causing corrosion. The foil is lacquered for further reinforcement of the protection against corrosion.

The board terminations are marked with numerals to facilitate the connection of incoming wires.

Bell

The bell is a polarized A.C. bell with magnet of high coercive properties for avoidance of demagnetization. The bell is designed for connection in series with a 1 μF capacitor. The impedance of bell + capacitor is 4 KΩ and the starting voltage at 25 Hz is 20 V. At a generator voltage of 80 V five bells in parallel ring in series at the end of a 1500 Ω line and with 900 Ω resistance in the ring trip relay.

At 50 V the bell in the telephone set delivers a sound pressure level of 70 dB (B) ref. 2×10^{-5} N/m^2 measured at a distance of 1 m in an anechoic chamber. When measured in an ordinary room, the volume is higher owing to the reverberation time of the room.

The bell has a volume control wheel by means of which the level can be regulated from full output down to the sound of a buzzer.

Connection of the bell is effected with a plug fitting into jacks with twin contact springs.

The Handset

The handset is of conventional type with separate receiver and microphone caps for ease of servicing. The plastic parts of the handset are of ABS thermoplastic, which has satisfactory strength properties and a fine gloss which is not stained by lipstick, hand-sweat etc.

The handset has the same easy grip as the DIALOG and has no joints in the grip which would collect dirt.

Cords

The spiralized *handset cord* has good elastical properties and can be extended to 1200 mm without moving the telephone set. The cord has a plastic sheath of PVC and tinsel strands with high fatique strength. The plastic material leaves no marks on varnished surfaces.

The telephone set cord is straight but of the same quality as the handset cord. The high tensile strength of the tinsel strand ensures that the cord will not break through careless movement of the telephone set.

Wall Terminal

The telephone set can be provided with optional terminations, but in its standard form has a wall terminal box.

The telephone set cord enters through the lower edge of the box and is anchored in a moulded-in zig-zag channel. Incoming cable can be introduced into the box on all four sides, which facilitates the work of the fitter.

Dielectric Strength

To ensure reliable operation of the new telephone set, special care has been devoted to adequate insulation properties and high dielectric strength.

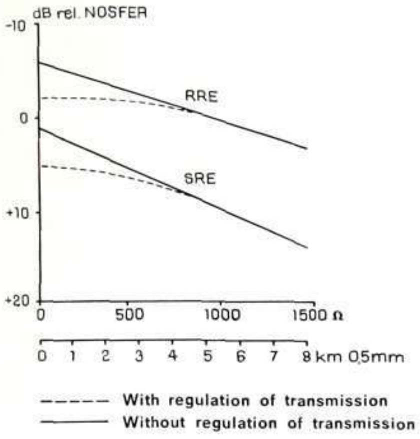


Fig. 7
Sending and receiving reference equivalents as function of the length of 0.5 mm cable

The wiring between bell, cradle switch springset, printed circuit board and dial consists of insulated conductors. The cradle switch springset has been so formed and the spacers are of such material that no conductive carbon paths after a short-circuit can jeopardize the reliability of operation.

In the transmission circuit, which consists of a printed circuit board, the placing of components and the wiring are such that points which can attain a high potential difference are widely separated from one another. In this way, in the event of overvoltage in the telephone set, a number of parallel circuits are formed and the incoming energy is distributed over as large an area as possible.

Transmission Characteristics

The receiver, microphone and transmission circuits have been dimensioned to comply with CCITT's recommendation P 11 of June 1964, i.e. sending reference equivalent (SRE) max. + 20.8 and receiving reference equivalent (RRE) max. + 12.2 dB. When these values are reduced by 3.5 dB for the national four-wire circuit, there remain SRE max. 17.3 dB and RRE max. 8.7 dB. These values include the telephone set, local line and junction circuit if any.

The telephone set has an automatic sensitivity control controlled by the line current, which reduces the sending and receiving levels on short lines by about 4 dB. This ensures

- that the listener is not subjected to troublesome high speech levels
- that the 4-wire network repeaters are not overloaded
- that crosstalk risks are reduced
- that the side-tone attenuation is improved.

SRE and RRE relative to NOSFER for telephone set including local line will be seen from fig. 7 for the supply systems:

48 V at 2×200 Ω, 2×250 Ω or 2×400 Ω
60 V at 2×500 Ω.

New Subscriber's Meter

A. REJDIN & B. BARKLAND, TELEFONAKTIEBOLAGET L M ERICSSON, STOCKHOLM

UDC 621.395.663.2
LME 7359 8333

A new subscriber's meter, type RSA 211, has been designed and will successively replace the present RSA 200. It is a 5-digit non-zeroable meter, which is both quicker and occupies less space.

The meter is normally mounted in sets of 100, with 20 sets accommodated on a double-sided rack, i.e. 2000 meters. The meter can also be used separately and in such case is provided with an individual cover for panel mounting.

Mechanical Design

The new subscriber's meter, like its predecessor *RSA 200*, is a 5-digit meter, but, compared with the latter, is smaller, quicker and has a longer life. The total length of the meter, from fore edge to rear end of the soldering tags, is 53.5 mm.

The front of the meter essentially resembles *RSA 200*. It has the same size of digit wheels and digits. The digit wheels and gears are made of polyacrylate, and the ratchet wheel of polyamide. The pawl, which on the new meter is carried on the same spindle as the four gears, is an acetal resin moulding.

The two spindles for digit wheels and gears are rigidly fixed in one side of the body. The armature is pivoted in a recess in the body and held in position by a bent down lug forming part of the body. On the armature there is a tongue which directly actuates the pawl. The return of the armature is effected by a helical spring attached to the pawl and body.

The bobbin is of glass-fibre-filled polyamide, so it can be made thin-walled without loss of stability. This has resulted in adequate winding space despite the small dimensions of the bobbin. The coil tags are designed for top wiring.

Fig. 1
Subscriber's meter RSA 211

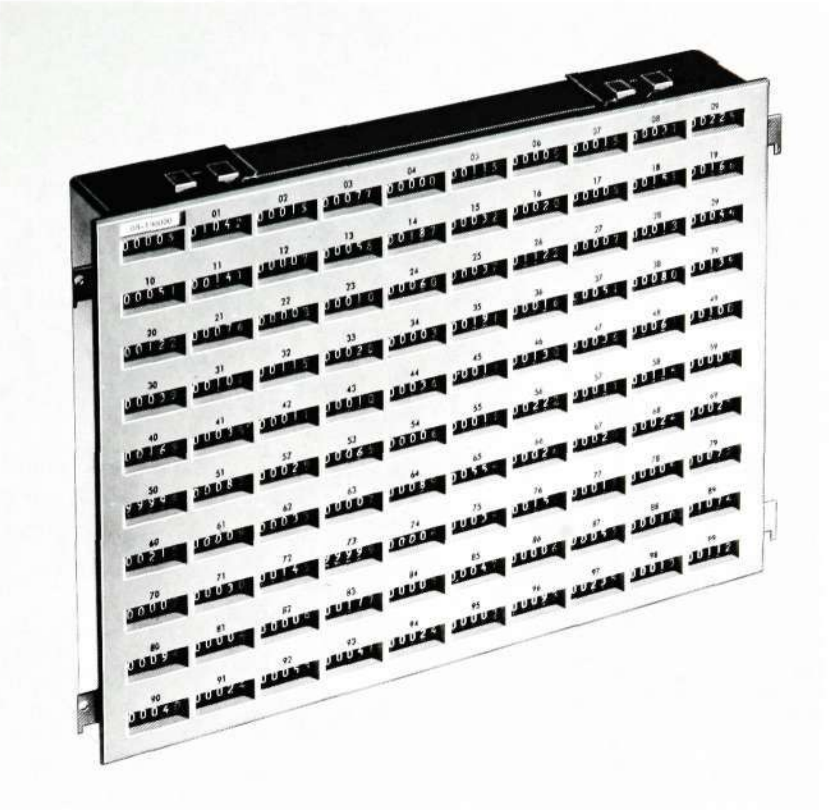


Fig. 2
Set of 100 subscribers' meters BCT 960-961

To ensure satisfactory magnetic properties the coil and core are riveted to the body of the meter.

Electrical Data

The meter has an efficient magnetic circuit. This has been achieved through the avoidance of unwanted air gaps, and the dimensions of the components of the magnetic circuit could therefore be kept relatively small. The inductance of the meter is low, which in combination with the small mass of the armature and pawl makes the meter quick in operation.

For replacement of *RSA 200* in its use as subscriber's meter, *RSA 211* has been fitted with a diode in parallel with the coil. The diode delays the release so that there is no risk of unintentional double metering caused by short interference pulses.

Meters with diode are coded *RSA 21101—RSA 21107* and without diode *RSA 21121—RSA 21127*. Meters with diode are dependent on the direction of the current. Other electrical data are tabulated below.

Data for RSA 211

Code No.	Model	Operating voltage V	Resistance Ω	Min. time for pulse	Min. pause	Max. stepping frequency
RSA 21101	With diode	6	20	25 ms	30 ms	18 Hz
RSA 21102		24	500			
RSA 21103		48	1500			
RSA 21106		36	1000			
RSA 21107		12	100			
RSA 21121	Without diode	6	20	25 ms	10 ms	28 Hz
RSA 21122		24	500			
RSA 21123		48	1500			
RSA 21126		36	1000			
RSA 21127		12	100			

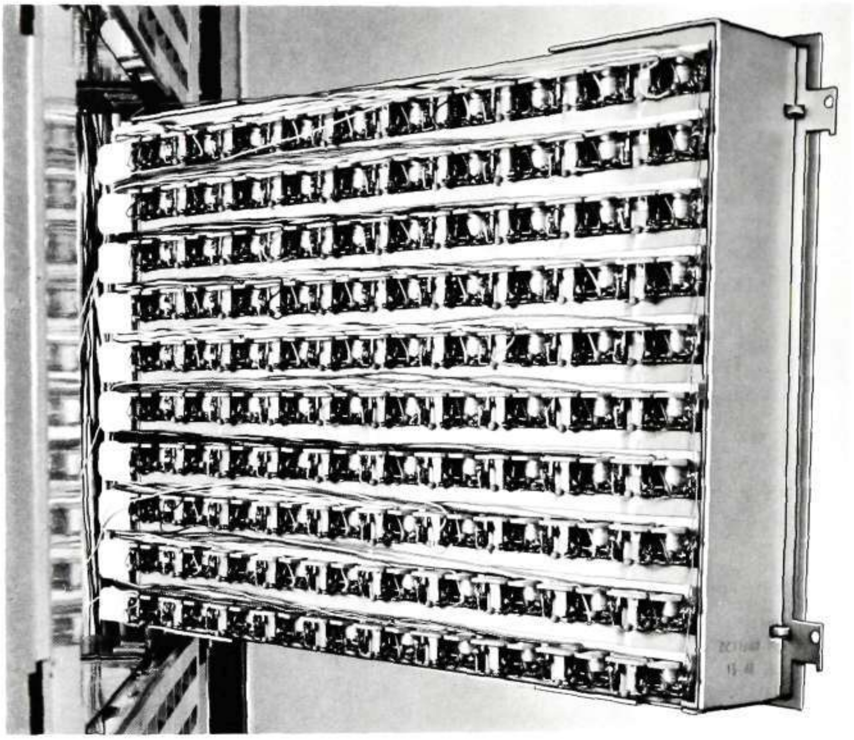


Fig. 3
Subscriber meter set swung out from rack (rear view)

Meters in Sets of 100

Owing to the low weight of the meter, only about 45 g, it has been possible to mount it in sets of 100. The new subscriber meter set *BCT 960—961* consists of a frame with 100 partitions, one partition for each meter, and a front panel in which there are windows for display of the digits. The front snaps on under spring pressure and, in order to avoid unwarranted interference with the meters, the front can be sealed, so that it cannot be removed without breaking the seal. Both frame and front panel are made of light-grey plastic. The set is 59.5 mm deep including wire guide; the front panel is 355 mm wide and 232 mm high.

Above the first meter in the set there is space for a label indicating the number of the first meter. For the other meters the last two digits 01—99 are indicated above each meter.

The soldering tags of the meters are accessible from the rear of the sets. Moulded-in wire guides simplify installation, as the connecting wires can be laid directly over the wire guides up to the soldering tag without being first formed into a cable. If there are rectifiers in series with the meters, soldering tag strips are placed on the rear.

2000 Meters per Rack

The rack, type *BAC 160*, consists of Z-shaped uprights with recesses in which the sets of meters are suspended so that the right-hand attachment serves as a hinge and the left-hand attachment runs in a slot in the left-hand upright. In this way only one upright per rack is required apart from the outer upright for the suite. Through the hinging arrangement the set of meters can be swung out for connection of switchboard cable or inspection. This makes it possible to place sets of meters both on the front and rear of the rack, so that the rack becomes double-sided.

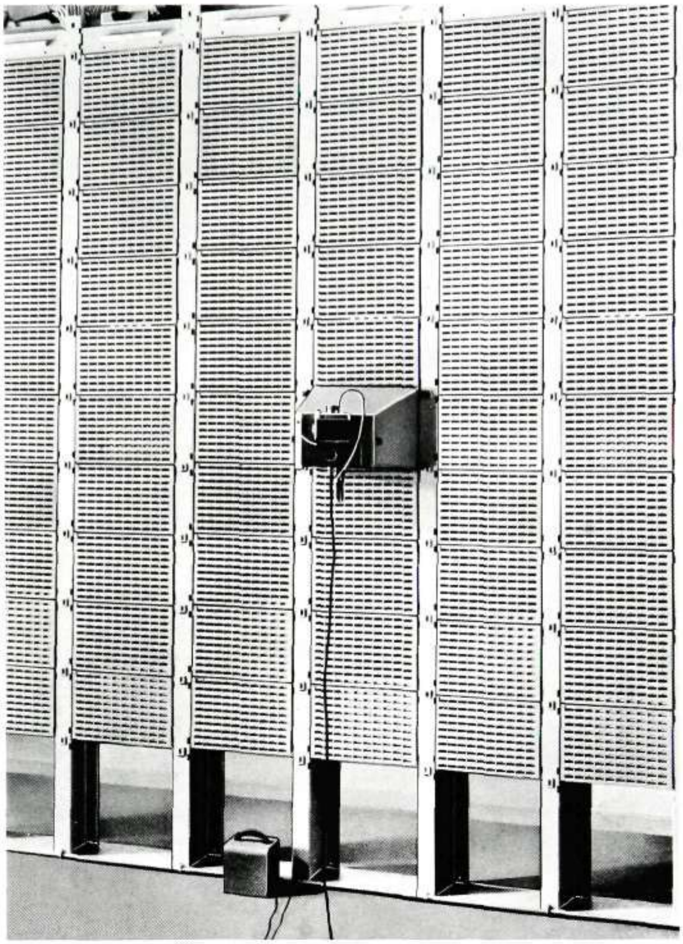


Fig. 4
Suite of BAC 160 racks with 1000 subscribers' meters on each side of each rack, and hood with camera for photographing the meters

With 10 sets of meters on each side a rack accommodates 2000 meters. The rack can also be placed against a wall, but then accommodates only 1000 meters. The rack module is 400 mm and its standard height 2900 mm.

At the top of the rack there is space for rack fuses and terminal blocks for termination of, for example, coin box stations or subscriber's private meters. These are placed under a hinged cover with labelholder for labelling of the rack.

A jack box accommodating 20 standard jack strips has also been designed for special equipment which may need to be placed on the subscriber meter rack. Such equipment may consist of separate meters, protector equipment, relays, jack units, lamps or keys etc. The jack box occupies the same space as a set of meters.

Installation

The rack upright provides the necessary space for the cable to the subscribers' meters. For connection to the meters the individual wires are laid directly over the wire guides, which greatly reduces installation work. As one soldering tag of the meters must normally be connected to a common polarity, this wiring within the set of meters is done in the factory. This contributes still further to the reduction of installaion work.

Wall Frame for 100 Meters

This frame type *BAC 901*, is designed for attachment to a wall. It consists of two profiled uprights placed on a rear plate with detachable top and bottom covers.

Fig. 5
Subscriber's meter with individual cover

In its basic form the frame is designed for one set of meters and is 411 mm wide, 250 mm high and 75 mm deep. It can be extended so as to accommodate two additional sets and, if necessary, fitted a 100 mm high upper portion with space for fuses and labels.

At the time of installation the cable is run into the right-hand upright from the upper or lower side of the frame.

Photographic Recording

The rack is designed for photographing of the meters, the uprights having plastic-lined recesses for the fitting of a photographic hood and camera. As before, 100 meters are photographed at a time and, after minor modification, the previous hood can be used also for the new set of meters. In the design of the front panel special attention has been paid to the requirement that the meter digits and the labels shall be distinctly photographed without disturbing reflections.

In the same way as the rack the wall frame is designed for photographing of the meters.

Individual Cover

For separate use of the meter it can be supplied with an individual cover. In such case it is designed for panel mounting in a rectangular recess 33×24 mm. The panel may be between 0.5 and 3 mm thick. The cover, of plastic, consists of a front and rear piece joined together by a snap-on catch, which fixes the meter to the panel. In front of the digit window there is a transparent plastic cover, which also covers a label, if required, for the meter.

ERICSSON News from

All Quarters of the World

On Monday, February 10, 1969, the installation was shown to the press in conjunction with an official opening ceremony presided over by the Director General of the Swedish Railways, Eric Upmark (on right in the photograph). Dr. Christian Jacobæus, Technical Director of L M Ericsson, handed over the large PABX and is seen (left), in front of the service supervision desk in the switchroom, receiving the thanks of Director General Upmark for a well and quickly carried through job.

Swedish Railways' New LME PABX One of the Largest in Sweden

On January 31, 1969, one of the largest PABX in Sweden was cut over at the Swedish Railways Offices at Tomteboda, Stockholm.

The PABX is of code switch type and consists of a local unit AKD 791 for 3600 subscribers and a long distance unit AMK 301 for 270 circuits. The PABX also contains equipment for automatic interworking with a subexchange and 46 selective calling lines.

The relays and switches, totalling 1900 units, are mounted on 140 racks. The total length of wire in the switchboard cables amounts to more than two million metres and, during the period of installation (one year), nearly three million points have been soldered.

The Swedish Railways possess an impressive telephone network: at the year end 1968 they had 11 group centres, 39 terminal exchanges and a large number of selective calling exchanges of L M Ericsson type in operation. This state enterprise has spent more than 200 million kronor on its telecommunications.

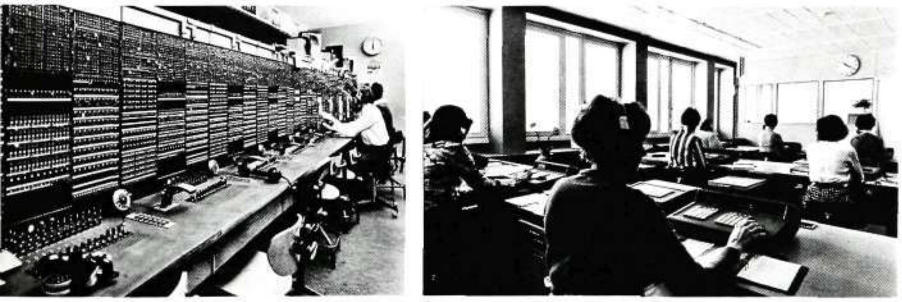
The automatization programme for the Swedish Railways telephone network has recently been completed through the cut-over of the Ånge group centre.

To carry the traffic on the Swedish Railways telephone system (from Kiruna in the north to Malmö in the south) an interconnection technique is required between the new exchanges and the internal railway telephone network, which is of an uncommon character and extent.

- The number of long distance circuits is very large—270, when required, on 30 routes.
- All transit traffic is through-connected on a 4-wire basis—a guarantee of good transmission characteristics.
- All long distance traffic is normally put through without operator assistance.
- Routing prefix and subscriber number are dialled in one sequence without waiting for a new tone—there may be up to nine digits to dial.
- If necessary, the switchboard operator can put through all types of traffic from her ordinary telephone set—outgoing, incoming and transit traffic, and can also enter the circuit of engaged extensions.

L M Ericsson has had a great success with the AKD exchanges, which were developed specially with a view to customers who require large and very qualified PABX. Up to now 18 PABX have been delivered and there are 23 orders on hand from, among other countries, the Scandinavian countries, Latin America and the Far East.

(Left) The old LME exchange from 1946 which was cut over at 6 p.m. on January 31, 1969. For the absolutely last time the operators take down the connections. It took two minutes to transfer the traffic to the new exchange. Now the picture is quite different (right). Ten girls serve the public and the Swedish Railways personnel with the aid of elegant consoles in teak. Their place of work is more like a modern office than a telephone exchange.



Large American Order for Intercom Telephones

L M Ericsson Telemateriel AB has received a large order from Motorola Inc., Chicago, for altogether 2340 intercom lines for hospitals connected to 13 exchanges. The order amounts tom ore than two million kronor.

Motorola Inc. is a large American enterprise which manufactures, among other items, TV equipments, semiconductors, telecommunications systems for hospitals, and hospital signalling systems. It is the leading supplier in the U.S.A. of equipment for the very expansive hospitals sector.

The long-term credit agreements in Ecuador were signed in Quito on December 20, 1968. In the centre of the photograph is seen Dr. Olmedo del Pozo, Notary Public, with the head of the Guayaquil telephone administration, Sr. Enrique Alarcón, on his left, and the head of the Quito administration, Dr. José Sanchez Ibarra, right. The other persons, from the left, are Mr. Bengt Looström, L M Ericsson, Stockholm, Mr. Lennart Nilsson, Head of L M Ericsson Sales Company in Ecuador, and the company's lawyer, Sr. Cesar Palacio.

Long-term Credit Agreement with Ecuador

At the end of last year the President of Ecuador, José Maria Velasco Ibarra, granted permission to the telephone administrations of the cities of Quito and Guayaquil to sign a contract with L M Ericsson, Stockholm, without calling for tenders, for the purchase of telecommunications equipment amounting to some 60 million Swedish crowns.

L M Ericsson is undertaking the financing of this contract through credit agreements with the two administrations.

The agreements cover the delivery of automatic equipment for extension of the telephone exchanges in the two cities by some 50,000 subscriber lines and associated outside plant and long distance equipment.

All equipment will be delivered from the Group's factories in Sweden, while the installation work will be done by indigenous labour.

Long-term credit agreements of the same type have been earlier signed with the two administrations, the first in 1962—for 6.8 million US dollars—and the second in 1966 for 10 million US dollars.

The agreements generally run for 10 years and are financed to a large extent out of telephone rentals. The present installation charge in Ecuador is about 85 US dollars.

Extensive long distance network

In the last six years the Long Distance Division of L M Ericsson has built up an extensive long distance network in Ecuador, principally based on radio links. The backbone of the network is a broad-band radio link between Quito and Guayaquil with associated multiplex equipments. The network was commissioned in January this year.

Subscriber trunk dialling will therefore soon be a reality in large parts of the country. Among the many radio links installed by L M Ericsson there is also an international link with Colombia. Extensions planned in conjunction with the new agreement include a radio link to Peru.

Ecuador will thereby obtain access to the international satellite network via the ground stations in Peru and Colombia.

L M Ericsson 60 years in Ecuador

The first Ericsson equipments were supplied to Ecuador about 60 years ago. The opening date for automatic switching was December 27, 1945, when 6000 ARF lines were contracted at a cost of some 5 million kronor.

Ecuador now has in operation 76,000 lines connected to urban exchanges, 2950 to rural exchanges, 1000 trunk lines and 200 to line concentrators.

New Major Orders

Egypt

The national Egyptian telephone administration is to extend its trunk exchanges in Cairo, Alexandria and other towns by equipment valued at some 12 million kronor.

In the early 1960's L M Ericsson started work on the automatization of the trunk network, which made subscriber-dialling possible between the seven largest cities in Egypt.

Brazil

On New Year's Eve 1968 a contract was signed for some 11 million kronor between the Brazilian state-owned telephone company EMBRATEL and Ericsson do Brasil (EDB). The contract covers the third phase of the extension of the São Paulo telephone network—the addition of 2600 new junction circuits at an ARM exchange.

(From left) General Francisco Galvão, Chairman of EMBRATEL, and Sr. Jorge Leal, EMBRATEL, sign a contract for some 11 million kronor with Ericsson do Brasil (EDB). On the far left is Mr. Gunnar Vikberg, President of EDB, and on the far right Sr. Geraldo Nóbrega, EDB.

◀ Mr. Svante Lundkvist, Swedish Minister of Communications, accompanied by Secretary of State Lars Peterson, Departmental Secretary Bo Järmark and Secretary of the Information Section, Lars-Eric Eriksson, were informed about L M Ericsson's activities and shown over the factory and other departments during a visit to Midsommarkransen on March 10.

Mr. Svante Lundkvist (centre) with Mr. Björn Lundvall, president of the Ericsson *Group (right), in front of some of* L M Ericsson's products in the Quality Control Section. Mr. Arne Mohlin points to a *multicoil* relay.

▲ Dr. Marcus Wallenberg, sports-interested chairman of the board of L M Ericsson, met last autumn the L M Ericsson engineer, Alvaro Gaxiola, who was Silver Medallist in the High Dive in the Mexican Olympic Games.

▲ On January 10 the Colombian Ambassador to Sweden, Dr. Guillermo Nannetti, and Counsellor Juan Gilberto Moreno visited L M Ericsson in Midsommarkransen. The visitors were received by the President, Björn Lundvall.

The photograph shows the Ambassador (right centre) and Counsellor Juan Moreno (left). Mr. Göte Fernstedt, L M Ericsson, demonstrates an automatically turned component of a telephone exchange during a tour of the factory. The visitors was shown round the exhibition room by Mr. Juan Arpa (centre left), L M Ericsson.

The Ericofon has been marketed in West Germany during the past years. A recent market survey shows that 90 per cent of subscribers prefer colourful telephone sets. The girl in the picture illustrates this in her special way. ▼

This secretary with Ericofon works at L M Ericsson's office in Addis Ababa, Ethiopia. She is wearing the national Ethiopian costume and, *on the wall behind her,* is a typical Ethiopian monkey-skin rug. ▶

Dr. Marcus Wallenberg Denotes One Million Kronor to L M Ericsson Gold Medallists

A fund has been formed through the donation of one million kronor by Dr. Marcus Wallenberg, Chairman of the Board of Telefonaktiebolaget L M Ericsson.

The donation was announced in conjunction with the Group's award of Gold Medals on December 16, 1968.

The fund is to be used for the benefit of necessitous persons among Gold Medallists of Telefonaktiebolaget L M Ericsson and its subsidiaries, and their wives or husbands.

Grants will be made from the yield on the capital of the fund

- for home care or after-care following a lengthy illness
- for holidays in conjunction with convalescence
- in other cases of financial difficulty, especially if due to causes outside the control of the person concerned
- in urgent cases of humanitarian need in which a grant would confer happiness and ease the life of lonely elderly people in modern society.

Major Advance for L M Ericsson on the British Market

L M Ericsson's subsidiary in the U.K., Swedish Ericsson Telecommunications Ltd. (SEE), has recently received a large order in London, worth some 6.2 million kronor, for the building of a private branch exchange for the Greater London Council.

This is L M Ericsson's largest contract in Britain since Ericsson Telephones Ltd. was sold to a British consortium more than 20 years ago.

In the contract of sale it was agreed that L M Ericsson should not sell telecommunications equipment on the British market during the next 20 years. The agreement ran out in June last year and the Group now has free hands once again in the U.K.

All L M Ericsson companies in the U.K. have their offices in Crown House, Morden, Surrey. They are five in number: Centrum Rentals Ltd. (CRL), Swedish Ericsson Telecommunications Ltd. (SEE), Centrum Electronics Ltd. (CEN), Swedish Ericsson Company Ltd. (SEL) and Production Control (Ericsson) Ltd. (PCE).

LME Symposium in Leningrad

Following on L M Ericsson's large contract with the Soviet Union, signed in 1968, the Russian PTT requested that the Ericsson Group should hold a symposium in Leningrad.

The symposium started on February 24 and lasted for one week. The head and coordinator of the L M Ericsson delegation was Dr. Christian Jacobæus. Some 20 addresses were delivered and discussions were held with Russian specialists within different fields of telecommunications. A full account was given of the Group's research and technique, with special emphasis on future plans.

A small exhibition was held in conjunction with the symposium.

Dr. Christian Jacobæus, L M Ericsson, addresses the LME symposium held at Leningrad 24—28 February.

(From left) M. Stojanov, Vice President of PTT Central Research Institute, Moscow, N. Voronin, PTT, Moscow, Dr. Christian Jacobæus, L M Ericsson, Vice Minister I. Klokov, PTT, Moscow, Head of Leningrad Telephone Area, B. Malinnikov, and I. Golubtsov, Vice President of PTT Research Institute, Leningrad.

New Appointments

Mr. Torsten Lindstedt has been appointed Head of Sales for the Latin American and Spanish markets, and Mr. Lars Edmark for the Asian (excl. Near East) and Oceanian markets, in succession to Mr. Göte Fernstedt, who retired on pension on January 31, 1969.

Torsten Lindstedt

Lars Edmark

L M Ericsson Sells AB Ermi

L M Ericsson has sold its shares in its subsidiary company, AB Ermi, Karlskrona, manufacturers of electricity meters.

This deal was a step in the Group's striving to concentrate the manufacture of its main products to the telecommunications field.

The new owners, Bergman & Beving AB, Stockholm, have marketed electricity meters and other electrical instruments for many years. Ermi's products, will be marketed in Sweden, as before. Mr. Lars-Eric Törnberg continues as president of Ermi.

ICL Acquires Share Majority in DKB

Europe's leading computer manufacturer, the British firm International Computers Ltd. (ICL), has acquired the share majority in L M Ericsson Data AB (DKB), which was previously fully owned by L M Ericsson. ICL is taking over 75 per cent of the shares, L M Ericsson retaining 25 per cent.

Since 1935 L M Ericsson has represented British punched-card machinery and computer suppliers, who have since merged with ICL. The latest and most notable merger—which led to the formation of ICL—took place in mid-1968 and gave ICL a predominant position on the British home market.

The activities of L M Ericsson Data AB will be conducted on the same lines and under the same management as hitherto.

New Subsidiary Company in Norway

A subsidiary company has been formed in Norway for the marketing of Svenska Radio AB's radiocommunication and certain marine equipments. The company, which started its activities on December 1, 1968, is called Radiocom A/S and is headed by Mr Knut Nitteberg.

The Ericsson Group

Associated and co-operating enterprises and technical offices

· EUROPE ·

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GNT AUTOMATIC A/S *DK-2060 Søborg*, Telefonvej 6, tel: (01) 69 51 88, tgm: automatic, telex: 5264, "AUTOMATIC KH"

Dansk Signal Industri A/S *DK-2650 Hvidovre*, Stamholmen 175, Avedøre Holme, tel: (01) 49 03 33, tgm: signaler københavn

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Société Française des Téléphones Ericsson *F-92-Colombes*, 36, Boulevard de la Finlande, tel: Paris (1) 242 35 00, tgm: ericsson colombes, telex: 62179, "ERICSSON CLOMB"

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CONTENTS

On cover: Tests with SL-GV tester in an ARF exchange, Melbourne, Australia.

Equipments for Maintenance of ARF 102 Automatic Telephone Exchanges

V. ERIKSSON, TELEFONAKTIEBOLAGET L M ERICSSON, STOCKHOLM

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Ericsson Review No. 2, 1966, under the heading "Centralization Trends in Exchange Maintenance", contains an account of the maintenance philosophy recommended by L M Ericsson and of how maintenance work can be rationalized through centralization.[1]

The present article contains a brief account of standard equipments used for maintenance of ARF 102 exchanges and of equipments for centralized service supervision of a multi-exchange area. The choice of equipment will depend on the size of the exchange and on the network structure. An exchange in a single-exchange area will not have the same equipment as exchanges in a multi-exchange area with centralized supervision. Suitable equipment for some typical cases is listed in a table at the end of the article.

Owing to the high requirements placed at the design stage on the reliability of circuitry and components, L M Ericsson's crossbar switching systems are very reliable in operation. There are therefore good prospects of maintaining these types of equipment for a very low labour effort. This is confirmed by many administrations.[2]

But even if faults seldom occur, it is important that disturbances which affect subscribers should be immediately indicated and that means should exist for tracing the faults. To fulfil this requirement with a minimum of manual labour, equipment is required which automatically supervises the functional quality, primarily from the subscriber's point of view, and provides indications when the quality is unsatisfactory. This equipment is supplemented by supervisory circuits, built into common control devices, which indicate disturbances in the function of these devices.[3]

Maintenance Equipments

A prerequisite for the maintenance philosophy recommended by L M Ericsson is the use of maintenance equipments which are so reliable that all doubt concerning their objectivity can be excluded.

They may be divided into six groups for the following purposes:

- supervision
- indication
- fault tracing and testing of switching equipment
- repair of faults
- fault tracing and testing of subscriber lines
- traffic measurements.

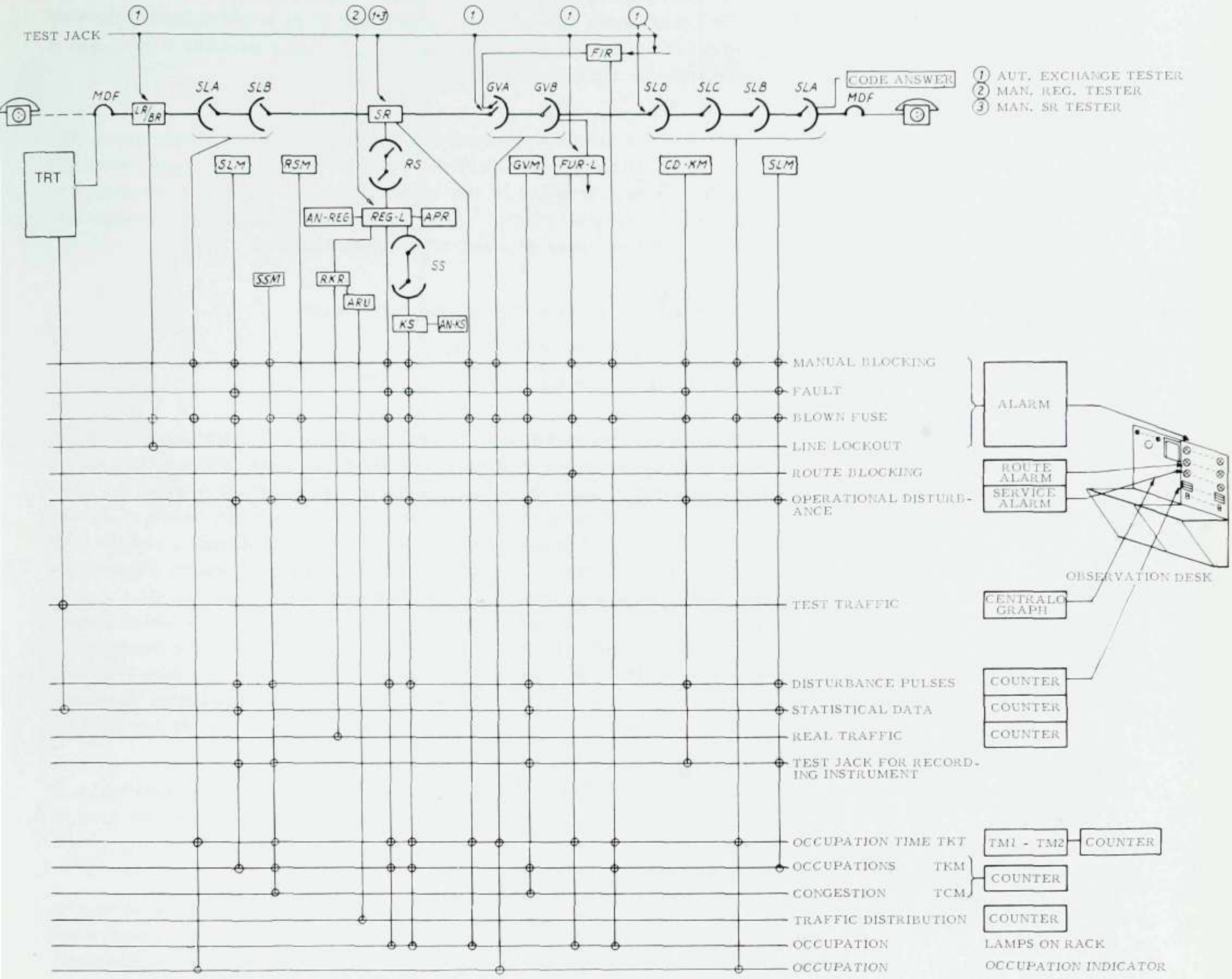


Fig. 1
Schematic representation of supervisory equipment

Supervisory Equipments

Fig. 1 shows how different equipments continously supervise the function of each part of the switching system of the exchange. For supervision of the entire switching process, i.e. from subscriber to subscriber, use is made of the method of generating traffic with a traffic route tester, *TRT*, and of the method of supervising real traffic. The two methods supplement one another, and both are used by many telephone administrations. Supervision of real traffic is generally done manually. It is therefore expensive, but on the other hand provides certain information which *TRT* cannot give, e.g. the subscribers' behaviour.

Traffic Route Tester (TRT)

The traffic route tester is supplied in two mechanically differing types, one on a detached, special purpose rack and one on a standard *BDH* rack.

For each programme a maximum of 20 test circuits can be connected to the traffic route tester, 10 as *A* test number and 10 as *B* test number. The programme comprises 100 connections, a test circuit being established from each *A* test number to each *B* test number.

The traffic route tester is connected to an exchange as a telephone set. The reliability of the exchange equipment recorded by the traffic route tester will therefore be representative of the service offered to subscribers connected to the exchange. A failed attempt by the traffic route tester to set up a connection is immediately recorded on a centralograph and counter.

The traffic route tester can be used in two ways

- for checking the functional quality
- as automatic fault tracer.

When the traffic route tester is used for *checking the functional quality*, it sets up test connections between *A* and *B* test numbers. When a fault occurs during the test, the fact is recorded on the centralograph, after which the tester takes down the connection and continues to the next. In the course of the test the total number of attempted connections from *A* test numbers and the total number of satisfactorily completed connections are recorded on counters. By reading of these counters at the end of the test programme or after a given number of connections one obtains a measure of the quality within the exchange or exchanges on which the test was carried out. If, for example, the traffic route tester has made 5000 attempts at connection, of which 4995 were completed without fault, this means that 99.9 % of the connections were satisfactory or (expressed in a more conventional way) that the fault rate is 0.1 %.

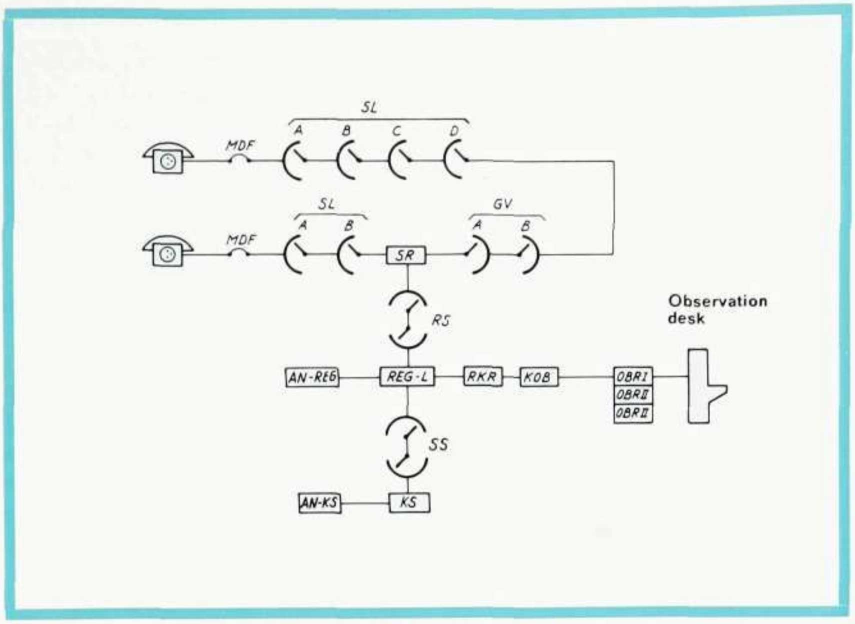
From the record on the centralograph char one can see between which *A* and *B* numbers the various faults have occurred and the type of fault in question.

When the traffic route tester is used as *automatic fault tracer*, it constitutes a very valuable aid to the maintenance personnel. If the functional check shows that some part of the exchange or a given route has an unsatisfactory functional quality, the tests are concentrated to that point, with the tester set for fault tracing. When a wrong connection occurs, it is held, the tester stops and issues an alarm, and indicates on a lamp panel certain information for guidance in tracing of the fault. The tester starts on new connections only after manual release.

Every established test connection is checked in respect of the following functions:

- receipt of dial tone
- transmission of ringing signals and ringing tone
- switching to correct subscriber
- no unwarranted tripping of signal
- current feed
- satisfactory communication
- no third party on line or crosstalk
- no short breaks
- no incorrect metering
- correct metering
- correct clearing of test connection.

Fig. 2
Supervision of real traffic



Supervision of Subscriber-Generated Traffic

By means of *RKR* (register control relays) the *A* subscriber's line can be automatically measured in respect of leakage and the subscriber's meter circuit can be checked in respect of disconnection and leakage.

RKR is connected to a normal register, usually one per 10,000-line group. This register must be accessible from all subsribers within the 10,000-line group.

RKR can be strapped for three alternative leakage measurements on the subscriber's line:

a) insulation resistance 30 kΩ ± 20 %
b) ,, ,, 100 ,, ± 20 %
c) ,, ,, 1 MΩ ± 20 %

If the insulation resistance is below the preset value, or if a fault is encountered in the metering circuit, the established connection can, if desired, be held for identification of the *A* subscriber. The result of the supervision of subscriber lines and subscriber meter wires is recorded on a number of counters.

Manual Observation of Connections

To permit an operator to supervise connection from subscriber to subscriber, two types of auxiliary equipment are required, *KOB* (relay set for connection of observation desk to *RKR*) and *OBR* (observation desk relays) (fig. 2).

The operator can monitor the connection and, on a lamp panel, sees the digits dialled by the *A* subscriber. Even if the *A* subscriber replaces, the connection can be held from the observation desk.

There is a 2-wire loop between *KOB* and *OBR* and the equipment works with up to 4000 ohms on this loop, so that in multi-exchange areas the observation desk can be placed at the main exchange.

Supervision of Common Control Equipment

Markers, registers, code senders etc. are continuously supervised by means of built-in supervisory circuits. All functional disturbances—due to faults in the device itself or in interworking devices, as also to a lack of devices—are recorded on *statistical counters*. For various groups of devices the numbers of occupations and disturbances of different kinds are recorded, and from these data one can obtain the average fault rate for the groups of devices, and so a measure of the reliability.

Normally the fault rate is low and is caused by temporary faults which it is not worth while searching for. If a serious fault occurs, the fault rate rises abruptly. To obtain quick information of this situation, the common control devices are equipped with an arrangement for *disturbance ratio supervision*. A *disturbance memory* in the form of a relay chain totals the number of disturbances. At the same time the number of occupations is totalled on a counter which can be preset. When this counter shows the preset number of occupations, the disturbance memory is zeroed. If the number of disturbances is too large before zeroing takes place, a *service alarm* is issued. The disturbance ratio, i.e. the number of permissible faults for a given number of occupations, is selected so that an alarm is not issued for temporary random faults but is issued in the event of an abrupt increase caused by permanent faults. The disturbance ratio can be set very much higher than the average fault rate.

The following groups of devices are equipped with disturbance memories

- Subscriber stage: one per marker for 1000-line groups
- *GV* stage: one per two markers for 320 *GV* inlets
- Register: one for one or more racks, but max. 10 *REG*
- Code sender: one per 10 *KS*

For zeroing of the disturbance memories only four occupation counters are required per 10,000-line exchange—one for each of the groups of devices above. The occupation counters are connected to devices which provide a representative picture of the variations in traffic intensity.

Supervision of Outgoing Routes

The junction relay sets are blocked in the event of a fault and an alarm is issued. For route supervision the blocking alarm circuit for all junction relay sets on a route is connected to a sensing relay in a route alarm relay set. A route alarm relay set contains circuits for 10 routes, and by means of strapping per route one can decide for what number of blocked devices a route alarm shall be issued. When a device on a route has been blocked its alarm lamp glows faintly, but changes to a bright light when the preset number of blocked junction relay sets has been reached. Only then is an alarm issued.

Indication Equipments

Alarm System

This system is constructed so that the type of alarm—e.g. blown fuse, service alarm, blocking, locking—is indicated on lamps on the relay set or rack where the fault has occurred.

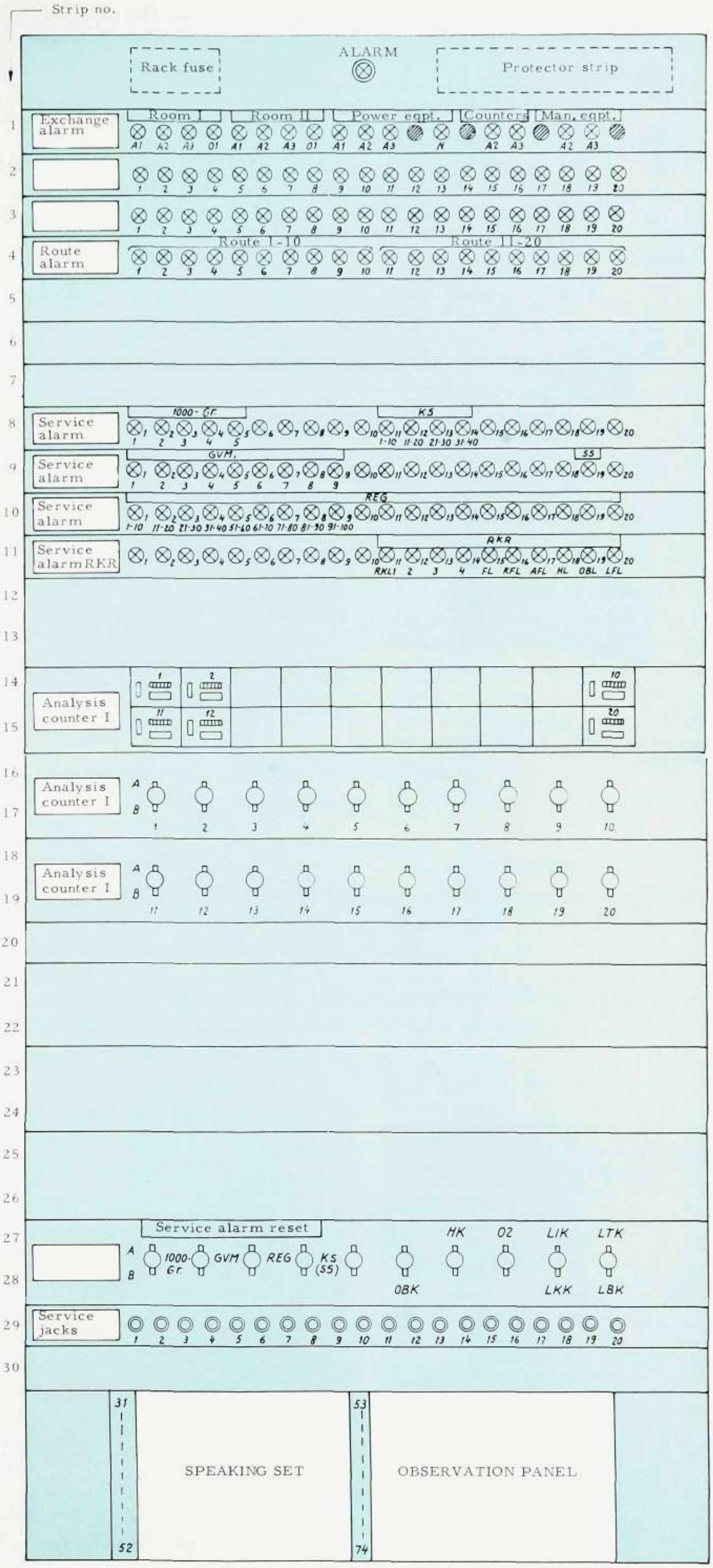


Fig. 3
Arrangement of supervisory panel for exchange with max. 5000 lines

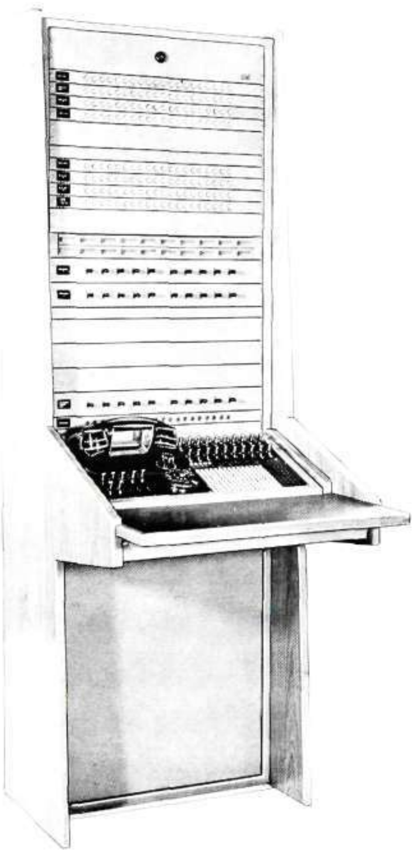


Fig. 4
Supervisory panel for exchange with max. 5000 lines

For indication on the suite supervisory equipment or on centrally placed alarm panels a category of alarm is instead issued which indicates how quickly action must be taken.

Fault alarms are divided into the following categories:

A1 fault which must be repaired immediately, both within and outside working hours (day and night)

A2 fault for repair as soon as possible, but only in normal working hours

A3 fault which can be repaired when convenient.

Observation alarms are divided into the following categories:

01 condition which must be investigated as soon as possible, but only in normal working hours

02 condition which can be remedied when convenient.

Control Panel

As will have been apparent from the above remarks, lamps, counters and keys are required for operation of the supervisory equipments and for indication of the results. For effective supervision, and at the same time to keep the maintenance personnel outside the switchroom as far as possible, it has been arranged that all operation and indication from the supervisory equipments take place on a control panel in a room outside the switchroom. Figs. 3 and 4 show a control panel for an exchange with max. 5000 lines.

Occupation Indicator

For deciding whether a condition is caused by the traffic load in the exchange or faults in the switching equipment, it is important to know whether all avaiable switching paths in the group in which the congestion occurs are being utilized. For this purpose every crossbar switch vertical has been furnished with a circuit connected to a terminal of a 200-point jack in the rack jack box.

An occupation indicator can be connected to the jack. When a vertical is occupied, a hole is burnt in a replaceable metallized chart.

At the end of the test one can decide from the holes in the chart whether all verticals have been in operation.

Equipment for Fault Tracing and Testing of Switching Equipment

When fault indications or statistics show that fault tracing is required, special units are used for supervision and testing of individual devices.

Automatic Exchange Tester (*SL-GV* tester)

The *SL-GV tester* can be connected either to the subscriber's multiple or direct to a switching device (*SR, GV, SLD, FIR, FUR*), fig. 5. For small ex-

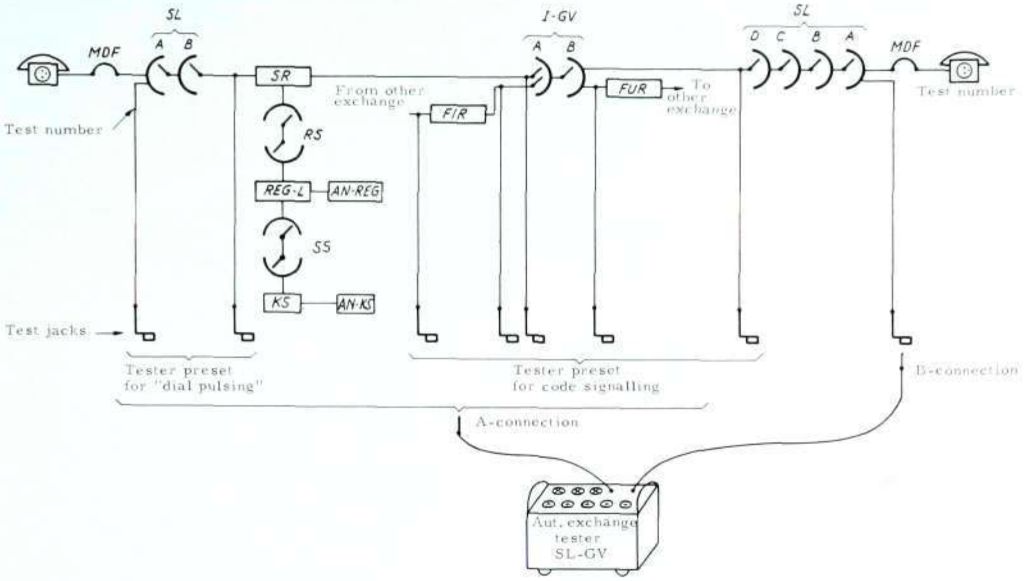


Fig. 5
Connection of SL-GV tester

changes in which there is no *TRT* equipment, the tester can be used for supervising the quality by setting up connections from subscriber to subscriber. The numbers of attempted and failed connections are indicated on counters (fig. 6). The tester can include equipment for tests of incoming traffic from other systems, e.g. from *AGF*, if such traffic occurs in the exchange.

Fig. 7 shows fault tracing with an *SL-GV* tester.

Manual *SR* Tester

This tester functions, generally speaking, as a subscriber equipment. Connection is made with test cords direct to the *SR* to be checked and to a test number in the exchange as *B* number (fig. 8).

For check of the connection, after receipt of an answer a tone is sent from the tester on the switching path that has been set up. This tone is monitored in the receiver of the tester.

Fig. 6 (left)
Automatic exchange tester (SL-GV tester)

Fig. 7 (right)
Fault tracing with SL-GV tester

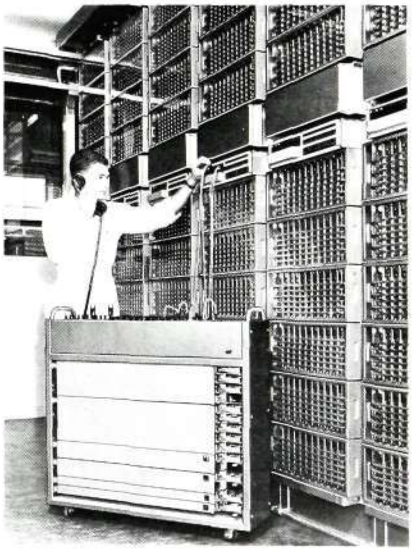


Fig. 8
Fault tracing with manual SR tester

It is also possible to connect line and insulation resistances and category marking for pay stations and restricted service subscribers. The metering function of *SR* can be checked on a counter (fig. 9).

Manual *REG* Tester

This tester is designed primarily for use on manual tests of local registers. The tester is connected via cords to the supervisory jack of the register to be tested and to a group selector inlet (see fig. 10). If there is no group selector, the other cord is connected to an *SLD* inlet.

From the tester the register can be tested in respect of the following functions:

- call from pay station
- call from restricted service subscriber
- tripping of ringing from register and *SR*
- switching of *SR* from current feed to reception of reversed polarity signals
- switching of *SR* for time-zone metering and last party release
- the pulsing relay in the register is tested with 1800 ohms line resistance or 15 kohms insulation resistance.

Tests can also be made of a group selector inlet or an *SLD* inlet in exchanges without group selector if a fault is suspected at these points.

Fig. 9
Manual SR tester

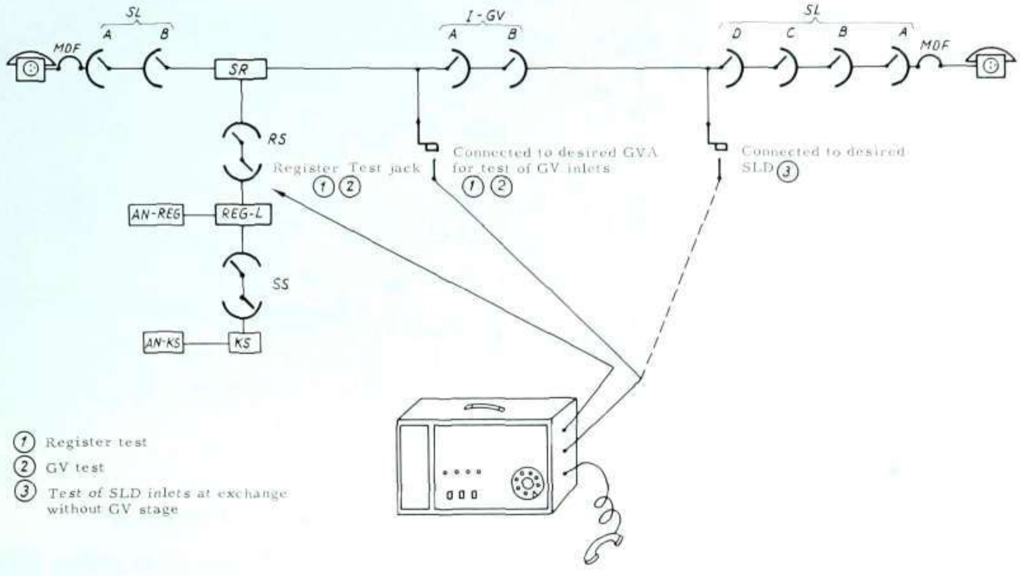


Fig. 10
Connection of manual REG tester

Lamp Panel for Recording of Switching Processes (*DKL*)

For ease of fault tracing, recording contacts have been introduced on certain relays in *SLM* and *GVM*. The contacts are connected to jacks and, by connecting *DKL*, which in principle is a lamp panel with relay memory, information can be obtained as to which relays in the marker are operated when a disturbance occurs.

Multirecorder

The multirecorder is used for simultaneous recording of a number of functions (max. 30). As the recorder has a high-impedance inlet, it can be connected either directly to a relay winding or to the jacks referred to in the preceding section, or to special measuring contacts placed on the relay armatures. From the multirecorder chart one can read how the supervised relays work in relation to one another in time (fig. 11).

For larger units such as markers it is of value to use sequence diagrams for different functions. By constructing a new chart when a fault occurs one can compare it with the standard diagram and obtain guidance for tracing the fault.

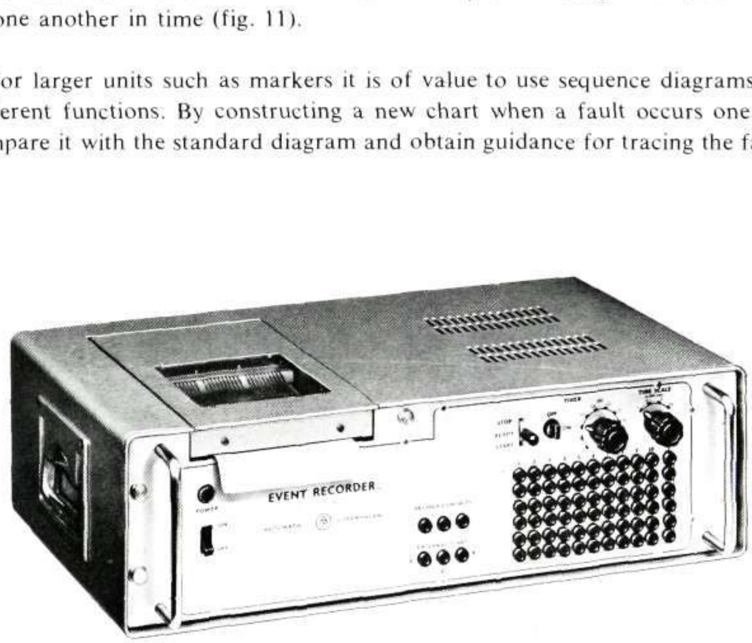
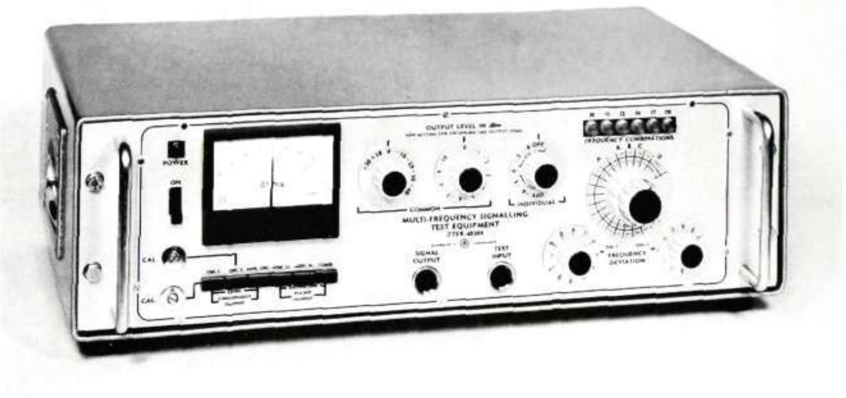


Fig. 11
Multirecorder

Fig. 12
MFC tester



Unit for Directing Calls in Code Sender Finders *SS*

In the new register arrangement *ANA 11* with code senders *KS* for different methods of signalling, an optional code sendder can be connected for register testing by means of this unit. The code sender finders are connected to the register tester via terminals in the rack jack box. A given register can thus be tested against a given code sender, which facilitates fault tracing.

Equipment for Analysis of Disturbances

On a service alarm from a group of devices, e.g. a register or code sender, or from markers, fault tracing is simplified if the group of devices or marker is connected to special analysis counters.

For devices within a group a record is obtained of individual occupations and disturbances, and one can easily se which device has the highest fault rate.

For the markers the counters are connected so that, in adhition to occupations, a record is obtained of the number of disturbances in different switching phases, from which conclusions can be drawn for fault tracing.

Subscriber Observation Recorder

A subscriber may for different reasons wish to have a check of all outgoing calls from this telephone. By connecting the subscriber observation recorder to the subscriber's speech and metering wires, a record is obtained on a chart of

- the time of starting of the call
- the called number
- the time of ending of the call
- the number of pulses received by the subscriber's meter.

Fig. 13
Electronic time meter

Other Instruments

Various instruments can be used for special investigations, e.g. *MFC* tester (fig. 12), electronic time meter (fig. 13), pulse timers and recorders of different types.

Filing of Circuit Diagrams

If circuit diagrams are kept in an ordinary file and taken out when required, there is a risk that in due course they will become torn or dirtied. By placing often used circuit diagrams in a plastic pocket file they are readily available when required and do not become dirty or torn. Plastic pocket files are supplied in three sizes.

Equipment for Fault Repair

Even if faults in relays and switches occur very seldom, there must be special tools for adjustment or replacement of components. A tool cabinet (fig. 14) contains the necessary tools for a crossbar exchange of max. 5000 lines. At small unattended exchanges the tools need not be kept at the exchange but can be carried by the maintenance-man. In such cases a tool case (fig. 15) is used instead.

Equipment for Fault Tracing and Testing of Subscriber Lines

Several equipments are available for fault tracing and testing of subscriber lines and telephones.

The choice of equipment depends on several factors, such as the size and location of the exchange in the network, and the desires of the administration concerning centralized or decentralized line plant maintenance.

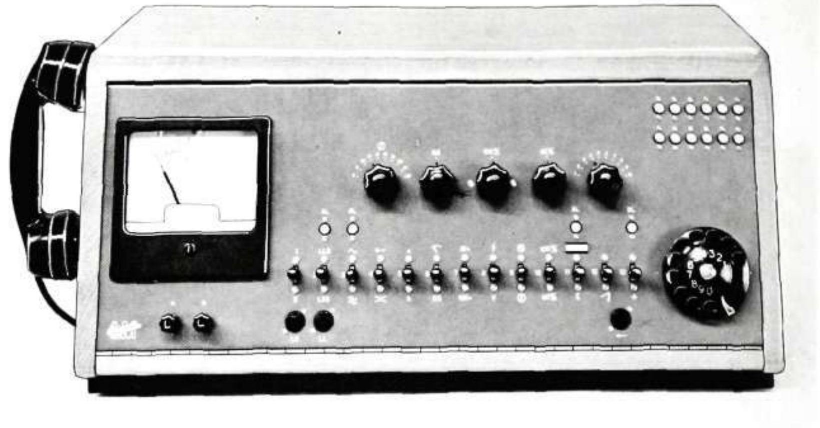
Manual Connection of Test Equipment to Subscriber's Line

The simplest equipment is the test set *AEP 1611*. This is a portable set, designed chiefly for small unattended exchanges. Measurement is done manually

Fig. 14 (left)
Tool cabinet

Fig. 15 (right)
Maintenance tool case

Fig. 16
Test set AEP 1622



via a cord plugged into the test jacks of the *MDF*. The following measurements and tests can be made:

1. Check of connected line in respect of
    a) extraneous voltage
    b) leakage from *a*-wire to earth
    c) leakage from *b*-wire to earth
    d) insulation resistance between wires
    e) line resistance

2. Check that line and telephone are connected

3. Check of subscirber's line in respect of
    a) dial speed
    b) make-break ratio

4. Check of line relay

5. Check that ringing voltage is being transmitted.

AEP 1622 (fig. 16) can be used when a permanent test set is required at small or medium-sized exchanges.

A subscriber's line can be connected to this test set, so that it can be used also for reception of fault reports.

The test set should preferably be placed on a desk or shelf in the *MDF* room. Connection to the subscriber's number to be tested is done by plugging a cord into the subscriber's test jack on the *MDF*.

Apart from the measurements referred to above for *AEP 1611*, *AEP 1622* can be used for the following purposes:

- Check of subscriber's dial in respect of number of pulses

- Transmission of howler tone to a telephone with raised handset.

Automatic Connection of Test Equipment to Subscriber's Line

At large exchanges the work on the *MDF* is facilitated if measuring equipment can be automatically connected to the subscriber's line. For this purpose *AEP 1622* can be connected to a test cord circuit *SNPR* (fig. 17). From *AEP 1622* a connection to the desired subscriber's number can be made via this *SNPR* in the same way as on a normal connection. The subscriber's number is dialled on the *AEP 1622* dial.

SNPR can be connected to *RS* via one of the local registers. These registers, however, must be wired for category indication. Otherwise a separate register is required.

For measurement solely within the home exchange *SNPR* can be connected direct to a *GV* inlet.

As an alternative to *AEP 1622*, there is a test desk *AEP 6022*. This desk is specially suited for large exchanges, since it accommodates a total of eight incoming lines for fault reports. These lines can be multipled over several desks. There is also equipment for internal traffic between the test desks. The test facilities in this desk are the same as those for *AEP 1622*.

Equipment for Testing of Subscriber's Line, Dial and Bell from an Extension (*APR*)

When a repairman has replaced or installed a telephone at a subscriber's premises, he can himself check that the installation is functioning satisfactorily without needing to trouble the *MDF* personnel. From the telephone he wishes to have tested the repairman dials a special number, where-upon connection is established with an automatic line test equipment, *APR*, which is accessible to all registers in the exchange (fig. 18).

When the connection has been established, which is signalled by a tone, the repairman dials a code digit for the test he wishes to have made.

Fig. 17
Test desk and SNPR

Fig. 18
Connection of APR

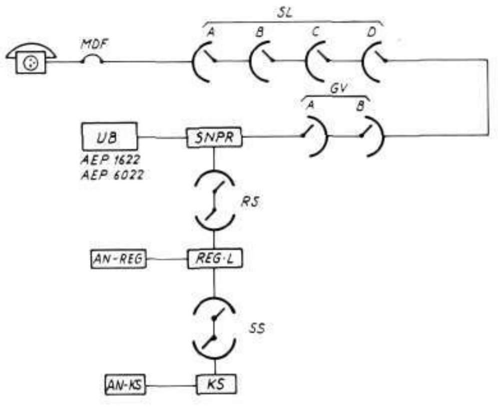


Fig. 17.

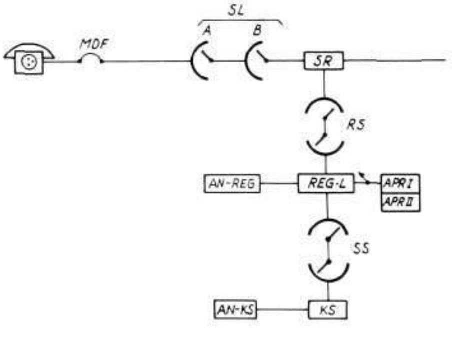


Fig. 18.

The following tests can be made:

- Measurement of dial pulse speed, nominal speed = 10 Hz
- ,, ,, ,, ,, ,, ,, ,, = 20 ,,
- Testing of bell with full ringing voltage, continuous signal
- ,, ,, ,, ,, half ,, ,, intermittent ,,
- Measurement of insulation resistance of *a*-wire to earth
- ,, ,, ,, ,, ,, *b*- ,, ,, ,,
- ,, ,, ,, ,, between *a*-wires and *b*-wires
- ,, ,, line resistance.

The result of the test is delivered from *APR* in the form of buzzer tone. If a measurement of the dial pulse speed has been made, three different tones can be obtained, indicating normal, too slow or too fast dial.

Equipment for Traffic Measurement

For continuous supervision of congestion, permanent congestion counters are connected to every route and 80-line group. If extended supervision of the routes is required, a special relay set, *TMR*, can instead be connected per 80-line group. This relay set is available in three types, for 5, 10 and 20 routes.

When *TMR* is used, a record is also obtained of the number of occupations per route and 80-line group, the number of calls lost owing to congestion per route and five 80-line groups, and the number of occupations per alternative route and five 80-line groups.

The traffic intensity, *TKT*, is measured with an automatic traffic meter. Depending on the size of the exchange and the desires of the administration, this traffic meter can be either permanently installed or portable. *TKT* wires from 20 devices are interconnected into a group on the *IDF*. Connection to the jack of the traffic meter is thereafter done in such a way that if possible, all devices of the same type, e.g. *SR*, can be measured simultaneously.

The traffic meter measures the number of occupied devices in every group 100 times during an hour. On every measurement the number of occupied devices in the group is recorded on individual counters. The meter can be started and stopped automatically. The number of counts can be preset on a zeroable counter.

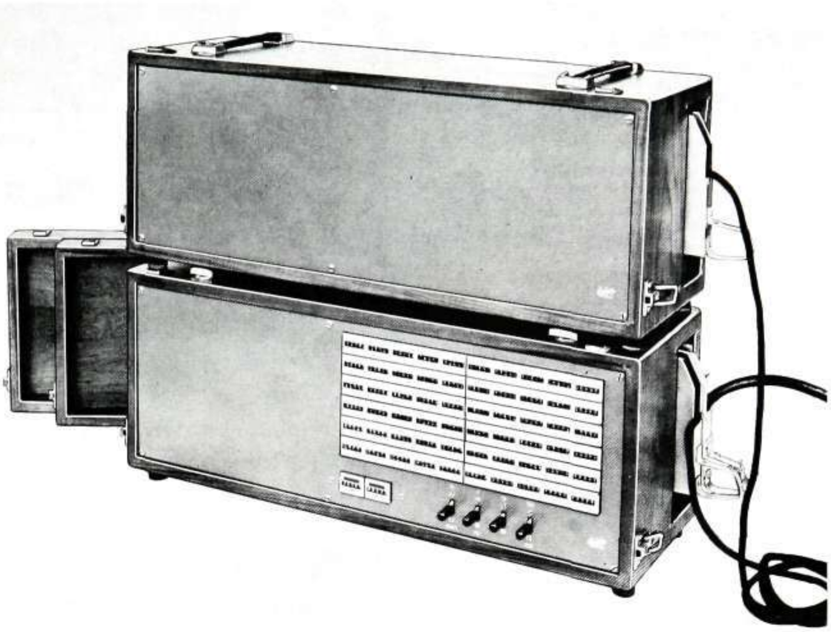
The permanently installed traffic meter can at the same time measure the traffic intensity of 20×60 devices and consists of relays for automatic connection of the *TKT* wires, measuring equipment and counters for the groups of devices to be measured.

With an auxiliary unit *TMVR* four different programmes can be selected with keys, with 1200 devices in each programme.

The number of occupations, *TKM*, is measured on separate counters. For measurement of *TKM* during the same period as *TKT*, the voltage to the *TKM* counters is steered via a relay into the traffic meter.

The portable traffic meter (fig. 19) is assembled in two portable cases, one of which contains the measuring equipment and the other the *TKT* counters. This meter can simultaneously measure the traffic on 20 devices in 45 groups, i.e. 900 devices. In one type of this traffic meter the meters have been replaced by a tape punch. A code is punched on the tape, indicating the number of occupied devices in each group at the time of measurement.

Fig. 19
Portable traffic meter



For measurement of incoming traffic to 1000-line groups, special traffic measurement plugs with built-in *TKT* resistors must be used. The plugs are connected to the same 200-point jack on the *SLCD* rack as is used for the occupation indicator.

Traffic Distribution Indicator *ARU*

In multi-exchange areas there may sometimes be a need to discover the community of interest with a given exchange to which there are no direct routes. By connection of a relay set *ARU* to the digit magazine (*OBR II*) of the observation equipment the first four digits of the dialled number can be transmitted to *ARU*. By programming of multicoil relays in *ARU* one counter is stepped every time a call on the desired route is supervised.

Centralized Supervision

The foregoing account has dealt mainly with equipments for maintenance of the home exchange.

Centralization of maintenance is recommended in multi-exchange areas, whereby certain exchanges can be left unattended. For this purpose certain additional equipment is required, which will be briefly described below.

In a centralized maintenance area the unattended exchanges are not furnished with all the equipment described above. The table at the end of the article shows the equipment recommended for different typical cases.

Equipment for Test Traffic between Exchanges

With *TRT* and its interworking equipment such as code answering unit, remote-controlled relay selectors and code answering unit with secondary call (*CASC*) the functional quality of all exchanges and of all routes within a multi-exchange area can be supervised from a maintenance centre.

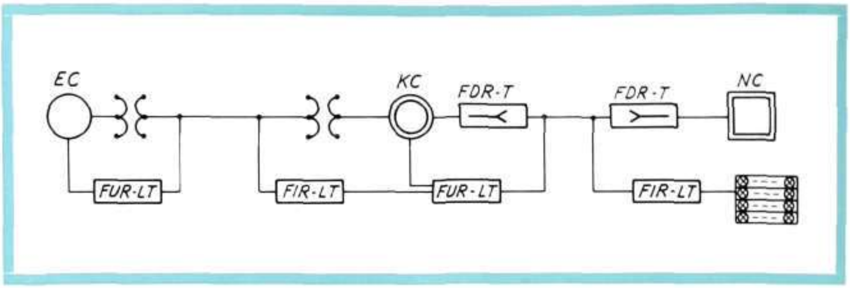


Fig. 20
Transmission of alarm

A detailed description of the traffic route tester with associated equipment will be given in a coming number of Ericsson Review.

Equipment for Supervision of Subscriber-Generated Traffic

As earlier mentioned, subscriber-generated traffic can be centrally supervised. A supervisory operator at an observation desk can connect to *RKR* at any of the supervised exchanges. Max. 20 *KOB*, i.e. 20 exchanges, can be connected to an *OBR* equipment.

Alarm Transmission Equipment (*FUR-LT*, *FIR-LT*)

Unattended exchanges always signal to the maintenance centre when an alarm condition arises. From exchanges which are attended during the daytime an alarm is transmitted at nighttime to a maintenance centre which is manned all round the clock. The alarm transmitter, *FUR-LT*, and alarm receiver, *FIR-LT*, are connected to normal junctions in traffic. The alarm transmission does not disturb calls in progress on the junction. The exchanges may be connected via different types of circuits such as D.C. circuits, carrier circuits etc., so that the transmission system must be flexible. The equipment developed by L M Ericsson fulfis this requirement.

In its standard form the equipment is supplied for transmission of 9 or 29 simultaneous messages, which of course permits the transmission of other information than alarms from the switching equipment. As soon as a change of condition takes place, i.e. if an alarm is issued or disappears, this is automatically transmitted to the maintenance centre. A lamp panel shows from which exchange the alarm comes, and the category of alarm.

If an exchange has no direct circuits to the exchange in which the maintenance centre is located, *FIR-LT* at an intermediate exchange is interconnected with *FUR-LT* having a circuit to the maintenance centre (fig. 20).

Equipment for Remote Measurement of Subscriber Lines

Earlier remote measuring equipment required separate physical conductors between the exchanges. For an exchange far from or connected via a radio link to a superior exchange, remote measurement could not be arranged. The method recently developed by L M Ericsson can be used irrespective of distance and method of transmission between the exchanges.

The equipment consists of two main parts. Depending on the number of subscriber lines, the frequency of fault reports, repair times etc., one or more centrally placed order transmitters and result receivers, *PR-A*, are connected, and at each of the indivdual exchanges an order receiver and result transmitter *PR-B*.

Both *PR-A* and *PR-B* are connected as ordinary subscribers at their respective exchanges. The circuit *PR-A—PR-B* is set up in the normal way on normal switching paths.

When a measurement is to be made, the *B* subscriber's number is dialled with a dial or keyset. *PR-A* analyses the *B* subscriber's number and decides which *PR-B* is to be called. The connection is then set up between *PR-A* and *PR-B*.

PR-B can carry out the same type of measurements as the earlier described *AEP 1622*.

Code digits sent from *PR-A* to *PR-B* on the circuit decide which measurement *PR-B* is to make. The result of the measurement is then sent from *PR-B* to *PR-A* and is indicated on lamps on the test desk.

Apart from the measurement of subscriber lines, *PR-B* can be ordered to switch on and off standby power units, ventilation, door opening devices etc. Voltages can also be measured and buzzer tones and alarm conditions checked.

Recommendation for Choice of Equipment

The table on the following page contains recommendations concerning equipment for some different sizes of exchange. The table shows the quantity of equipment for single-exchange and multi-exchange areas in which a maintenance centre has been established at exchange *A*. The quantity of each article recommended is indicated. Where special factors affect the quantity, the recommended equipment is marked ×.

Concluding Remarks

Even if this has been a brief account, it should nevertheless be apparent that there are considerable possibilities of furnishing telephone exchanges with suitable maintenance equipment on an economic basis so as to obtain high reliability at a low maintenance cost. More detailed information concerning the functioning and use of the equipments will be provided by L M Ericsson representatives.

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1. Ericsson, O.: *Centralization Trends in Exchange Maintenance*. Ericsson Rev. *43*(1966): 2, pp. 56—66.
2. *Automatic Telephone Exchanges with Crossbar Switches. Maintenance Results.* Telefonaktiebolaget L M Ericsson, Stockholm 1968. (Publ. no. 2226)
3. *Maintenance Manual, ARF 10.* Telefonaktiebolaget L M Ericsson, Stockholm 1964. (Ord. no. B 20313)

MAINTENANCE EQUIPMENTS ARF	SINGLE-EXCHANGE AREA*				MULTI-EXCHANGE AREA WITH CENTRALIZED SUPERVISION**			
	Exchange				Exchange			
	A	B	C	D	A	B	C	D
	Number of lines				Number of lines			
	10,000	5000	2000	≦1000	10,000	5000	2000	≦1000
Supervisory desk	1	1			2	1		
Supervisory frame			1	1			1	1
Disturbance memory (DL)	×	×	×	×	×	×	×	×
Zeroing relay set NR	1	1	1	1	1	1	1	1
Route alarm equipment	×	×	×	×	×	×	×	×
Alarm	×	×	×	×	×	×	×	×
Supervisory register RKR	1	1	1	1	1	1	1	1
Observation panel OBR I	1	1			1			
,, ,, OBR II	×	×			×			
Connecting relay KOB	1	1			1	1	1	1
Statistics counter	×	×	×	×	×	×	×	×
Counter for analysis of disturbances	×	×	×	×	×	×	×	×
Connecting relay set	4	2	2	2	4	2	2	2
Occupation indicator	10	5	2	1	10			
Lamp panel for recording of switching processes					1			
Traffic route tester					1			
Aut. exchange tester (SL-GV tester)	1	1	1	1	1	1	1	1
Manual SR tester	1	1	1	1	2			
Manual REG tester	1	1	1	1	2			
Code *answering unit*					1			
Code answering unit with secondary call (CASC)								1
Test number group selector						1		
Remote selector, A *subscriber*						1	1	
,, ,, B subscriber						1	1	
Test set for subscriber lines	1	1	1	1				
Test cord circuit SNPR	1	1						
Remote measuring equipment PR-A					1			
,, ,, ,, PR-B					1	1	1	1
Aut. line test equipment APR	1	1	1	1	1	1	1	1
Alarm transmission FUR-LT (9 alarms)						1	1	1
Alarm transmission FIR-LT (9 alarms)					3			
Traffic meter, permanently installed	1	1	1	1	1			
,, ,, portable					1			
Traffic measuring plugs	×	×	×	×	×			
Instrument case					1			
Multirecorder	1	1			1			
Electronic time meter	1				1			
Pulse recorder	1	1			1			
Subscriber observation recorder	1				1			
Pulse timer	1				1			
Pulse generator	1				1			
MFC tester	1				1			
Universal instrument	1	1	1	1	2			
Tool cabinet	1	1			1	1		
Maintenance tool case			1	1	1			
Set of adjusting tools and gauges	1				1			
Drawings file	×	×	×	×	×	×	×	×
Steps, 8-rung	×	×	×	×	×	×	×	×
,, 5-rung	×	×	×	×	×	×	×	×
Wheeled ladder	×	×			×	×		
Wheeled bench	×	×						

* *Exchanges A—D attended.*

** Maintenance centre at exchange A attended, exchange B—D unattended.

Keyset for Telephones with V. F. Code Signalling

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UDC 621.395.636.1
LME 8223

Ericsson Review No. 1, 1969, contained two articles[1, 2] one presenting a comparison between conventional dialling and push-button dialling, the other an account of the introduction of push-button dialling in conventional telephone systems. Systems have been developed both for D.C. and V.F. code signalling, but this article will be confined to keyset equipment for telephones with V.F. code signalling. This is the most usable form, as, irrespective of telephone system, V.F. signals can be transmitted on the speech paths. A later number of Ericsson Review will deal with the mechanical adaptation of the keyset to different telephone sets, and with maintenance aspects etc.

General Considerations

For the subscriber the most troublesome operation in telephoning is the actual dialling. He must know the number and then dial the digits in the correct order. Disregarding pure memory or reading errors, the risk of wrong manipulation should be reduced if dialling could be made more convenient. As already pointed out in the preceding articles, convenience is one of the motives for the introduction of push-button dialling, in which the subscriber merely has to select the correct key and press it. Push-button dialling is also quicker — about half of the time for rotary dialling with 10 pulses per second — so that calls are put through more quickly.

Investigations have shown, however, that push-button dialling does not reduce the risk of dialling the wrong number, and this is because, in all types of dialling, one must count on errors of memory. In push-button dialling there is also the risk that subscribers are in too much of a hurry and dial carelessly, but after some training they adapt their speed to their capacity.

Inquiries made in Denmark show that subscribers who have tried out push-button dialling appreciate its rapidity and convenience and only a few — usually elderly people — wish to return to ordinary dialling. Of those questioned, many were willing to pay an extra non-recurrent chare for the advantage of push-button dialling. It should therefore be possible for administrations to obtain some coverage for the extra investments involved in the introduction of push-button dialling in the form of increased costs for telephone sets and auxiliary equipments in the exchanges.

Important as it is to facilitate dialling, it is equally important to ensure that the transmitted digit code is correctly detected in the automatic exchange equipments. Dial pulses may be distorted by line resistance and leakage or by other disturbances on the subscriber's line, which, despite correct dialling, result in wrong connection. With V. F. code signalling the digit code can be selected so that disturbed digit signals are not identified as digits. One then gets an incomplete number and usually an uncompleted connection, which is less troublesome than calls to the wrong subscriber.

V. F. Code Signalling

As indicated in the introduction, V. F. code signalling, compared with other systems, has the advantage that signals from push-button telephones can be used not only for setting up of connections, but, at a future stage of development, can also be transmitted on the speech paths. This facility will be used to a greater extent for different types of simple data communication.

In its first trials with V. F. code signalling L M Ericsson used only one frequency per digit within the 525—2100 Hz band. To prevent signal imitation through interference frequencies via the microphone, the feed was blocked by a diode during dialling. When dialling had been completed, a reversal of polarity took place in the telephone exchange so that the microphone feed was restored. The trial plant is still in operation and working satisfactorily, but the reversal of polarity is technically troublesome and not generally feasible.

The introduction of *MFC* (Multi Frequency Code) for register signalling between two exchanges with two frequencies of nearly the same level per digit showed this method to be very reliable.

For V. F. code signalling on subscriber lines with the microphone in circuit during the interdigit intervals, however, the risk of disturbance and signal imitation is considerably greater than for traffic between exchanges. The protection against signal immitation, however, was satisfactory since L M Ericsson, like Bell Telephone Laboratories, chose the two frequencies per digit from each group of four, i.e. signal code 2 × (1 out of 4).

Choice of Frequencies

Originally L M Ericsson used the MFC frequencies for push-button dialling, while Bell Systems, who, it is estimated, have some million push-button telephones for V. F. code signalling in operation, used other frequencies. A condition for data transmission from push-button telephones after setting up of international connections, however, is the standardization of frequencies throughout the world. As Bell Systems have reached furthest in this respect, it was natural, at the C.C.I.T.T. meeting in Tokyo in 1967, that the frequencies used by Bell Systems were recommended as standard. This was finally decided at the plenary meeting in Mar del Plata in 1968. The standardized frequencies are

Group I:	697	770	852	941 Hz
Group II:	1209	1336	1477	1633 Hz

These 2×4 frequencies provide 16 combinations with the signal code 2 × (1 out of 4). L M Ericsson has naturally adopted these frequencies but for the time being does not employ the 1633 Hz frequency. We thus have 3×4 frequency combinations corresponding to digits 1—9, 0 and, when two extra signals are required, the buttons denoted X and Y by C.C.I.T.T. are placed on each side of the "0" button.

Tone Generator

The development of a tone generator for telephone sets has, of course, been done in compliance with C.C.I.T.T.'s recommendation (document AP IV/32/ Comm. XI No. 165, published July 2, 1968) with all frequencies within the speech band.

On every depression of a button two frequencies are transmitted, one from each of the two groups. The two frequencies are generated by two oscillators, which together constitute fundamental parts of the generator.

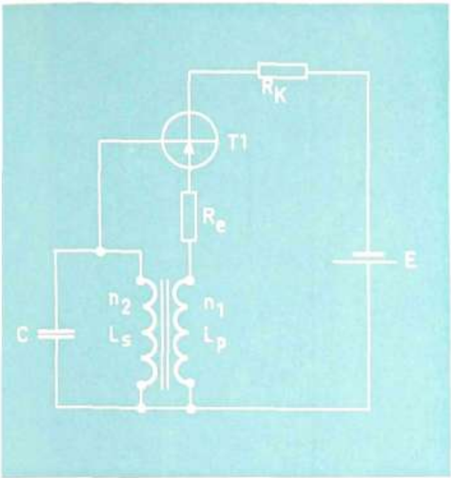


Fig. 1
Simplified circuit diagram of oscillator

Oscillator Circuit

Fig. 1 shows a simplified circuit diagram for an oscillator. The circuit consists of the transistor $T1$, emitter resistor R_e, emitter winding n_1, which is inductively coupled to the tuned resonant base circuit (L_s, C), and the load resistor R_K and power source E.

The transistor output is partially dependent on the value of the emitter resistor. Part of this output signal is returned via the transformer to the base circuit.

Since an emitter follower circuit is used, the voltage gain of which is close to 1, the transformer ratio $m = n_2/n_1$ must exceed 1 for a return of energy to take place to the base circuit of the transistor. The optimal transformer coupling is obtained for $m = 2$. The voltage gain is 1 and the phase shift 0. This is achieved through the manner of winding the base coil. In a feedback system wish gain F and feedback factor β the condition for critical maintained oscillation is $F \times \beta = 1$. This is fulfilled when the emitter resistance R_e is equivalent to the resonance resistance R_{res} reflected into the primary winding of the transformer. In order to automatically maintain the relationship $F \times \beta = 1$, a voltage-dependent resistor is introduced across the resonant circuit to vary its Q-factor, i.e. the gain of the tuned circuit. A silicon varistor is a suitable choice as voltage-dependent element.

Practical Design of Tone Generator and its Connection to the Transmission Circuit of the Telephone Set

For every digit or character two frequencies are transmitted, which are taken from the two groups in the table below. Group II also contains a frequency 1633 Hz, but as it is not required for digit signalling it is not included here.

Digit		1	2	3
Frequencies from group	I/II	697/1209	697/1336	697/1477
Digit		4	5	6
Frequencies from group	I/II	770/1209	770/1336	770/1477
Digit		7	8	9
Frequencies from group	I/II	852/1209	852/1336	852/1447
Digit/character		X	0	Y
Frequencies from group	I/II	941/1209	941/1336	941/1477

In the table, which also shows the layout of the push-buttons, the frequencies from group I run horizontally and from group II vertically.

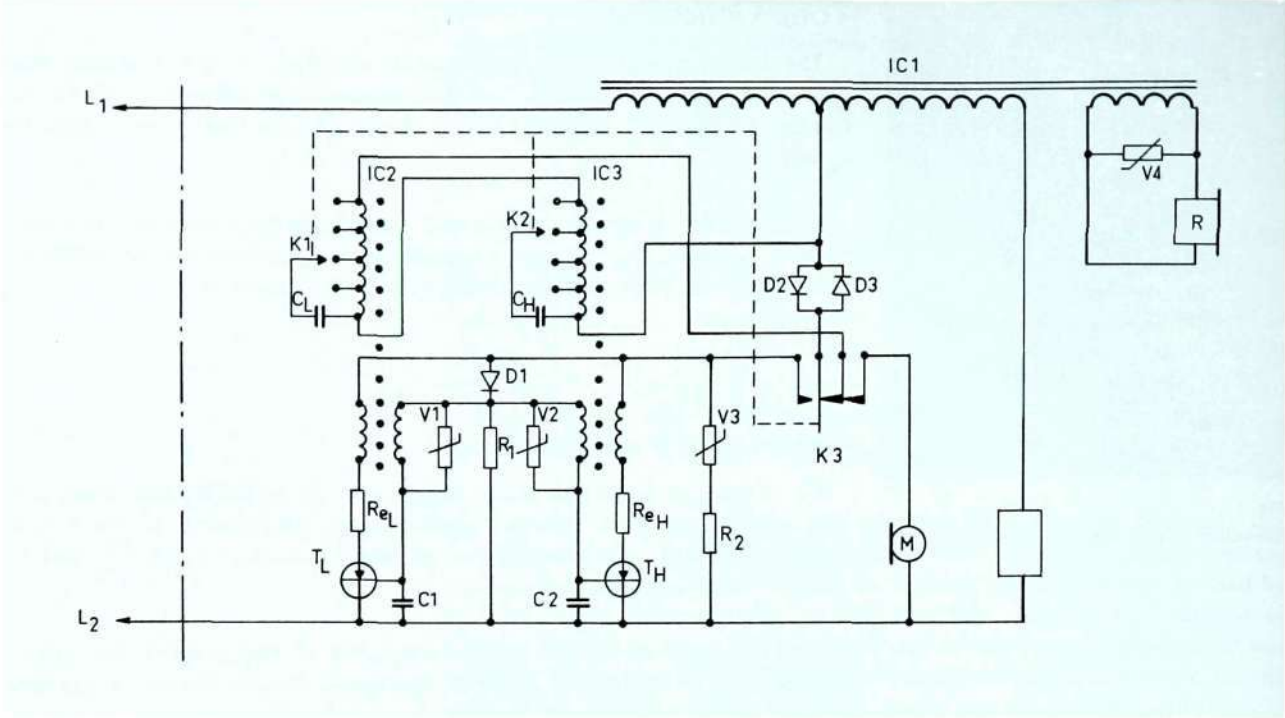


Fig. 2
Insertion of tone generator in telephone set circuit

The two groups of frequencies are produced by two oscillators which together form the tone generator (fig. 2). The frequencies for group I are generated by an oscillator consisting of *IC*2, T_L, R_{eL}, *V*1, C_L, *C*1. The frequencies for group II are generated by *IC*3, T_H, R_{eH}, *V*2, C_H, *C*2. The components R_1, *D*1, *D*2, *D*3, R_2 and *V*3 are common to the two oscillators.

The resonant circuits are connected so as normally to store energy from the telephone line, and this energy is released only when a push-button is actuated (shock excitation).

When a button is pushed by the subscriber, the tuning capacitors C_L and C_H are connected via contacts *K*1 and *K*2 to the desired outputs from the resonant circuits so as to obtain the correct frequency combination. This is followed by a make-before-break contact action (*K*3). The microphone is disconnected and the oscillator connected to the speech transformer. Since the resonant circuits are loaded with diodes *D*2 and *D*3, the oscillators do not oscillate until *K*3 disconnects these diodes. Energy stored in the resonant circuits is then released and the oscillators start near full amplitude. This shortens the starting time. The amplitude is limited by means of the two voltage-dependent resistors *V*1 and *V*2 (silicon varistors).

The oscillations are then extended via *K*3, *D*2 and *D*3 to the speech transformer and out on the line.

The purpose of the components *V*3 and R_2 is to limit the telephone set D.C. voltage and at the same time regulate the output level from the oscillator according to a desired characteristic as function of the line current. *V*3 is composed of two silicon varistors in series, each being shunted by a resistance.

The diode *D*1 and resistor R_1 keep the emitter current for the respective transistors constant irrespective of the telephone set D.C. voltage.

Frequency Characteristics

The temperature dependence of the circuit in respect of frequency is negligible in the temperatur range —25° C to +55° C. At low temperatures the frequency rises. The positive frequency change is percentually greatest for the highest frequencies in the respective group. Ageing and load also produce a positive frequency change.

In order to obtain a symmetrical tolerance range relative to the nominal frequency in long-time operation, the circuits are adjusted at the time of delivery to a slightly lower frequency than the nominal.

The total frequency tolerance including manufacturing tolerance, temperature, ageing and load amounts to ± 1.3 %.

Output Level Characteristics

Different output level characteristics can be obtained by varying the choice of the regulating elements $V3$ and R_2. A typical example is given, measured at a resistive load of 900 ohms and at + 25° C.

Frequency group	Frequency Hz	Output level, dB ref. 1 mW Line Current 20 mA	75 mA	150 mA
I	697	— 4.4	— 8.5	— 11.7
I	941	— 3.5	— 7.2	— 10.3
II	1209	— 2	— 5.4	— 8.6
II	1477	— 1.4	— 4.8	— 7.8

The manufacturing tolerance is ± 1 dB on the above values. The variation in output level is ± 2 dB between temperatures of — 25° C and + 55° C.

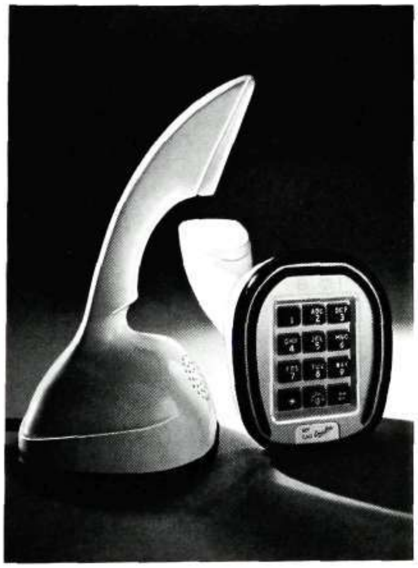
Distortion

The distortion is dependent on the output level. With variable line current, temperature and frequency the distortion is less than 10 %.

Starting Time

The oscillator starting time is less than 2 ms counted from the time of movement of the last contact in springset $K3$.

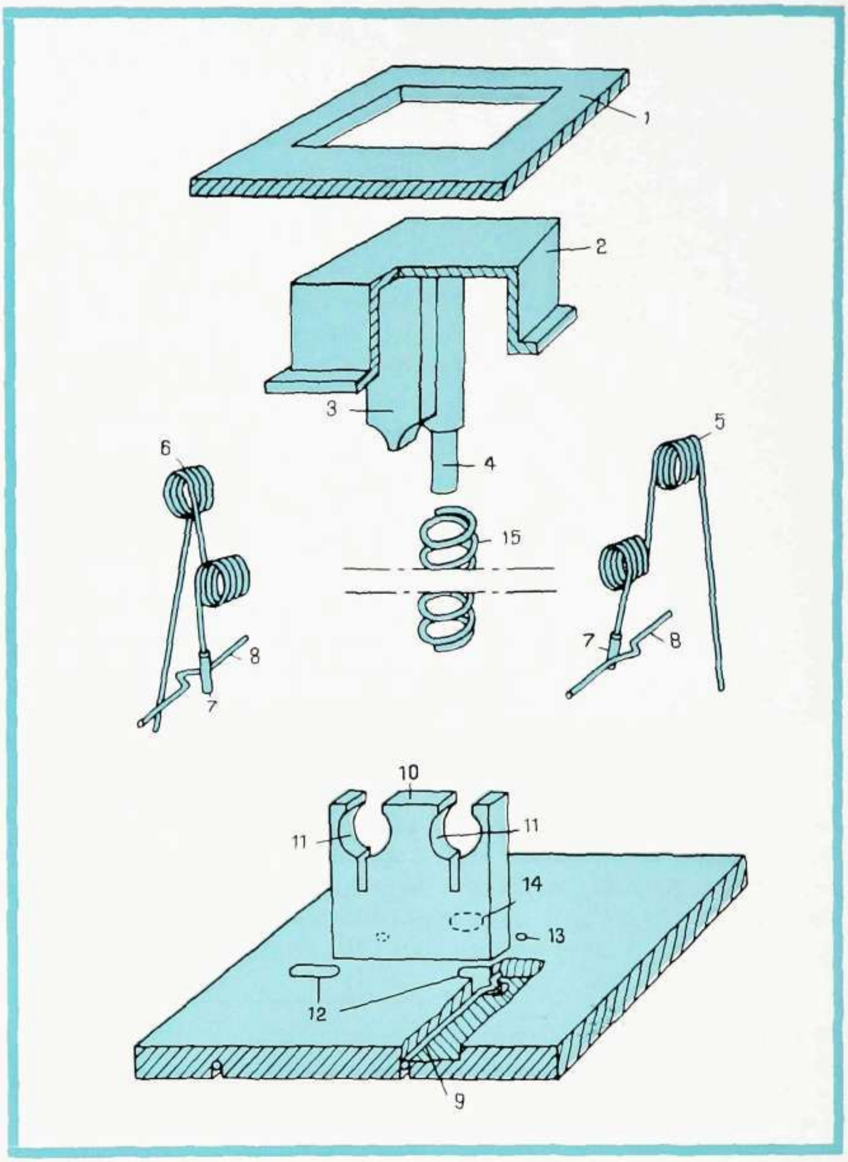
Fig. 3
Ericofon with push-button set



Mechanical Design of the Keyset

This keyset is designed for use in L M Ericsson's various types of telephone sets. Certain mechanical adjustments necessitated by space, method of fitting, usage etc. may, of cource, be necessary, but the main principles—both mechanical and electrical—will remain unchanged. Fig. 3 shows the keyset fitted to an Ericofon.

Fig. 4
Exploded view of the push-button mechanism



Push-Button Arrangement

The buttons are normally mounted in four horizontal rows with three buttons in each of the three upper rows and one in the lower row. The numbering runs from left to right, from the top downwards.

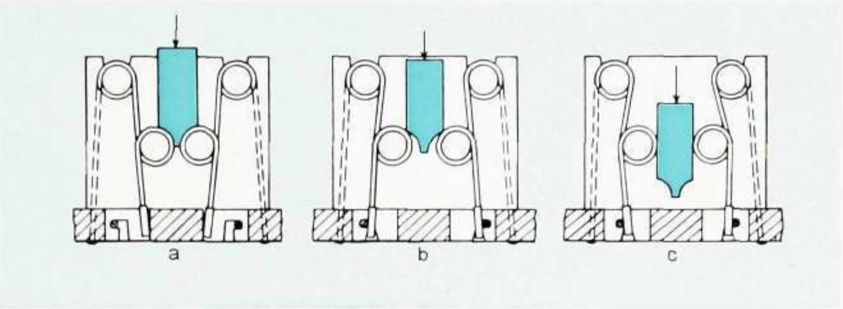
Extensive tests have shown that this placing of the buttons is superior to all other alternatives and C.C.I.T.T. has rightly recommended the international use of this method.

If necessary, two additional buttons for special purposes are fitted in the lower row.

Mechanical Features and Function

Apart from the springset *K*3 common to all buttons, which is actuated via a linkage system, each button has two individual make functions which are actuated direktly when the button is pressed.

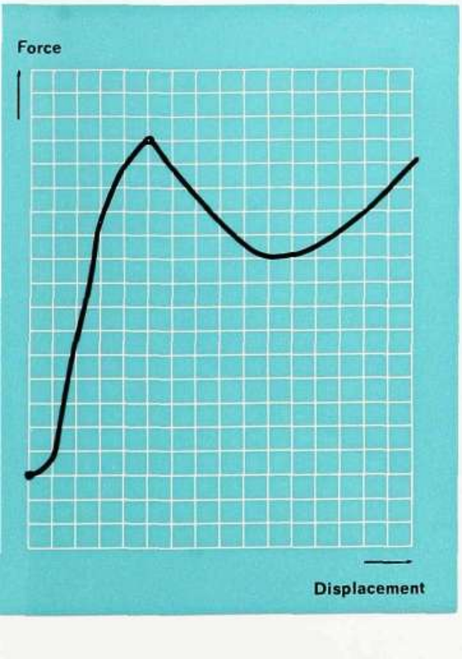
Fig. 5
Effect of wedge on contact springs



The description of the function of the individual buttons will be facilitated by reference to the exploded view (fig. 4). At the top is seen a portion of the cover plate (1) with a square hole for the button (2). The two individual make contact functions are produced when the two twin-coil springs (5) and (6) make contact with the V-shaped strips (8). The springs (5) and (6) may be equipped with their respective cylindrical contacts (7) at one end and at the other end are connected to a printed board (not shown) under the base plate. The contact function may sometimes be provided by the actual wire in the springs (5) and (6). When a button is pushed, the wedge (3) actuates the two lower coils of the springs (5) and (6), which then make contact with strips (8) and produce a twin contact action.

The contact strips are placed in grooves in the base plate (9), which is also equipped with fixed springholders (10), one for each button mechanism. For assembly of the contact springs in the springholder the upper coil is snapped into the recess (11), so that the contact enters the hole (12) and is thereby in position to make contact with the V-shaped indentation in the contact strip, as already described, on actuation of the button.

Fig. 6
Diagram showing the effective change of force with displacement on depression of a button



The function of the helical spring (15) is to restore the button to normal when it is no longer actuated.

The button is guided in its downward movement by the square hole in the cover plate (1) and by the round hole (14) in the base plate in combination with the guide pin (4).

Fig. 5 shows schematically how the wedge actuates the contact springs. Fig. 5 a illustrates the position of the wedge in relation to the lower coil when the button is normal. Fig. 5 b illustrates the situation when the button has been pressed down so far that contact is just attained between the moving contact and the contact strip. At this moment an increased mechanical resistance is felt against continued depression of the button. The resistance increases still further until the two coils slide over the parallel surfaces of the wedge, the resistance then being suddenly reduced so that the button goes fully down without possibility of being arrested in an intermediate position. A force-displacement curve is shown in fig. 6, illustrating what happens. The total movement of the push-button is 3.2 mm.

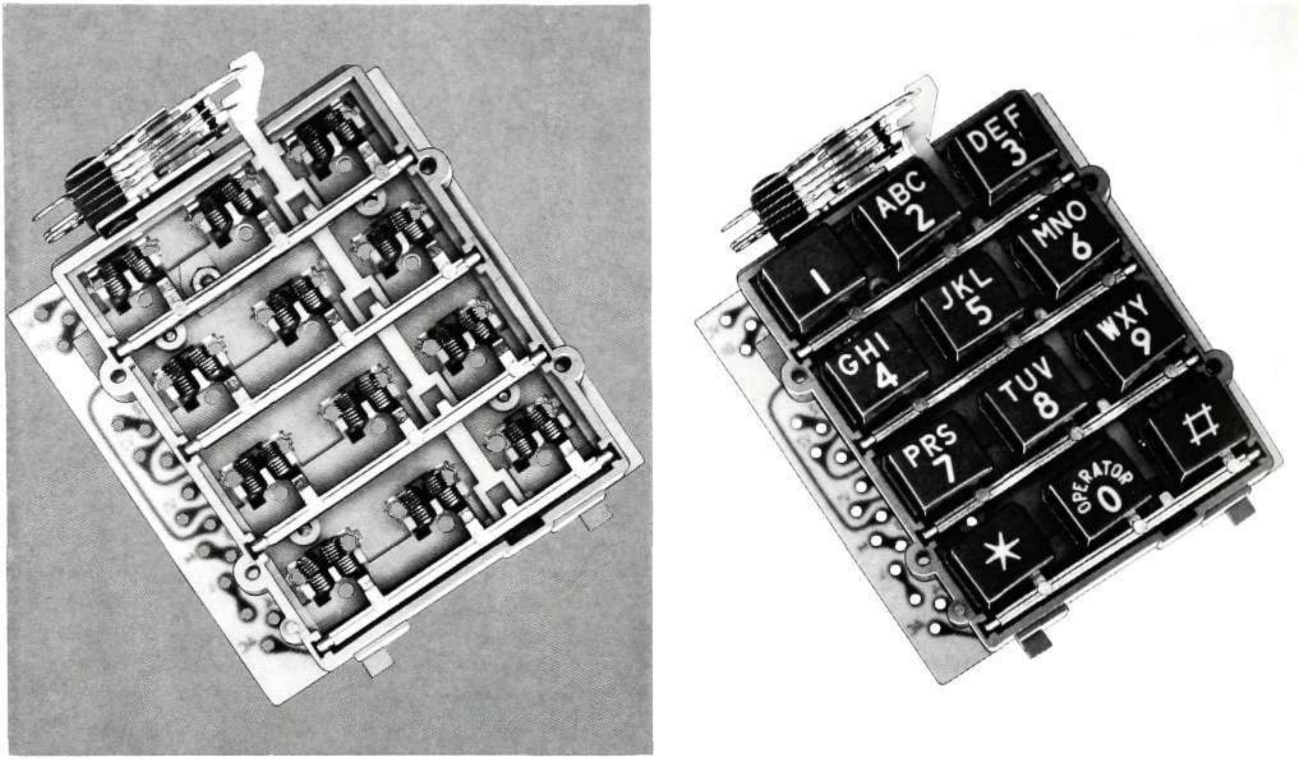


Fig. 7
Push-button mechanism with linkage system and common springset

Fig. 7 shows the details of the individual push-button mechanisms and the linkage system which actuates the common springset.

The four spindles seen between the buttons have three levers each, one for each button. When a button is pressed, one of the levers is actuated, with the result that the corresponding spindle describes a rotary movement. This movement is transferred by means of a fourth lever on the spindle to the longitudinal slide which has four rectangular holes, one for each spindle. In this way the common springset is actuated in the final phase of each depression of a button, when the resistance to depression has diminished. Not until then are tone signals sent on the subscriber's line.

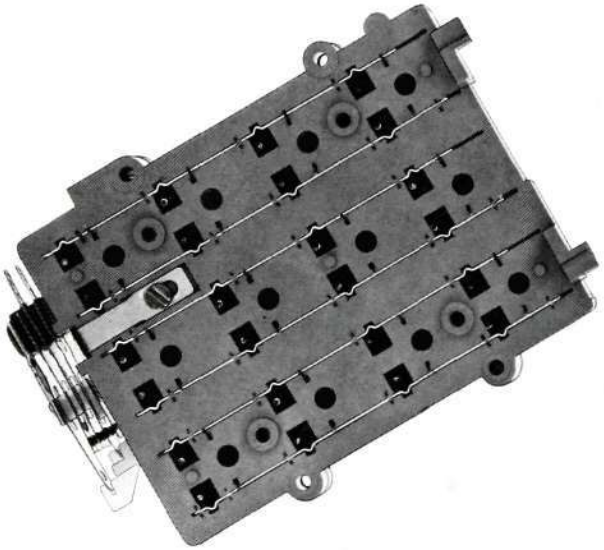


Fig. 8
Underside of push-button mechanism with contact strips

Fig. 9
Printed board for push-button mechanism

Fig. 8 shows the underside of the keyset with the contact strips and their V-shaped contact positions, the cylindrical contact and the terminations of the contact springs which in the complete keyset are soldered to the printed board. It will also be seen that the common springset is fitted to a sliding support for ease of adjustment.

The printed board will be seen from fig. 9.

Keying

It may perhaps be of interest to discuss to some extent how the described form of keyset affects the subscriber's behaviour, and so the reliability of keying.

On pressing a button the subscriber may unintentionally touch another button as well. Owing to the large button movement, however, this does not normally result in false digital transmission.

When the selected button is pressed, a certain mechanical resistance is felt at first, which suddenly disappears when the button is pressed fully down. This guarantees that the digit signal transmitted is sufficiently long to be detected by the V.F. code signalling receivers even if the latter have been subjected to microphone disturbance before pressing of the button. The relatively large initial resistance also ensures a sufficiently long pause between digit signals, which is of importance when the same digit is pressed several times in succession. After brief training the subscriber acquires a feeling for the correct button-pressing procedure and adapts his speed thereto.

On economic grounds there is no interlocking between the buttons. It is thus possible to actuate two buttons simultaneously. In such case two tappings on one of the tuning coils *IC*2 or *IC*3 are interconnected and thereby short-circuited. One of the oscillating circuits will then not function, and only one frequency is transmitted. This is interpreted by the V.F. code signalling receivers as a microphone disturbance and no digit is registered. The number registered by the V.F. code signalling receivers will be incomplete and connection can normally not be established. The subscriber will, however, usually notice the fact that he has pressed two buttons and will make a new call.

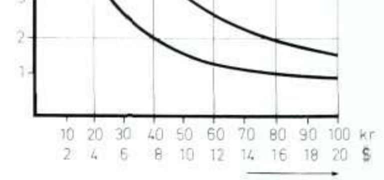
The risk of pressing two buttons diminishes if only one finger is used for keying. The buttons have a shallow depression so that the finger does not slip.

References

1. Jacobæus, C.: *Push-Button Dialling from Subscribers' Telephones.* Ericsson Rev. *46*(1969): 1, pp. 2—6.
2. Olofsson, L.: *Applications of Push-Button Selection in Conventional Telephone Systems.* Ericsson Rev. *46*(1969): 1, pp. 7—12.

Note

In the article "Push-Button Dialling from Subscribers' Telephones" in Ericsson Review No. 1, 1969, fig. 2 has unfortunately been reproduced in the wrong scale. The correct curves are shown below. They show a considerably more favourable picture for the keyset than the previous, wrong curves.



Separation of Multiplex and Physical Circuits in Trunk and Local Networks

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UDC 621.395.74.003.1
LME 518 8077

With the development of modern multiplex systems of carrier and PCM type, multiplex — owing to the continued price development — is penetrating down to increasingly short-distance circuits and lower levels in the network. A growing number of multiplex circuits are found even in large local networks. Owing to different cost structures the structure of a network containing multiplex circuits may differ greatly from that of a network with solely physical circuits. This circumstance, together with separation of the various kinds of circuits on routes and cable runs, leads to complicated and extensive calculations.

The object of this article is to present methods for systematization of these calculations, and so to permit mechanization of the work of numerical calculation.

Cost Structures

Cost structures differ greatly for physical and multiplex circuits, as illustrated in fig. 1. The point of intersection represents the least distance for which the multiplex technique pays. The slight incline of the cost curve for multiplex is the result of the fact that a greater number of circuits in this technique share the cost of a common h.f. line. The structure of a network containing multiplex circuits may therefore differ from that of a network containing solely physical circuits.

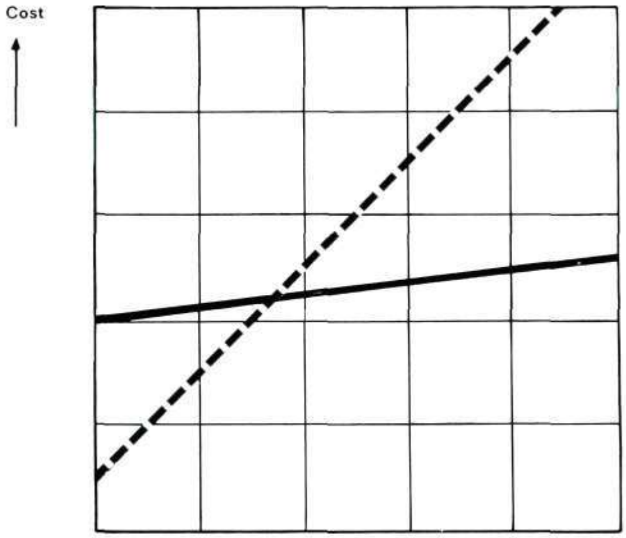


Fig. 1
Relation between cost and length of physical and multiplex circuits
– – – Physical circuits
——— Multiplex circuits

Description of a Junction Network

For the description of a junction network the following data are required:

☐ a *cable run matrix*, a table or diagram showing the distance between neighbouring switching points (exchanges and tandem stages). This matrix defines the permissible cable routes in the network.

☐ a *junction matrix*, a table or diagram showing the division of the exchanges into tandem areas and the possible traffic routes between exchanges, first choice, second choice, third choice, etc.

☐ a *route matrix*, a table or diagram describing the path through the network, i.e. the cable runs on which the route passes, the number of circuits on the route, the types of circuits on the cable runs passed by the route, and the class of circuits (tandem, high usage or direct low usage).

The cable run matrix and junction matrix together define the *structure* of the network.

The Problem

The planning of the junction network implies that all of these data must be determined in such a way that the total costs of the network are as small as possible ; at the same time the plan must comply with the current transmission and signalling schemes and congestion limits.

An explicit solution of this problem is not possible. This is because the task implies introduction into the junction network of two different transmission systems of essentially differing cost structure. The high basic cost for h.f. terminals in a multiplex system means that the circuits must be combined into larger groups than in the case of physical circuits, which leads to alterations in the cable run matrix as new multiplex circuits are introduced. A change in system or cable run matrix causes abrupt changes of the cost at other points than where the change takes place, as the transmission and signalling conditions must always be filfilled.

Changes in the junction matrix give rise to similar changes of cost.

For a network in which the traffic between the exchanges is given, therefore, the following groups of discrete variables must be determined through the use of certain data concerning costs, transmission, signalling and congestion:

- junction matrix
- cable run matrix
- type of circuits
- number of circuits.

This can be done only by carrying out calculations under different assumptions concerning the *structure* of the network defined by the junction and cable run matrices and comparing the total costs for each alternative.

This involves extensive numerical work which, however, can be greatly reduced by programming of the most laborious operations for a computer.

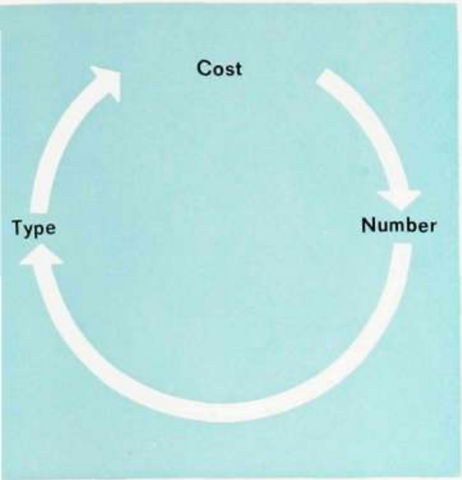


Fig. 2
Relation between costs, number and type of circuits

The Solution

As is known, the number of circuits on a high usage route is determined principally by the traffic offered between the exchanges and the cost ratio between high usage and tandem circuits.

The cost of a circuit is dependent on the type of circuit to be installed.

Finally the type of circuit depends on the number of circuits.

The mutual relations between costs, number and type are illustrated in fig. 2.

On these grounds the calculation must start with an approximate assumption, e.g. that the cost ratio between high usage and tandem routes has a single value for all circuits in the network.

On the basis of the number of circuits and given cost data for different types of circuits, transmission and signalling schemes, and distances, the types of circuits to be used in different parts of the network can be determined.

As soon as the type of circuit has been decided for all cable runs through which a route passes, new and more exact values of the cost ratio between high usage and tandem routes can be calculated from given cost data, and the procedure can be repeated until sufficient accuracy is attained.

This iterative procedure is illustrated in fig. 3.

The planning procedure has now been described in broad outline. There remains, however, to describe the method of determining the types of circuits on routes and cable runs when the number of circuits on each route and cable run is known.

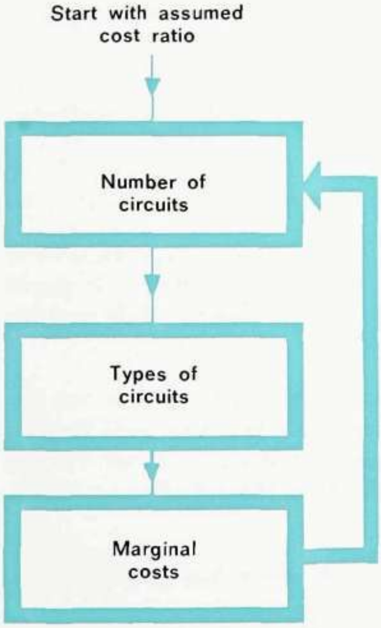


Fig. 3
Calculation scheme for determination of number and type of circuits

Separation Process

The determination of the extent to which a route shall consist of physical or multiplex circuits is done on the basis of the calculated number of circuits between exchanges and tandem stages.

In the following separation process the following three stages may be distinguished for each choice of junction matrix:

1. Specification of unconditional physical routes.
2. Specification of remaining routes.
3. Specification on cable runs and calculation of total costs.

Specification of Unconditional Physical Routes

The first step is, on the basis of a cable run matrix describing permissible cable routes in the network (fig. 4 a), to determine the routes which must unconditionally consist of physical circuits throughout their length. This is done by comparing the cost of a physical circuit with a calculated lower limit for the cost of a multiplex circuit.

The result of this calculation is final and is not affected by changes in the cable run matrix which must be made later in conjunction with the introduction of a multiplex system.

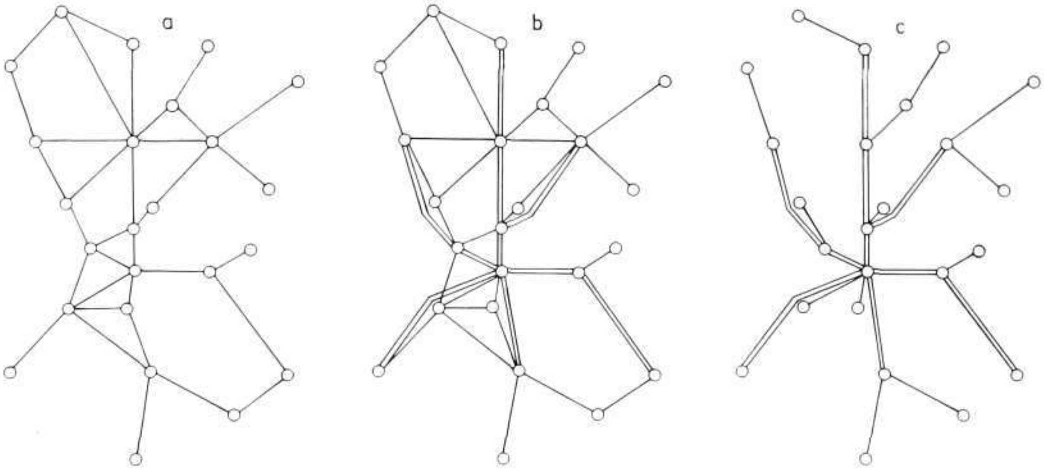


Fig. 4

Example of cable runs in a local network

— Physical circuits
═ Multiplex circuits

a Cable run in a network of physical circuits
b Cable run in a network of multiplex and physical circuits
c Only cable runs which contain routes with a multiplex system on at least one run are drawn

The calculation is made on the computer and the result is obtained in printed form under the following heads:

Route	*No. of circuits*	*Type*	*Attenuation dB*	*Length km*	*Cost/ circuit*	*Nodes passed by the route*
—	—	—	—	—	—	—
—	—	—	—	—	—	—
2—45	10	0.64	6.5	11.8	3 010	1—13—9—30—43—45
—	—	—	—	—	—	—
—	—	—	—	—	—	—

Specification of Remaining Circuits

By projecting the remaining number of circuits over a number of main cable runs a first estimate is obtained as to which cable run should have a multiplex system. These cable runs are shown on the cable run matrix (fig. 4 b).

The remaining routes must be separated into two groups:

- routes which are physical throughout their length for the given configuration of the multiplex cable runs
- routes which are multiplex on at least one cable run.

This separation is effected by comparing the costs for a circuit assumed to be entirely physical with a circuit based on the multiplex principle. It should be noted that a circuit need not necessarily take the same path through the network when it is multiplex as when it is physical.

A physical circuit must always take the shortest route between two exchanges. A multiplex circuit (multiplex system on at least one cable run), on the other hand, must be connected to the nearest multiplex terminal. For calculation of the cost of multiplex circuits therefore a reduced cable run matrix (fig. 4 c) is used.

After the calculations according to the points above, the routes are now into two groups:

- physical circuits
- multiplex circuits.

The specification of multiplex routes is analogous to that stated above, with the exception that the cable runs on which the route is multiplex are marked C. For example a printout such as

9—13—2C59C61—68

means that route 9—68 is physical between nodes 9—13—2, multiplex between nodes 2C59C61 and physical between 61—68.

Specification of Cable Runs and Calculation of Total Costs

The specification of cable runs is done on a computer, based on the specification of routes, and provides particulars of number, type and cost for h.f. system terminals and circuits for all routes passing through the cable run.

The costs of the multiplex terminals, on the other hand, are included in the cost per circuit under the specification of routes, since a route may have both physical and multiplex terminals.

Finally a statement of the total costs is given for comparison between different alternatives for junction and cable run matrices.

Fig. 5 shows separation processes in the form of a flow chart. The figure also indicates where in the process impulses are given to new multiplex systems. The optimal division between physical and multiplex circuits for each number of circuits is obtained, as appears from the figure, by an iterative procedure.

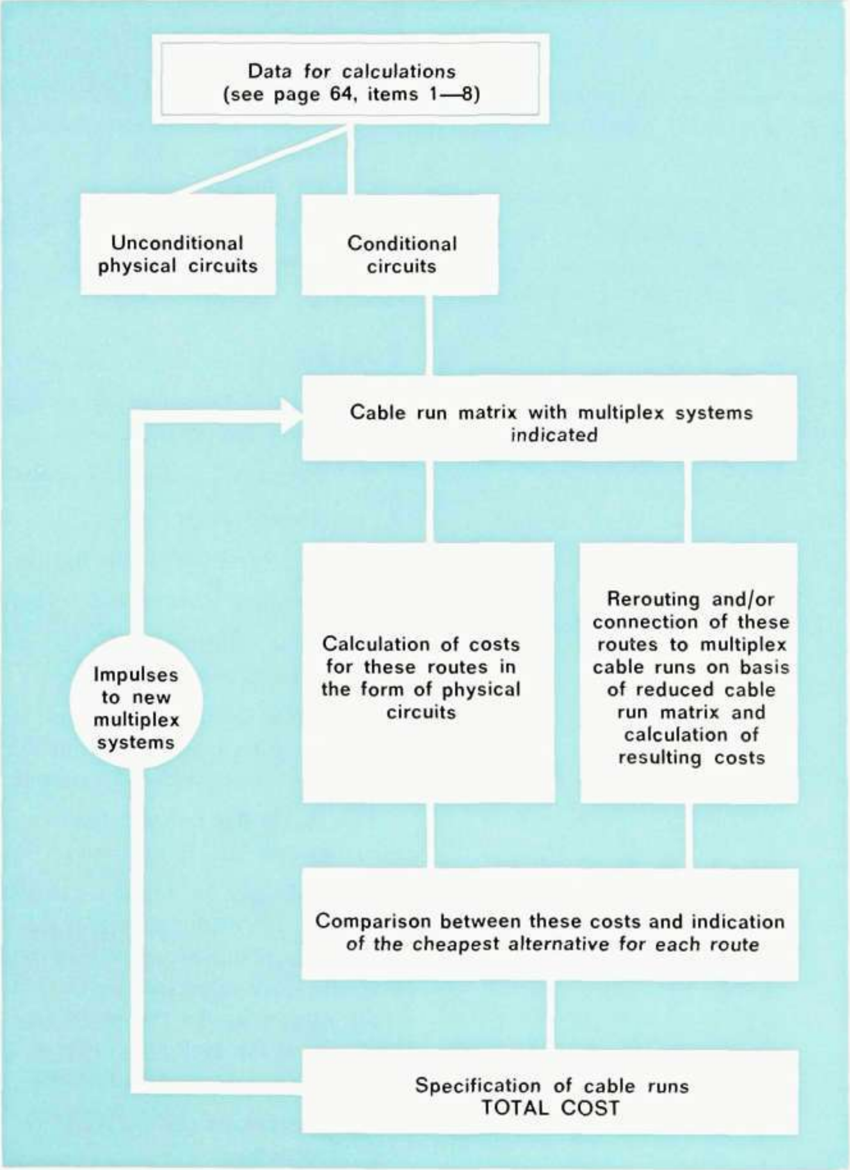


Fig. 5
Survey of separation process

Data for Programming

The calculations require the following data:

1. *Transmission and signalling scheme* indicating permissible attenuation and resistance between exchanges and tandem stages.
2. *Data for physical circuits* indicating attenuation/km, resistance/km and cost/km for different conductor diameters.
3. *Data for multiplex system* indicating cost/h.f. system terminal pair, circuit cost/km, cost per repeater, repeater spacing for systems with different capacities.
4. *Data for terminals* indicating cost/multiplex terminal and cost of physical terminals for different types of circuits, repeatered and non-repeatered, connected or not connected to the system. Gains for different kinds of amplification are also indicated.
5. *Data for switches* indicating cost/switch.
6. *Cable run matrix:* a list of the distances between adjacent nodes in the network. Cable runs in the multiplex system are indicated by negative distance. The programme calculates the length of a part of a route on which there are to be physical circuits.
7. *Location of exchanges:* a list of the locations of exchanges and tandem stages. Several exchange units can be placed in the same node. For 6 exchanges and 2 tandem stages the exchange units are numbered 1—6, the tandem stages 7—8. The location can then be defined by the following table:

Exchanges	1	2	3	4	5	6	7	8
Node no.	3	3	4	1	2	5	3	5

8. *Number of circuits* between exchanges and tandem stages obtained from a separate programme.

Summary

The described method for separation of physical and multiplex circuits is a man-computer programme.

The manual work consists essentially of

- selection of suitable alternatives for junction and cable run matrices
- marking of suitable cable runs for multiplex circuits.

The computer work consists essentially of

- calculation of number of circuits between exchanges and tandem stages on the basis of successively improved cost data
- projection of this result over the cable runs and provision of a detailed specification of type and number of circuits on each cable run and route, and cost for physical and multiplex circuits.

The metod has hitherto been used on a large local network with over 100 exchange units and has proved to be very labour-saving.

Finally it may be mentioned that the programme can also be used to obtain, from forecasts of the growth of the need for circuits of different types between the exchanges, the expected growth of the need on cable runs, which facilitates planning work as regards the evaluation of the location, time and size of future plant extensions. In the same way one readily gains an impression of the future need for multiplex systems, for example, which facilitates the drawing up of a plant extension budget.

The programme for the computer was prepared by L. Ringström, Autocode AB, Stockholm.

ERICSSON News from All Quarters of the World

L M Ericsson's head offices and main factory at Midsommarkransen, Stockholm.

The Ericsson Group 1968

The Ericsson Group has had another successful year of activity. Its position as one of the foremost telecommunication manufacturers in the world in respect of modern technique has been further reinforced.

In stiff international competition, and with customer demands for long-term credits, order bookings have increased by 24% compared to 1967. The rise is especially marked in East Europe, Latin America, Australia, Asia and Africa. Swedish orders remained roughly at the 1967 level.

The stored-programme-controlled telephone exchanges, the new types of privat exchanges, and the new construction practice for transmission equipments, are evidence that the extensive technical work also results in products of great interest to the Group's customers.

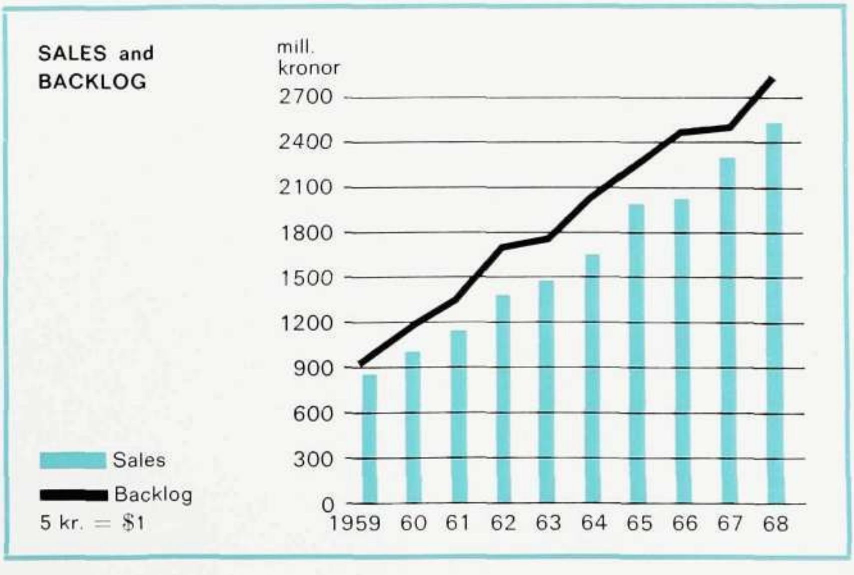
Highlights from 1968

- Consolidated net sales of the Group were 2,521 mill. kr.
- Income before special adjustments and taxes was 365.9 mill. kr., equal to 14.5% of sales.
- Order bookings totalled 2,898 mill. kr.
- The backlog of orders at the year-end was 2,836 mill. kr.
- The major markets of the group were: Sweden 33%, Europe (except Sweden) 36.5%, Latin America 19.4%.
- The number of telephone lines cut into service during 1968 was 1,422,860, as follows:

	Lines
Local exchanges	
— **with 500-line switches** in 14 countries	130,710
— **with crossbar and code switches** in 33 countries	787,470
Rural exchanges with crossbar switches	203,120
Line concentrators	670
Trunk exchanges with crossbar switches	293,650
Stored-programme-controlled exchanges with code switches	
local lines	6,400
junction lines	840
	1,422,860

7538 lines for telex exchanges with crossbar switches were also cut over.

- To support expanding activities, unsecured loans totalling $ 26,112,000 were arranged in Sweden and Switzerland at rates of 6 ½% and 5 ½% respectively.
- The Ordinary General Meeting at the head offices of the Group at Midsommarkransen, Stockholm, on May 30, 1969, approved a cash dividend of 97 cents per share and a stock dividend to be distributed on a one-for-five basis.



At a large exhibition in Stockholm, "Protection 69", L M Ericsson Telemateriel AB (LMS) showed for the first time its complete programme of security systems. The Head of the Group, Mr Björn Lundvall, visited the exhibition and is here seen with (left) the President of LMS, Mr Per-Bertil Janson, and (right) the Sales Manager of LME, Mr Arne Stein.

Interesting New LME Items at "Protection 69" Exhibition

Through its subsidiary L M Ericsson Telemateriel AB (LMS) the Group sells a varied assortment of security systems for, among other purposes, protection against fire, burglary, interruption of operations, and unauthorized entry.

The company's complete programme was shown for the first time at the "Protection 69" Exhibition in April this year in Stockholm.

Arranger of the exhibition, and of the congress held at the same time, was the Swedish Fire Defence Association, which celebrates its fiftieth anniversary this year. 205 exhibitors from some ten countries participated. The congress was visited by some 3000 persons, of whom 800 from abroad.

Some of the new LMS items within the security field are presented below.

Laser detector for burglar alarm

One of the more advanced items at the exhibition was the LMS laser detector for burglary alarm. This consists of a sender unit which delivers a narrow, fully invisible beam of light with very long range. The beam is aimed direct or via mirrors at a receiver unit. If the beam is broken, or if the function of the detector is otherwise disturbed, an alarm is issued.

Entry control system

This new LMS item consists of a card reader with keyset placed at the entries to a building or area. The card readers are connected to a central equipment which supervises the function of the system.

Every employee has an identity card and personal code number. On passing a control, the card is inserted in the reader and the code number keyed. If the combination does not tally, the card disappears through the "card snatcher" and an alarm is issued.

Oil overflow alarm

A means of protection against oil damage which may arise in the filling of oil tanks from tanker vessels is the overfill alarm developed by LMS in cooperation with AB Shell.

The alarm device consists of a signalling unit of TYFON type driven by compressed air from a separate container. When the oil level in the tank has risen to a specific level, a valve is actuated which supplies compressed air to the TYFON unit. The signalling takes place immediately and continues as long as there is air in the container.

LME protects the new banknote printing works of the Bank of Sweden

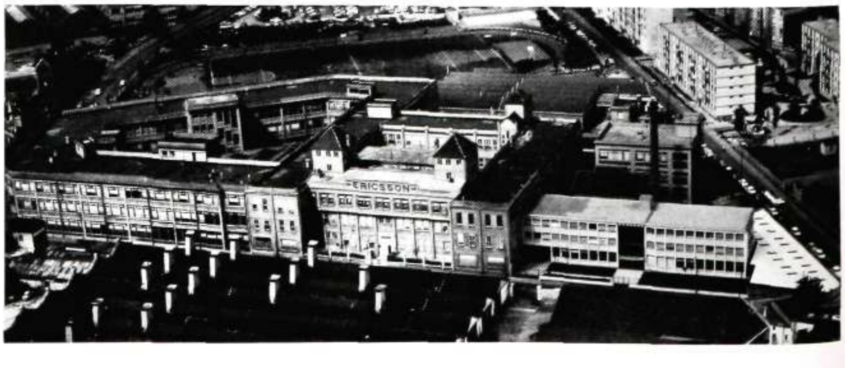
The Bank of Sweden had decided to protect its new banknote printing works at Tumba outside Stockholm against fire and burglary with equipment from L M Ericsson Telemateriel AB (LMS).

Centrum, France, integrated with STE

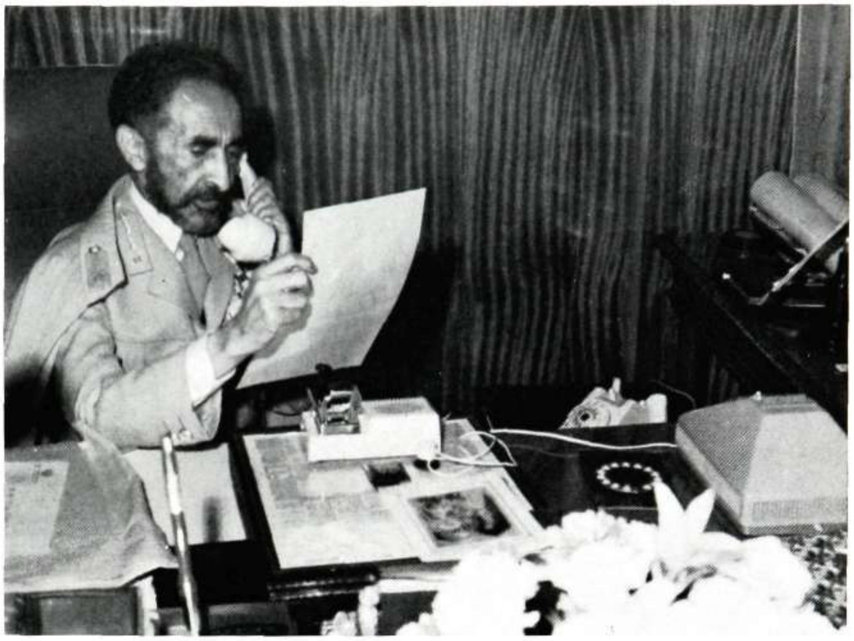
As from the beginning of this year Centrum Electronic S.A. in Paris has been integrated with the French company of the Ericsson Group, Société Française des Téléphones Ericsson (STE).

Through this fusion L M Ericsson Telemateriel AB (LMS) will have greater opportunities of intensifying its work on the French market. STE has some 25 branch offices, in Paris, Nantes, Bordeaux, Lyon, Marseilles, Rouen, Toulouse and Metz, among other places.

The French company of the Ericsson Group, Société Française des Téléphones Ericsson (STE), has its main factory at Colombes near Paris.



Interested visitors to L M Ericsson in Midsommarkransen were Mrs Nualpong Senanarong (wife of General Savaeng Senanarong) and the Head of the Thailand Budget Office, Dr. Reno Suvarnasit.



▲

At the opening of a radio link between Addis Ababa, capital of Ethiopia, and Abidjan, capital of the Ivory Coast, the Emperor Haile Selassie in Ethiopia used an LME telephone (the photograph shows also an Ericovox) in his conversation with the President of the Ivory Coast, M. Felix Houphouet-Boigny.

◀ A delegation from the Ukrainian Republic, headed by the Minister of Posts and Communications, G. Z. Sinchenko, was in Sweden at the beginning of the year. Apart from a visit to the head offices at Midsommarkransen, the delegation also visited the LME factory at Karlskrona. The picture shows the Minister on the far right with (from left) the Factory Manager, Mr Erik Olsson, LME, Karlskrona, Chief Engineer E. V. Denisov, Ukraine, the interpreter Mrs Levtchenko, Mr Bertil Ljunggren, LME, Stockholm, and Director Erik Lindström, LME, Stockholm.

At the large-scale charity campaign for cancer research in Sweden the Prime Minister, Mr Tage Erlander, was interviewed by Radio Reporter Lennart Hyland. The interview took place via an experimental model of LME's videophone and an outside broadcast link between the TV studio and the Prime Minister's dwelling. The photograph shows Mr Erlander's home with Mr Per Ahlström, Head of LME's ERGA Division, an interested spectator. ▼

LME's new building close to the main factory at Midsommarkransen as it appeared at the end of April 1969. It will have nine floors with adjoining canteen. The gross area will be around 20,500 m². Occupation of the new offices is expected to start in October this year and to be completed during January 1970. Among other departments moving into the new building are the Treasury and Training Departments and the Data Processing Centre. ▼

New Head of Telecommunication Group within the Parent Company

Mr Malte Patricks, Head of the Telecommunication Group within the parent company, retired on pension on May 31, 1969. The Head of the Telephone Exchange Division, Mr Fred Sundkvist, has been appointed his successor.

Mr Patricks will remain chairman of the Board of L M Ericsson Telemateriel AB and of Instruktionsteknik AB.

Mr Hans Sund, Head of Military Electronics Division, is to become Head of the Telephone Exchange Division as from September 1 this year.

Fred Sundkvist

Hans Sund

LME engineers Göran Einarsson and Bengt Wallström appointed professors this year.

LM Ericsson Engineers Professors in Lund

Two L M Ericsson engineers have been appointed professors at the Institute of Technology in Lund:

Dr. Göran Einarsson from January 1, 1969, in Telecommunications Transmission Theory, and Dr. Bengt Wallström as from March 21, 1969, in Telecommunications Traffic Systems.

IN MEMORIAM

Curt Mårten Green

Curt Green died on February 8, 1969, at the age of 41.

After graduating from the Technical Gymnasium in Gothenburg and studying at the School of Economics in Stockholm, Curt Green worked for a brief period with Mölnlycke Väveriaktiebolag.

In June 1950 he joined L M Ericsson's Telephone Exchange Division, where in due course he became engaged entirely on sales of automatic exchanges on foreign markets.

After about one year as consultant to North Electric Co., Galion, U.S.A., Curt Green returned in 1962 to sales work within one of the Telephone Exchange Departments of L M Ericsson in Stockholm.

In April 1964 he was transferred to the Management Staff Departments and appointed head of marketing for U.S.A., Canada and Oceania.

In January 1965 Curt Green was appointed Vice President of North Electric Co., U.S.A., and head of its Telecommunication Division, an appointment which he held until he became head of L M Ericsson's Long Distance Division, Sales Department, in January 1968. At the same time he was nominated Chief Engineer.

Curt Green

Erik L. Andersen

Erik Andersen died on March 11, 1969, at the age of 47.

After graduating from the Danish Institute of Technology he came to L M Ericsson in 1946, where he started to work on telephone exchange technique, with which he continued until his death.

It is particularly Erik Andersen's work on systems and circuit technique that has been of value for the company and its customers.

During 1952—55 he led the installation work on the first 500-line switch exchanges in Lebanon.

He was oppointed head of the Department of Systems and Circuit Technique during 1968.

Erik Andersen

Ingvar Thomsson

Ingvar Thomsson died on April 21, 1969, at the age of 51.

He was taken on by L M Ericsson in 1936 in the Technical Division immediately after taking his engineering degree, but was soon transferred to the Telephone Exchange Division.

Ingvar Thomsson's main work was on the development of new telephone systems — the code switch system AKF 10 in particular carries his signature.

In April 1954 he became Head of the Section for Applied Technology and held that appointment until July 1965, when he was made President of the new subsidiary company, Casa Konsult AB.

Ingvar Thomsson

The Ericsson Group

Associated and co-operating enterprises and technical offices

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A/S Tele-Center *2600 Glostrup*, Sandager 8, tel: (01) 96 18 88, tgm: telekommun

Finland

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Production Control (Ericsson) Ltd. *Morden*, Crown House, London Road, tel: (01) 542 1001, tgm: productrol, telex: 935979, "SWEDERIC LDN"

Centrum Electronics Ltd. *Morden*, Crown House, London Road, tel: (01) 542 2222, tgm: celefon, telex: 935979 "SWEDERIC LDN"

Centrum Rentals Ltd. *Morden*, Crown House, London Road, tel: (01) 542 1001, tgm: celefon, telex: 935979 "SWEDERIC LDN"

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SETEMER, Soc. per Az. *I-00100 Roma*, Via G. Paisiello 43, tel: (08) 86 88 54, tgm: setemer

SIELTE, Soc. per Az. *I-00100 Roma*, C. P. 5100, tel: (06) 577 8041, tgm: sielte, telex: 61225, "61225 SIELTE"

Netherlands

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A/S Industrikontroll *Oslo 6*, Grenseveien 86/88, 3. etg., tel: (02) 68 72 00, tgm: indtroll

A/S Norsk Kabelfabrik *Drammen*, P.O.B. 369, tel: (02) 83 76 50, tgm: kabel, telex: 18149, "KABEL N".

A/S Telesystemer *Oslo 6*, Tvetenveien 32, Bryn, tel: (02) 46 18 20, tgm: telesystemer, telex: 16900, "ALARM N"

Poland

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Spain

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Bjurhagens Fabrikers AB, *212 15 Malmö*, Fack, tel: (040) 93 47 70

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L M Ericsson Data AB, *171 88 Solna*, tel: (08) 83 07 00, tgm: ericdata, telex: 1093 "ERICDATA STH"

L M Ericsson Telemateriel AB, *135 01 Stockholm-Tyresö 1*, Fack, tel: (08) 712 00 00 tgm: ellem, telex: 1275, "1275 TELERGA S"

Sieverts Kabelverk AB, *172 87 Sundbyberg*, tel: (08) 28 28 60, tgm: sievertsfabrik, telex: *1676*, "SIEVKAB STH"

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Lebanon

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Thailand

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Lusaka, P.O.B. 2762, tel: (146) 772 90, tgm: *ericofon*

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Cia Entrerriana de Teléfonos S.A. *Buenos Aires*, Belgrano 894, tel: 332076, *tgm: catel*, telex: 0122196, "CATEL BA"

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Ecuador

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Cont. on next page

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Latinoamericana de Cables S.A. de C.V. *Mexico 12 D.F.*, Apartado 25737, tel: (25) 49 36 50, tgm: latincasa

Teleindustria, S.A. de C.V. *Mexico 1, D.F.*, Apartado 1062, tel: (25) 46 46 40, tgm: ericsson, telex: 01772485, "ERICSSON MEX"

Telemontaje, S.A. de C.V. *Mexico 1*, D.F., Apartado Postal 1062, tel: 46 78 11, tgm: ericssonmexicodf, telex: 01772485, "ERICSSON MEX"

Peru

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Soc. Telefonica del Perú, S.A. *Arequipa*, Apartado 112-1012, tel: 6060 tgm: telefonica

El Salvador

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Ericsson Centrum Inc. *New York, N.Y. 10016*, 16, East 40th Street, tel: (212) 679 10000, tgm: erictel, telex: 620149

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Automatic Monitoring of Subscriber Conversations

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The more subscriber dialling is extended to increasing distances the greater the need for improved methods to check the quality of service in a worldwide fullautomatic network with alternative routing and many tandem-switched links. Among else the transmission quality during conversation is important from subscriber point of view as poor transmission makes the exchange of information more difficult and increases the cost for a call.

At present manual service observations during conversation is the only method but it is subjective and expensive and the number of observed calls is usually too small to give reliable statistical results. Furthermore the method is forbidden in many countries. Hence an objective method permitting Automatic Monitoring of Subscriber Conversations is very desirable. In this article some possibilities based on the matching behaviour of the participants during the beginning of a conversation are discussed.*

Investigations of subscriber behaviour during conversation, carried out by Boeryd,[1] show that the talkers have a certain ability to match their voices to the transmission conditions of the connection they have got. Based hereupon contribution COM. XIII, No. 82, to CCITT contains a proposal for Automatic Monitoring of Subscriber Conversations. The question is, however, whether Boeryd's statistical results can be applied to an individual call with unknown transmission conditions and subscriber habits. In Automatic Monitoring mainly times, speech levels with variations, noise and echo levels can be measured. This paper will discuss some means for the measurement of significant parameters, using the *APL* principles developed by Brady,[2] and their evaluation to some figure of merit corresponding to the subscriber's mean opinion score – *MOS*.

Measuring Set-up

The subscribers may have different talking habits and we have to observe their reactions separately. Automatic Monitoring can therefore only be applied to 4-wire connections which according to fig. 1 consist of a number of 4-wire links switched at either end via hybrids *AA* and *BB* to the 2-wire networks connecting a call between two subscribers *A* and *B*. The *A*utomatic *M*onitoring *E*quipment – *AME* – is connected to measuring points *PA* and *PB* per transmission direction when a call in progress passes a 4-wire switching point chosen as control point.

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* Paper prepared for the 4th Symposium on Human Factors in Telephony held at Bad Wiessee near Munich in September 1968.

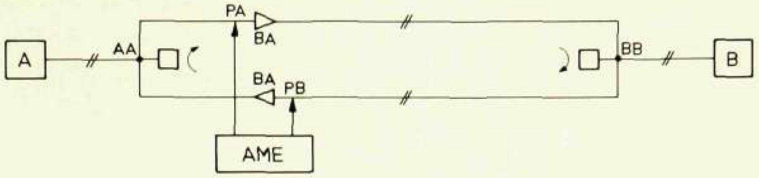

Fig. 1
Measuring set up

A, B	Subscribers
AA, BB	Hybrids with balances
PA, PB	Measuring points
BA	Blocking amplifiers
AME	Automatic monitoring equipment

There we not only can measure levels in the speech directions but also register electrical signals passing the control point – including the wanted subscriber's number and his answering signal. From the exchange of electrical signals a lot of information about the call can be gained, but that is outside the scope of this paper. Our main concern will be with the possibility of usable level and time measurements being started when *B*-answer is received.

Method for Level Measurements

On the speech wires there is a mixture of:

- "Conscious talk" – utterances – whereby the talkers try to give each other intelligible information
- "Unconscious talk" from the listener such as laughing, coughing, breathing, huhu, umum etc.
- Echoes due to mismatching in the hybrid balancing
- Circuit noise and crosstalk
- Other spurious noises via the microphones such as handset movements, room noise etc.

All these sources together will cause level variations during a conversation. The *AME* cannot interpret the spoken sentences, but in some way it has to distinguish between "conscious talk" – utterances – and the rest, as the level variations between consecutive utterances per speech direction ought to give the best information about variations in subscribers' behaviour. By an appropriate choice of threshold level and times we can distinguish circuit noise, unintelligible crosstalk and spurious noise from speech, but in this way we cannot distinguish conscious talk from unconscious nor from echoes or crosstalk with too high levels.

We can, however, assume that utterances, carrying sufficient information, ought to have a certain length, and then a lot of short unconscious speech bursts disappear from the level measurements. But in a real utterance we have a lot of gaps – caused by stop consonants, breathing, hesitation etc. – with levels below the chosen threshold.

"An utterance may be defined as talk during a certain time – *Tu* ms – without any gap exceeding *Tg* ms".

With respect to On-Off Patterns investigated by Brady[3, 4] $Tu = 500$ and $Tg = 200$ ms seems appropriate.

There is, of course, always a risk that long utterances are split into sub-utterances or that unconscious speech and long noise bursts may be taken for an utterance, but nothing can be done about that. The problems of high echo or crosstalk levels will be considered later after a feasible measuring method has been discussed.

For our purpose a conventional *VU* measurement can hardly be used due to the integration time of about 140 ms preventing identification of gaps below threshold with sufficient accuracy.

The *APL method* – where *APL* stands for *A*verage *P*eak *L*evel – developed by Brady[2] seems more promising. The *APL* meter – the principles of which are reproduced in fig. 2 – gives the true peak value in dBm independent of threshold choice, if the level distribution above threshold is log-uniform, i.e. the dBm distribution is a straight line.

The *APL*-method has for our purpose such desirable features as:

- It is fast and can easily be automatized.
- It has no integration time but summarizes energy and time on electronic counters for levels above threshold, thus excluding gaps below threshold within an utterance.
- Utterances may have different durations.

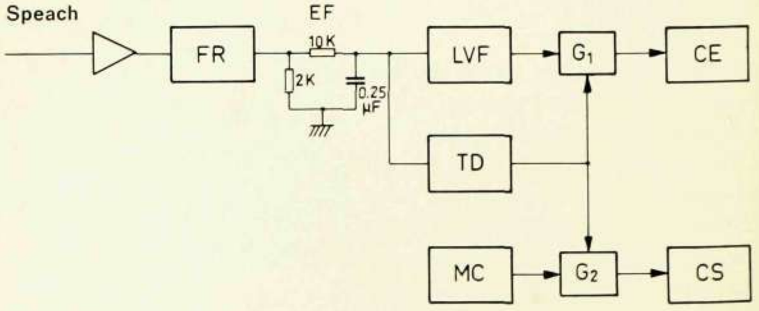

Fig. 2

Basic design of APL meter (Brady)

FR	Full-wave rectifier	
EF	Envelope filter	
LVF	Log volts/frequency converter	
TD	Treshold detector	
G_1	Speech gate	
G_2	Clock gate	
CE	Energy counter	for speech levels above threshold
CS	Time counter	
MC	Millisecond clock	

In a real conversation, however, the level distribution may not be log-uniform and then the *APL* values will be threshold dependent. Brady has, however, found that the errors are normally within a range of ± 2 dB, which is small compared with the natural speech variations during a conversation. It therefore seems reasonable to assume that the *APL* principles will give sufficient accuracy for *AME* purposes, but that has to be confirmed by further investigations.

The nominal reference levels in the measuring points may, according to the transmission plan, deviate from zero transmission level point. In the *AME* a correction for that can easily be inserted. In the following all levels are assumed to be relative to zero transmission level point.

Choice of Threshold

In automatic monitoring without recording of the conversation in both directions the speech levels can only be analysed once. We have no chance to adjust the threshold with respect to actual transmission conditions and subscriber talking habits, but have to choose the same threshold for all calls. The threshold must not be too low as then noise peaks will interfere too much with speech, nor too high as then the time above threshold for an utterance will decrease and the risks of too long gaps below threshold – splitting an utterance into parts–will increase. Those risks will be very disturbing when we have calls with high overall attenuation giving low speech levels in the measuring points.

A threshold level of – 40 dBm relative to zero transmission level point seems therefore appropriate.

According to definition[2]

$$APL = a + 2(M - a) = 2M - a$$

where a = threshold and M = mean level above threshold.

As we only are going to compare levels and for all calls we have the same threshold, we can therefore also compare mean levels, which make the calculations rather simpler. In the following we shall use these levels putting

MSL = mean speech level
MEL = mean echo level
MNL = mean noise level

Level Measurements

In the 4-wire circuit according to fig. 1 mismatched balancing in the hybrids *AA* and *BB* can cause severe 4-wire echoes between the measuring points *PA* and *PB* and the echo loss, seen from these points against the hybrids, can in rare cases be as low as 6 dB. The echo levels from a loud-speaking talker may sometimes be of the same magnitude as the talk-levels from a low-speaking one.

In determining echo losses we must not suppress echoes, but we can use the differential device from a conventional echo suppressor to detect in which direction there is speech, as shown in the block diagram, fig. 3.

The layout is symmetrical for both speech directions. Beside the devices used by Brady in fig. 2 consisting of:

- Envelope rectifier *ER* with smoothing filter and level adjustment relative to zero transmission level point
- Threshold detector *TD*
- Log volts/frequency converter *LVF*
- Energy counter *CE* and time counter *CS* for speech levels above threshold
- Millisecond clock *MC* common to many *AME*'s

there are added the following devices:

Common to the Two Directions

- Differential speech detector *DSD*
- Noise time control counter *CN*

Per Direction

- Gap control counter *CG*
- Utterance time counter *CU* which is started when *DSD* discovers talk in the direction and then runs until reset by *CG*, having found a gap longer than *Tg* ms
- Pause time counter *CP*, which is reset when an utterance is accepted – *CU* recording equal to *Tu* ms
- Noise energy integrating amplifier *NA* switched in by *CN* during *Tn* ms.

With these devices a lot of data can be registered during a conversation having repeated states of:

- Only one party talking – *MSL* and echo investigations
- Both parties talking – double talk
- Nobody talking – double pause
- Mutual gaps of sufficient length for noise measurements.

Only One Party Talking

TD on the *talk side* discovers speech and opens the *DSD* gate with some delay – about 5 ms – overbridging short nois peaks. *DSD* opens the talk-*CU* gate. After *Tu* ms without gaps longer than *Tg* the utterance is accepted and counter *CP* is reset after pause time registration. Counters *CE* and *CS* are running for speech above threshold.

The *echo side* counters *CE* and *CS* are also running for echo levels above threshold, but *CU* is not switched in and *CP* remains in operation. Also *CG* is running but has no function.

At the moment talk-*CG* discovers a gap *Tg*, *CE* and *CS* for both sides and talk-*CU* are reset. Before that their readings are registered if talk-*CU* shows *Tu* ms – otherwise all readings are cancelled.

At the beginning of an utterance we also register the talk-*CU*-value when echo is discovered – *TD* operates – at the echo side giving a rough estimation of echo delay round the hybrid.

Per undisturbed utterance we thus get 7 registrations enabling us to calculate:

- Pause length = *CP* reading reduced by *Tu*
- Echo delay = talk-*CU* reading when echo received
- Utterance length = talk-*Cu* reading reduced by *Tg*
- *MSL* = *CE*/*CS* readings for talk side
- *MEL* = Ditto for echo side
- Echo loss against hybrid roughly = 2(*MSL* – *MEL*).

Compare appendix!

With undisturbed talk in the other direction the same calculations can be made.

Double Talk

DSD disrovers speech in both directions and will jump between them. With an appropriate hangover time in *DSD* both *CU* counters will run independently until a gap *Tg* is discovered or the hangover time is ended. Then the corresponding *CU* together with *CE* and *CS* are reset and their records are registered if *CU* shows at least *Tu* ms. We can, of course, not register echo levels which are being disturbed by double talk. As echo from the other party is superimposed on the talk the *MSL's* may be a little too high, but that can normally be neglected. Suspected *MSL* values during disturbed talk can be especially marked. Noise bursts shorter than *Tu* will not be registered as double talk but will disturb echo measurements, which therefore must be rejected.

When one of the *CU* counters is reset after an accepted utterance, the other one is also read. The smallest value – belonging to the interrupting party – is registered together with a sign – *A* or *B* – for the interruptor. If the stops talking first, the reading is the time for double tak – otherwise *Tg* ms has to be deducted.

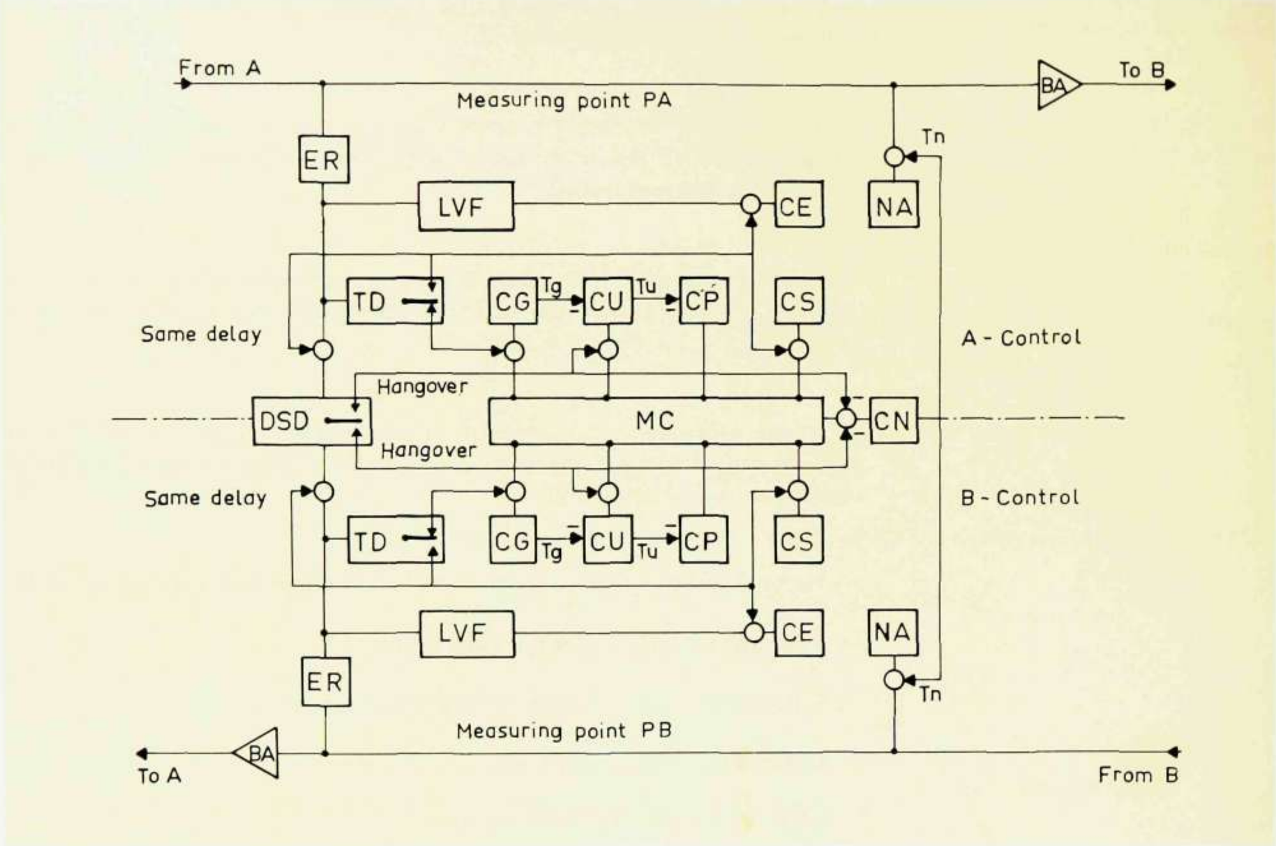

Fig. 3

Automatic monitoring

BA	Blocking amplifier
ER	Envelope rectifier with smoothing and level adjustment
LVF	Log volts/frequency converter
TD	Threshold detector
CE	Energy counter⎱ for speech levels⎱ reset
CS	Time counter ⎰ above threshold ⎰ together
CU	Utterance time counter
CG	Gap control counter. Resets CU after Tg ms
CP	Pause time counter. Reset by CU after Tu ms
NA	Noise intergration amplifier with intergration time Tn ms
CN	Noise time counter controlling integration time Tn ms
DSD	Differential speech detector with hangover
MC	Millisecond clock
→O	Gate

Double Pause

Both *CP* counters are running. When one stops – its *CU* counter shows *Tu* – the other one is read. The smallest value is registered and gives reduced by *Tu* the double pause time. A sign for the stopping party may be added.

Noise Measurements

With respect to echoes, noise measurements can only take place during mutual gaps of sufficient length, during which remaining echoes must first disappear before noise can be measured. The probability of finding appropriate mutual gaps increases the shorter the necessary gap length is. Therefore we need a fast measuring method.

As shown in the diagram the nor-gate for the noise time control counter is blocked when *DSD* discovers speech in either direction. During the hangover most echo will disappear but some more time can be added by *CN* before opening the gates to the operation amplifiers *NA*, which integrate the noise energy during *Tn* ms. With the help of weighting filters and appropriate choice of constants the noise level *MNL* can be registered in dBmp. If the mutual gaps are too short, giving integration times shorter than *Tn*, the *MNL* registrations are cancelled. After *Tn* ms *CN* and *NA* are always reset and in long mutual gaps repeated noise measurements will take place, but that does not matter.

Because of the circuit amplifiers the noise in the paths *PA-BB* and *PB-AA* cannot be included in *MNL*.

Crosstalk and Double Connections

Low crosstalk levels cannot be distinguished from circuit noise and will slightly increase *MNL*, which does not matter as subscribers do not care if it is noise or unintelligible crosstalk.

With increasing noise or crosstalk, however, the *DSD* will frequently discover speech in both directions, too short to be accepted as utterances but disturbing echo measurements. Too few accepted echo measurements, therefore, indicate certain noise conditions.

With severe crosstalk or in rare cases in a double connection there will be two talkers in one or both directions, causing more double talk and less pauses than normally. Maybe there will also be too few opportunities to find mutual gaps for noise measurements.

Evaluation of Registered Data

From the foregoing section we can estimate the number of registrations at 8–9 per utterance. According to Boeryd[1] some 15–20 utterances per direction – corresponding to about 2 minutes conversation time – seems necessary to determine subscriber matching behaviour. Most *LD*-calls are much longer but the most interesting part of the call is the first 2–3 minutes. Even if *AME* registrations are interrupted after such a time there will still be some 400–600 data to evaluate per call, which hardly can be done manually.

The only way out is an appropriate computer program in order to get a reduced number of data significant for a call. The raw data from *AME* measurements can of course be stored in sequence on a tape with an appropriate code for direction and type of measurements and then fed into a computer for further analysis and evaluation.

As we anyhow need a computer, a faster way is to connect a number of *AMEs* on line to a small computer, which after some calculations as described in section "Level Measurements" transfers in sequence a smaller number of data with type code to the memory such as:

Per Utterance and Direction

- *MNL* in undisturbed gaps
- Pauses between utterances
- Echo delay at the beginning of an utterance
- Utterance duration
- *MSL*
- Echo loss = $2(MSL - MEL)$ during undisturbed utterances.

Between Directions

- Duration of double talk with indication of interruptor
- Double pauses with indication of starting talker.

The called subscriber's number and answering time are also recorded.

Still the number of data is much too high but, after monitoring, a further compression of data is possible and we can calculate groups of significant call parameters such as:

Circuit Parameters per Direction

Average MNL with Reliability Figure

As we want pure circuit noise and some *MNL* values may be increased by undetected spurious noise, it seems appropriate to take an average only of the smallest *MNL* values – say 4. We can always add a reliability figure taking into account the number of usable *MNL* values and their deviations.

Estimated Echo Loss with Reliability Figure

As shown in the appendix, undetected noise peaks or too poor log-uniform speech level distribution will result in inaccurate echo loss calculations. Some values may be too high, others too low. An average value of, say, 4 calculated echo losses in the middle of the distribution with small variations ought to be an appropriate echo loss estimation. A reliability figure accounting for number of used values and their variations may be added.

If real echo loss is high, it is possible that some low level utterances may give echoes near threshold with only some few echo-*CU* ms. In such a case the echo loss will be at least $2MSL - a$, which may be compared with calculated echo loss values from high level utterances.

Estimated Echo Delay with Reliability Figure

We can always add the *DSD* delay to the talk-*CU* readings, but in spite of that undetected noise peaks may shorten the echo delay. On the other hand the first part of the speech envelope – especially at high echo losses – may be below echo side threshold, giving too long echo delays. Also in this case an average of about 4 values in the middle of the distribution with small variations ought to be a proper estimation, to which a reliability figure may be added.

On calls with poor transmission conditions we may get no or too few acceptable noise or echo measurements, which in itself is valuable information which has to be indicated in the final call report, for example by reliability figure 0.

Echo Suppressor Control

If echo suppressors are inserted on the right of the control point in fig. 1, there will be no echo from *BB* with proper suppressor function. Neither loss nor delay can be estimated, but reliability symbol + may indicate proper far-end suppressor function. The near-end suppressor cannot be checked this way.

If there are measureable echos with too long delays the echo suppressor does not function, which is indicated by reliability symbol – for reported estimated echo loss and delay.

Conversation Parameters

Except double talk and double pauses the parameters are given per direction:

Average MSL with Deviations

The average is the result of unknown talking habits and transmission conditions and no reliable conclusions can be drawn about the latter. With degraded transmission the talker are, however, forced to raise their voices – especially the low levels – and there are reasons to believe that the deviations will decrease with degraded quality of transmission.

- *Number of utterances and pauses* together with percentage *utterance time relative to monitoring time*, giving information about talking habits.

- *Number of sequences* of at least 2 or 3 utterances with *MSL* above average but shorter than about one second – probably hellos – together with *number of double talk interruptions* and *talk starts after long double pauses* indicating to a certain degree subscriber difficulties.

- *Numbers of double talk and double pauses* above a certain length and their total *duration relative to monitoring time*.

- *Number of sequences* of at least 2 or 3 utterances with *MSL* above average but shorter than one second in both directions simultaneously indicating hello-conversation and severe subscribers' difficulties.

- *A matching code* illustrating the combined trend in *MSL* variations during the first 10 utterances per direction corresponding to a matching pattern, observed by BOERYD.[1]

Figure of Merit

All parameters mentioned above are weighted together to a figure of merit for the call corresponding to an expected subscriber's *MOS* together with a code indicating suspected reasons for too low values.

Further investigations of test calls with known conditions are necessary to find out whether discussed data are sufficient and necessary or whether better ones can be evaluated.

As advocated by D. L. RICHARDS,[5] essential round trip delays–with or without inserted echo suppressors – will cause difficulties during conversation, which som people cannot manage as they in view of the high cost for such a call try to transfer the information too fast. On conversations with delay troubles we may expect an abnormal conversation pattern with too much double talk, double pauses, hellos and/or double hellos which may be possible to include in the figure of merit.

Anyhow, the computer delivers per call an *AME* report preferably in the form of a punched card with the above-mentioned circuit and conversation parameters together with the called number, answering time and monitoring duration.

Additional Information

We are mainly interested in the percentage calls with too low figure of merit. For some of them the reasons may be obvious, but other calls may only be suspicious. As the called number is known, we can always call a *B*-subscriber shortly after the call, directly or via a foreign *IMC*, to get additional information. Such an interview, as a lot about the call is known from the *AME* report, should be more efficient than an interview taking place days or weeks after the call.

Statistical Evaluation of Call Performance

With automatic monitoring a large number of call reports can be sampled at a reasonable cost. With the help of the called number the *AME* can always be switched to the most interesting calls in progress, such as expensive international calls. The figure of merit per call is a combined interpretation of other evaluated data and will never be more than a rough estimation.

The call reports can be split into groups with respect to call destination – for example a foreign country. An average figure of merit with deviation or distribution can be calculated per destination, giving an originating Administration the possibility to detect variations in transmission performance with time for a certain destination or to make a comparison between destinations.

We may also be able to estimate the percentage calls per call destination with subscribers not able to manage delay difficulties. The result may provide an indication for some kind of subscriber training.

If copies of the *AME* reports are sent to the terminating Administration the latter can sample reports from many other countries and group them with respect to destinations within its own country for further analysis. If poor transmission quality for a certain destination is suspected, the details in the *AME* reports can be studied if the figure of merit is insufficient, giving supervision and maintenance people valuable hints about possible weak points in international or national networks, so that they can start more detailed tests to find and remove fault sources.

Acknowledgements

The author wishes to express his gratitude to Mr. D. L. Richards at the British Post Office Research Station for valuable information about speech analysis and measuring methods, Mr. P. T. Brady at the Bell Telephone Laboratories for drawing the author's attention to the *APL* principles, and to the staff of the Swedish Telecommunications Administration and the L M Ericsson Telephone Company for valuable suggestions.

The main aim of the paper has been to discuss some hypothetical possibilities for measuring some transmission and speech parameters essential for a conversation, so that further investigations can be made more efficiently.

The author hopes that cooperation between participants in the Human Factor Symposia and other parties interested in speech problems will contribute to a further development of the outlined ideas into a usable monitoring method.

Appendix

Echo Loss Measurements

The accuracy is dependent on level distributions and disturbing noise in the echo.

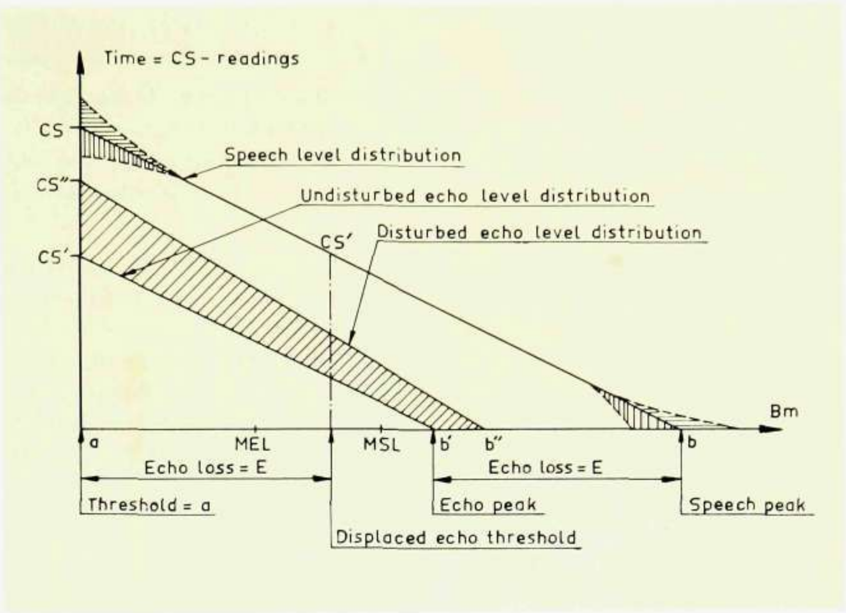

Fig. 4
Distribution of speech and echo levels during an utterance

Level Distributions

The areas between distribution curves and the dBm and time axes in fig. 4 represent the speech and echo level parts above threshold a.

Log-uniform distributions are represented by straight lines in the dBm scale having the same slope for speech and undisturbed echo the latter having the same distribution as speech when threshold is displaced by echo loss E. With following further designations:

CE = energy readings
CS = time readings
b = peak level

with ′ or ″ as marks for echo figure 4 gives

$$MSL = \frac{a+b}{2} = \frac{CE}{CS} \qquad (1a)$$

$$MEL = \frac{a+b'}{2} = \frac{a+b-E}{2} = \frac{CE'}{CS'} \qquad (1b)$$

which results in

$$E = 2(MSL - MEL) \qquad (2a)$$

Because of conformity we can also write

$$\frac{MSL-a}{CS} = \frac{MEL-a}{CS'} = \frac{MSL-MEL}{CS-CS'}$$

which combined with (2a) gives

$$E = 2(MSL-a)\left(1-\frac{CS'}{CS}\right) \qquad (2b)$$

If there are deviations from log-uniform distribution only near the peak level, the CS readings will be the same, but the CE readings higher or lower. As the echo has smaller CS readings than the speech, the deviations will have more influence on MEL, giving an error in calculated echo loss. It is, however, possible to reduce these errors if the difference between CE and CE' readings is used instead of the CE' reading itself. According to the figure the speech energy part above the displaced threshold is the same for echo and speech. With log-uniform distribution between real and displaced threshold we get:

$$CE - CE' = a(CS - CS') + E \cdot \frac{CS + CS'}{2}$$

where the expressions on the right correspond to energy differences below and above threshold:

$$E = 2\left(\frac{CE - CE'}{CS + CS'} - a \cdot \frac{CS - CS'}{CS + CS'}\right) \tag{2c}$$

All equations (2a)–(2c) will of course give the same echo loss value if the distribution is log-uniform from threshold to peak.

If the distribution near the threshold is non-log-uniform the influence will be much greater on CS than on CE or echo readings and will result in unknown errors in echo loss calculations, which can hardly be controlled as nothing is known about the real distribution during a certain measurement.

Noise Disturbances

A much more severe error source is, however, noise or speech disturbances not discovered by the differential speech detector during an accepted utterance longer than Tu. In the figure a disturbed log-uniform echo level distribution is shown, which gives a formal echo loss

$$E' = 2(MSL - MEL')$$

with

$$MEL' = \frac{a + b''}{2}$$

Put $b'' - a = p(b' - a)$ where $p > 1$

Use of (1a) and (1b) gives

$$MEL' = a + p(MSL - a) - \frac{p}{2} \cdot E$$

and thus a formally calculated echo loss

$$E' = 2(MSL - MEL') = pE - 2(p - 1)(MSL - a) \tag{3}$$

If we put $CS'' = q \cdot CS'$ with $q > 1$ we can according to (2b) calculate another formal echo loss

$$\begin{aligned} E'' &= 2(MSL - a)\left(1 - q \cdot \frac{CS'}{CS}\right) = \\ &= 2(MSL - a)\left[1 - q + q\left(1 - \frac{CS'}{CS}\right)\right] = \\ &= q \cdot E - 2(q - 1)(MSL - a) \end{aligned} \tag{4}$$

We then get the difference

$$\begin{aligned} E' - E'' &= (p - q)\, E - 2(p - q)(MSL - a) = \\ &= (p - q)[E - 2(MSL - a)] \end{aligned} \tag{5}$$

In equations (3) to (5) E is the real echo loss. In equation (5) the last factor can never be zero as then all echoes disappear below threshold and cannot be measured. When $p = q = 1$ we have log-uniform distribution without disturbances, giving $E' - E'' = 0$, but that is also the case when $p = q$.

Comments

The combined effect of the considerations in the foregoing sections seems to preclude satisfactory echo loss estimations, as the level distribution during a measurement may be non-log-uniform or disturbed by undetected noise peaks.

Even if control calculations according to equations (2a), (2b) and (2c) give echo loss values with small variations, undetected noise peaks may cause too low calculated echo loss.

During a conversation there will be many opportunities for echo measurements and some of them should be favourable. All measurements will give a distribution of echo losses, in which some values are too small, others too high, but in the middle there should be some with rather small variations. The average of the latter may be considered as a fair echo loss estimation. The more values we can use for the average and the smaller the deviations the higher the reliability, which can be indicated by a reliability figure added to the average echo loss value. Further investigations may show whether a formal calculation according to equation (2a) alone is sufficient.

It has to be noted that echoes below threshold cannot be measured. In such case the echo loss calculated from the highest *MSL* reading is reported. If there are no or too few *MEL* readings due to noise or talk bursts, this is indicated in the *AME* report, as then the transmission conditions are obviously too poor.

It should also be noted that loss deviations in used 4-wire circuits may give deviations between actual and nominal reference levels in the measuring points, causing slight errors in reported echo losses. If the echo losses for both directions are added, these errors will disappear and we shall get a fair estimation of 4-wire round-trip echo loss, giving an indication of the 4-wire stability.

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L M Ericsson's Thyristor-Controlled Rectifiers for Power Supplies

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LME 781 785 7256

Modern telecommunication equipment, with its considerable amount of electronic components, imposes more extensive and stricter requirements than did previous equipments on the quality of the energy delivered by the power supply, i.e. on the latter's performance and reliability.

At the same time the equipment designer in the static conversion field has gained new possibilities through the advent of new semiconductor components for high-power applications, such as silicon diodes and silicon-controlled rectifiers (SCR's, thyristors). The thyristor in particular has transformed the static conversion technique. The features which contributed to this development are briefly dealt with below.

Both of these circumstances—stricter requirements and greater possibilities for the designer—have contributed to the form of the new power supply equipment presented in this article. This equipment is intended for the supply of telephone exchanges and other telecommunication plants in sizes corresponding to current requirements from a few up to several thousand amperes. Different power supply systems can be used for this purpose, as described in the earlier article (Ericsson Review No. 4, 1968).[1]

General Conditions

A modern power supply equipment for telecommunication purposes must fulfil a number of requirements which may be summarized under the following items:

- The power supply must be uninterruptible
- Specified limits for the distribution voltage delivered to the exchange must be maintained under all conditions of operation
- Noise voltages and transient voltages must be limited to specified values
- The equipment must be adapted for unattended exchanges and therefore function automatically in all conditions of operation (e.g. after a mains failure the batteries must be recharged automatically)
- The equipment must not require any maintenance; the units must be of static design, without moving parts; the need for visits of inspection must be reduced to a minimum
- The equipment must be designed for natural cooling
- The equipment must fulfil a number of environmental requirements (temperature, humidity, mechanical stresses)

- It must be highly reliable ; its service life must fulfil specified requirements

- Protective devices must be provided which, in the event of a fault in the power plant, prevent damage or interruptions of service in the telecommunication equipment

- Abnormal operating conditions must be signalled ; as far as possible this must be done in such a way as to allow time to take the necessary action.

The power supply equipments developed by L M Ericsson fulfil these requirements.

To attain this goal it was necessary to develop not only power supply units such as rectifiers and converters, but also a number of special devices for control, supervision, protection etc. These unite the equipment units into a complete uniform system suited, for example, for automatic operation.

System aspects were also taken into account in the mechanical design of the equipment. Cabinets, units and subunits are based on a modular system which provides great flexibility and easy replaceability.

The reliability of the power supply is of primary importance in telecommunication plants. The reliability requirements are met by the following measures:

- The choice of components is based on systematic tests

- The design rules specify large safety margins in respect of current, voltage and temperature

- The circuitry includes automatic standby operation for important functions.

The Thyristor as Conversion and Control Component

The properties of the thyristor make it a typical high-power component. It can be designed for high currents and voltages. The crystal structure of the thyristor (four-layer) eliminates certain essential limitations attaching to the power transistor. The power transistor, for example, is difficult to construct for high voltages since the base region must be thin if a reasonable current gain is to be obtained.

The thyristor has excellent properties as control component: small power for gate triggering, very high gain, and operating times of the order of microseconds. At the frequencies used in power applications the thyristor may therefore be regarded as being free from delay.

The thyristor is a bistable component. This implies no limitation, however, in respect of its capacity of continuous regulation which is made possible by phase angle control. Its bistable character may even be regarded as an advantage, as characteristic problems in transistors such as second breakdown and power requirement for base drive are avoided.

For application in rectifiers the thyristor technique has permitted new solutions with substantially better performance compared with its predecessors —transductor-controlled rectifiers and rotary converters. The thyristor rectifier is characterized by higher efficiency, smaller space requirement, better control characteristics (accuracy of regulation, fast response, stability), freedom from maintenance and higher reliability.

Another important application which the thyristor technique has made possible is static inversion, i.e. conversion of D.C. to A.C. voltage. At the relatively low D.C. voltages required for the power supply of telecommunication plants it was previously necessary to use transistor inverters. But these covered only a small power area. This limitation was abolished through the advent of the thyristor. New types of equipment and new system ideas can now be realized. One of the new applications is the transformation of a D.C. voltage to another, galvanically separated, D.C. voltage. The booster converters described in a coming article are one example of this principle.

The thyristor was introduced on the market in 1958. L M Ericsson was among the first telecommunication companies to use the thyristor technique in its power supply equipment. By 1961 the Ericsson Power Laboratory had working models of thyristor rectifiers of different sizes. Deliveries of thyristor converters have been made since 1964 and comprise plants as large as 6000 A, 48 V. The experience of their operation has been very positive.

Thyristor-Controlled Rectifiers

L M Ericsson's line of rectifiers comprises D.C. voltages of 24 V, 36 V, 48 V and 60 V with the following current ratings:

6.3, 16, 25 A (and 40 A, 24 V)	for single-phase connection in two-pulse double-way circuit (single-phase bridge)
40, 63 and 100 A (400 A)	for three-phase connection in six-pulse double-way circuit (three-phase bridge)
160 and 315 A	for three-phase connection in 2× three-pulse single-way circuit (six-phase star with interphase transformer)
630 A	for three-phase connection in 4× three-pulse single-way circuit (twelve-phase star with three interphase transformers)

The 48 V line is presented below. A description will be given of three sizes of rectifiers representative of certain fields of application:

- 48 V, 630 A—for large exchanges. This rectifier represents the most complicated circuitry, including several control systems, and the most advanced protective and automatic equipment
- 48 V, 100 A—for medium-sized exchanges
- 48 V, 16 A—for small exchanges.

Rectifier 48 V, 630 A

The block diagram for this rectifier is shown in fig. 1. The mechanical design will be seen from fig. 2.

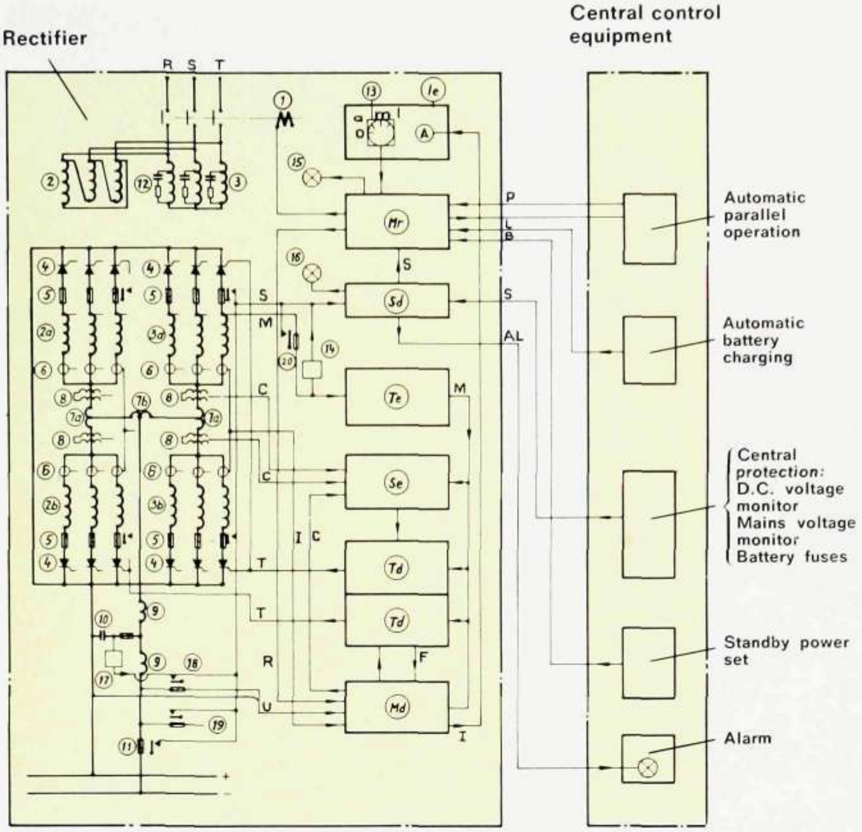
Main Circuit

Two three-phase transformers (2) and (3) are connected to three-phase mains via the contactor (1). The primary side on one transformer is star-connected, on the other delta-connected. This produces a phase shift of 30 electrical degrees between the respective secondary phase voltages. The secondary winding on each transformer forms a six-phase star consisting of two three-phase stars interconnected via the interphase transformer (7a). The two six-phase stars are

Fig. 1

Block diagram of thyristor rectifier 48 V, 630 A

1	Contactor
2, 3	Mains transformers
4	Thyristors
5	Fast-acting fuses
6	Current transformers
7	Interphase transformers
8	Measuring transductors
9	Filter chokes
10	Filter capacitors
11	Output fuse
12	Voltage surge protection
13	Operating switch positions: a automatic operation m manual operation l charge
14	Phase failure relay
15	Operation lamps "in operation" "pilot rectifier"
16	Alarm lamps "contactor released" "filter fuse" "phase failure"
17	Filter fuses – supervision
18	Fuse – voltage sensing circuit
19	Fuse – monitory circuits
20	Fuse – control circuits
Ie	Instrument unit
Mr	Monitory relay set
Sd	Protection
Te	Transformer unit (supply of control circuits)
Se	Current sharing regulator
Td	Trigger pulse device
Md	Sensing unit
T	Trigger pulses
U	Voltage sensing
I	Current sensing for constant current regulator
C	Current sensing for current sharing regulator
F	Feedback
M	Supply of control circuits
S	Shutdown
R	Preset control levels
P	Step connection (automatic parallel operation of rectifiers)
L	Voltage increase command (automatic battery charging)
B	Blocking of a number of rectifiers (when supplied from a standby set)
AL	Alarm, internal fault
A	Ammeter



interconnected by the interphase transformer (7b) and form a twelve-phase star with 30 electrical degrees phase shift between the respective voltages. The rectifier connection in the 12-pulse single-way circuit consists of 12 thyristors (4). The trigger pulses to the thyristors are sent at intervals of 30 electrical degrees. Commutation (change of current path) takes place 12 times per cycle and the output voltage from the rectifier contains a ripple component with 600 Hz frequency. This ripple voltage is smoothed by a low pass filter consisting of two chokes (9) and an electrolytic capacitor bank (10). Thanks to the 12-pulse operation the frequency of the ripple component is high and its amplitude low, which permits a smaller smoothing filter.

The function of the interphase transformer is to take up the voltage difference arising between the zero points in the respective windings. The interphase transformers (7a) operate with threefold and the interphase transformer (7b) with sixfold mains frequency. Each interphase transformer is passed by two equal but opposed direct currents. The total direct current is divided into four equal currents, which, via the interphase transformers, flow towards the zero points in the four three-phase stars (2a), (2b), (3a) and (3b). At every moment four thyristors are conducting, one in each three-phase star. The conduction time for each thyristor is 120 electrical degrees, while commutation takes place at intervals of 30 electrical degrees.

At full load the current amplitude of the thyristor is 1/4 × 630 A = 157.5 A and its mean value 1/3 × 157.5 A = 52.5 A. The thyristors are mounted on aluminium heat sinks for natural cooling and designed for low thermal resistance (below 0.5 °C/W). At full load the losses per thyristor are about 75 W and the temperature rise on the heat sink about 37 °C.

Control System

The rectifier is equipped with the following control devices: constant voltage regulator, constant current regulator, and current sharing regulator. Control is effected by change of trigger phase angle in the SCR's.

Voltage and Current Control

Voltage and current control circuits are gathered together in the sensing unit (Md). The sensing unit contains reference voltage, voltage and current sensing circuits, and control amplifier. The control circuits are supplied from the transformer unit (Te). A zener diode with temperature compensation is used as reference voltage. Voltage sensing is accomplished with a resistive voltage divider and current measurement with six small current transformers (6). The difference between actual and reference value (error) is fed to the control amplifier.

The trigger pulses to the thyristors (4) are generated in two trigger pulse devices (Td), each of which generates six pulses with 60 electrical degrees phase shift. The two trigger pulse devices together deliver twelve trigger pulses per cycle at intervals of 30 electrical degrees. With one amplification stage for each pulse, trigger pulses of sufficient power are obtained with rectangular shape and steep front, which is of significance for the turn-on of large thyristors. The phase displacement of the trigger pulses relative to the mains voltage is affected by the output signal from the control amplifier, so resulting in constant voltage regulation or constant current regulation.

The good dynamic properties of the control system (fast response, stability) are ensured by derivative feedback circuits. A feedback circuit adapts the

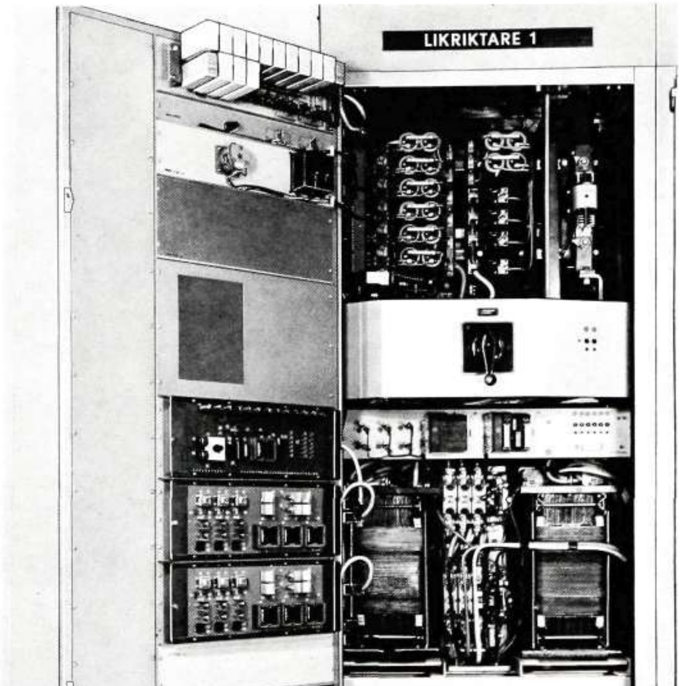


Fig. 2
Thyristor rectifier 48 V, 630 A

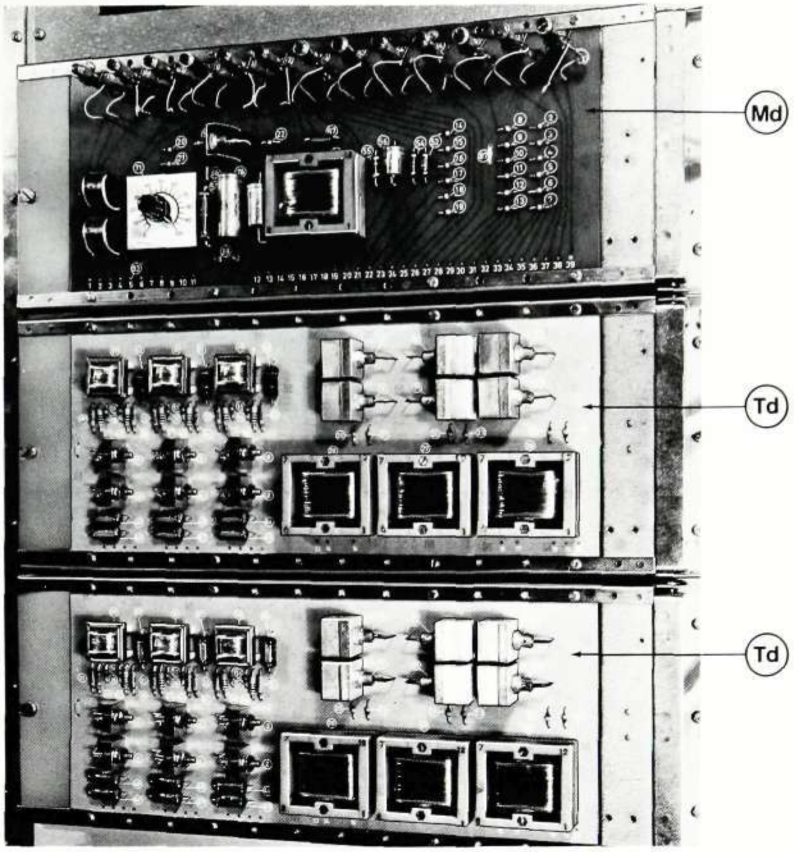


Fig. 3
Control unit in thyristor rectifier 48 V, 630 A
Md Sensing unit (voltage and current regulator)
Td Trigger pulse device

dynamics of the control system to properties of the load which vary, for example, with the size of the storage battery.

The sensing unit and the trigger pulse devices are assembled on their respective printed boards with plug and jack connection (fig. 3).

In normal operation the rectifier works with constant voltage regulation. Constant current regulation is used, among other purposes, when the load tends to rise above the rated value. The output current from the rectifier is then kept constant at about 110 % of the rated current $I_=$, while the voltage falls. This so-called current limitation protects the rectifier against overload. A typical application for current limitation is the recharging of discharged storage batteries. The rectifier is then forced to work with an output voltage which is considerably below the normal regulating level, the current being maintained at the preset value until the voltage attains its normal level. Thereafter the operation mode changes from constant current regulation to constant voltage regulation. Other modes of operation with constant current regulation will be described later.

To accomplish all modes of operation four voltage and five current control levels are required. Resistive voltage dividers for these levels are placed in the sensing unit and in the monitory relay set. The sensing unit also contains three potentiometers for fine adjustment of two voltage levels and for setting of current limitation.

Current Sharing Regulator

The function of this regulator (Se) is to bring about equal current distribution between the four three-phase stars (2a), (2b), (3a) and (3b) in the main circuit. An unequal load would lead to increased thermal stresses in individual thyristors and to D.C. magnetization in the interphase transformers.

The currents from every three-phase star are measured with four measuring transductors (8). After comparison small corrections $\Delta\alpha'$ are introduced in the trigger phase angle of the three thyristors in the three-phase star (2a) compared with the trigger phase angle of the three thyristors in the three-phase star (2b). In the same way currents in (3a) are balanced against (3b). A separate circuit balances the sum of currents (2a) + (2b) in relation to the sum of currents (3a) + (3b). This is accomplished by the introduction of correction $\Delta\alpha''$ in all six trigger pulses to the six-phase star (2) compared with the trigger pulses to the six-phase star (3).

Modes of Operation

With the operating switch (13) on the front of the cabinet the following modes of operation can be selected:

- *Automatic operation*. The rectifier is automatically switched on and loaded in parallel operation with the other rectifiers of the exchange (see page 97: Device for Automatic Parallel Operation).
- *Manual operation*. The rectifier is switched on manually and operates independently of other rectifiers; voltage and current levels are set manually.
- *Charge*. The rectifier output voltage is raised to 2.4—2.7 V per cell; voltage and current levels are set manually.

In all positions of the switch the rectifier works with automatic voltage and current regulation.

Protection, Alarms

Overload Protection

The overload protection consists of a fuse in the output branch and of the current limitation of the control system. The thyristors in the rectifier connection are protected by special fast acting fuses with characteristic adapted to the thyristor rating.

Voltage Surge Protection

The voltage surge protection (12) consists of one RC circuit per phase on the primary side of the transformer (3). This circuit protects against voltage surges due to switching and surges coming from the mains, and also provides power factor correction. The thyristors in the rectifier connection are protected against commutation spikes by their respective RC circuits.

Fuses

Electromagnetic fuses are used as protection for the following circuits: control circuits, monitory circuit and voltage sensing circuit. The auxiliary contacts of the fuses effect the shutdown of the rectifier.

Protection for Filter Capacitors

Each of the twelve electrolytic capacitors in the smoothing filter is protected by a fuse. An electronic supervisory circuit (printed board assembly 17) checks that all fuses are intact and switches off the rectifier on blowing of a fuse.

Protection against Single-Phase Operation

A special phase failure relay (printed board assembly 14) reacts on failure of a phase in the supply voltage and switches off the rectifier.

When a protective device operates, an alarm is issued and manual reset is required.

Control by Central Protective Devices

The rectfier can be shut-down or blocked in off condition by means of external protective devices. The external devices which can be used for this purpose are:

- *D.C. voltage monitor*. On an increase of voltage across the distribution busbars a sensitive transistorized voltage relay in the distribution bay effectuates the shut-down of all rectifiers. This protection can also be designed to function selectively, i.e. to switch off only the rectifier which has caused the voltage increase
- *Battery fuses*. On account of transient overvoltages rectifier operation without a battery is not permitted. On blowing of one or more battery fuses all rectifiers are shut-down
- *Mains voltage monitor*. On mains failure, low voltage or failure in one or more phases, all rectifiers are switched off. Comparison of indications from the mains voltage monitor and phase failure relay in the rectifiers enables a distinction to be made between phase failure in the exchange (blown fuse) and on the incoming mains supply. In the latter case it is desired that the rectifier shall start automatically on disappearance of the mains failure. This function is particularly important for unattended exchanges

  More complicated requirements can also be met, e.g. the rectifiers can be switched off on change from the ordinary mains to the standby power supply, but not on change in the opposite direction
- *Requirements when supplied from standby power source*. A number of rectifiers can be blocked in the off condition depending on the number of standby power sets in operation.

Other Functions

Automatic Battery Charging ("Operating Charge")

The rectifier output voltage can be raised to 2.35 V per cell on a command from an equipment for automatic battery charging. The rectifier then charges the battery in simultaneous parallel operation with the telephone exchange.[1]

"Walk-in" Device

This device eliminates surge currents on switching to a heavy load, e.g. a heavily discharged battery. At start the control system is locked to a no-load trigger angle. Within one second this limitation gradually disappears while the control system takes over the control of the trigger phase angle. The output current then rises to its stationary value.

Mechanical Design

The rectifier cabinet has a front door (fig. 2). Apart from the conventional arrangement with access from in front and behind, the rectifier can also be placed against a wall, which results in a considerable saving of floor space.

At the bottom of the cabinet is the SCR rectifier unit. This consists of a retractable grating carrying twelve thyristors with their heat sinks. The two main transformers (2) and (3) are placed on a separate pallet above the rectifier unit. Other components in the main circuit are placed on two horizontal gratings.

The hinged front contains the following units, to which access is necessary: the monitory relay set (Mr), lamp unit, instrument unit (Ie), sensing unit (Md) and two trigger pulse devices (Td). The printed boards for sensing unit and trigger pulse devices are made of glass fabric laminate with high mechanical strength. All these units are connected by plug and jack, which permits separate tests and simple replacements. The plug and jack connection is used also for auxiliary circuits in the other units.

On the front of the door the following components are placed: operating switch (13), ammeter, and five signal lamps: two operation lamps (15) and three alarm lamps (16). The operation lamps can be disconnected with a central switch.

The frame consists of welded steel of closed rectangular section. The hinged front is lined with 1.5 mm sheet steel. Rear and side linings are of 2 mm aluminium sheeting. All surfaces visible from in front are grey enamelled.

Continuous distribution busbars are placed at the top of the cabinet. This arrangement allows simple jointing of busbars for increasing the number of rectifiers. The cables from the rectifiers are connected to the busbars by means of resilient cable clips. Drilling of the busbars is therefore not required.

Types of Rectifier Equipment

The rectifier is supplied in the following types:

A For connection to a single busbar system (ordinary full float system, converter system)—basic type ; as described above.

B For connection to double busbar system (separate charging system, cell switch system). A D.C. switch is required on the output side.

C For elevated charging voltage (up to 65 V). An extra mains contactor is required ; the output voltage from the mains transformers is raised by 11 % in charge position.

D For double busbar system and increased charging voltage—as under *B* and *C*.

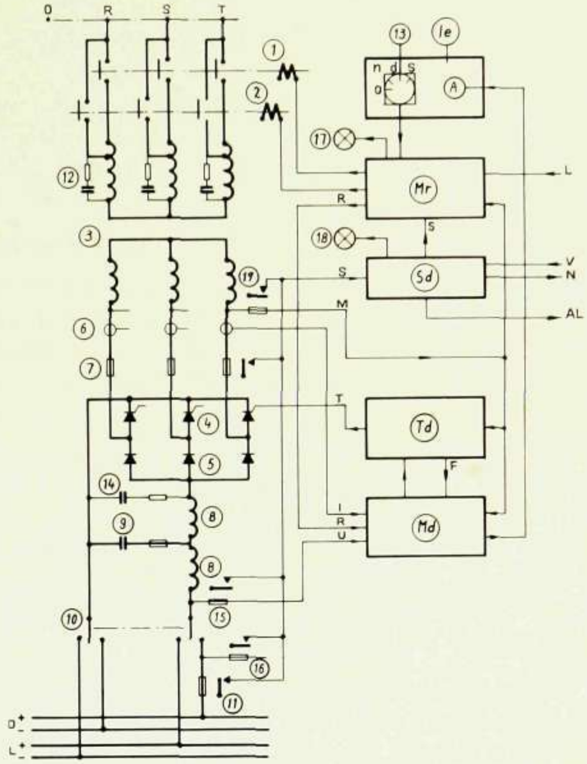
Rectifiers 48 V, 315 A and 160 A

In these units 2 × 3-pulse single-way rectifier connection is used. The main circuit contains one three-phase transformer, a rectifier connection consisting of six thyristors, and one interphase transformer. The design of the main circuit in other respects corresponds to that described for the 630 A rectifier. The control system, modes of operation and protection follow the same principles as for the 630 A rectifier.

Fig. 4

Block diagram for thyristor rectifier 48 V, 100 A

1, 2	Contactors
3	Transformer
4	Thyristors
5	Diodes
6	Current transformers
7	Fast acting fuses
8	Filter chokes
9	Filter capacitors
10	Switch
11	Output fuse
12	Voltage surge protection
13	Operating switch positions: n normal operation d operating charge s rapid charge
14	Protection against commutation spikes
15	Fuse — voltage sensing circuit
16	Fuse — monitory circuits
17	Operation lamp "charge"
18	Alarm lamps "mains failure" "contactor released"
19	Fuse — control circuits
Ie	Instrument unit
Mr	Monitory relay set
Sd	Protection
Td	Trigger pulse device
Md	Sensing unit
T	Trigger pulses
U	Voltage sensing
I	Current sensing
F	Feedback
M	Supply of control circuits
S	Shutdown
R	Preset control levels
L	Voltage increase command (automatic battery charging)
AL	Alarm, internal fault
N	Mains alarm
V	Shutdown from D. C. voltage monitor (high distribution voltage)
A	Ammeter



Rectifier 48 V, 100 A

The block diagram of the rectifier is shown in fig. 4. A cabinet containing two rectifiers is shown in fig. 5.

Main Circuit

The three-phase transformer (3) supplies the rectifier (4) and (5) in three-phase bridge connection. The primary of the transformer can be star- or delta-connected, so that the rectifier can be connected to two mains voltages (380 or 220 V as standard, other mains voltages on request). The rectifier connection consists of three thyristors (4) and three silicon diodes (5) (asymmetrical bridge). The trigger pulses to the thyristors are delivered at intervals of 120 electrical degrees. The ripple component has a fundamental frequency of 150 Hz. The block diagram in fig. 4 shows type *D*, i.e. for connection to a double busbar system and with extra mains contactor for increased charging voltage.

Control System

The rectifier contains a constant voltage regulator and a constant current regulator on the same principle as described for the 630 A rectifier.

Modes of Operation

The rectifier is supplied in two types as regards monitory circuits:

- With equipment for automatic parallel operation; in this case the modes of operation and the monitory circuits are as described for the 630 A rectifier.

- Without equipment for automatic parallel operation; the rectifier contains a simplified relay set. The following modes of operation can be selected with the operating switch: *normal operation*, *operating charge* (the rectifier voltage is raised to 2.35 V per cell), *rapid charge* (the rectifier voltage is raised 2.4—2.7 V per cell). In all positions the rectifier works with automatic voltage and current regulation. This latter type of monitory circuits is shown in the block diagram in fig. 4. (Several rectifiers of this type can naturally work in parallel.)

Protection, Alarms

The overload protection consists of a fuse (11) on the output side and the current limitation of the control system. The semiconductor cells in the rectifier connection are protected by means of fast acting fuses (7). Electromagnetic fuses for control circuits (19), monitory circuits (16) and voltage sensing circuit (15) disconnect the rectifier by means of their auxiliary contacts.

RC circuits (12) are used for voltage surge protection and power factor correction. Circuit (14) common to all phases is used as protection against commutation spikes.

Protection against abnormal mains voltage is reduced to an alarm on mains failure. The rectifier is not disconnected in such case. The protection can be supplemented by an external mains voltage monitor which disconnects the rectifier on mains failure, phase failure or low voltage on one or more phases. When the normal mains voltage returns, the rectifier starts without need for manual reset.

Other Functions

Automatic battery charging and "walk-in" are provided on the same principles as for the 630 A rectifier.

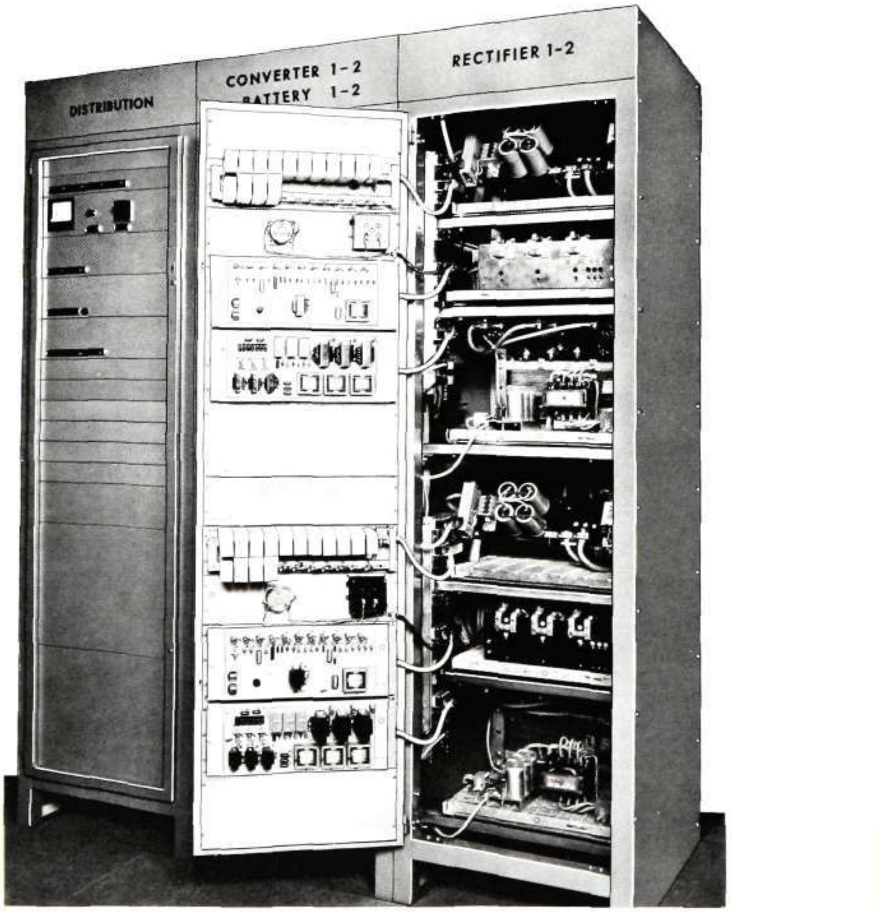


Fig. 5

Power supply plant with 2 thyristor rectifiers 48 V, 100 A, two series converters 7 V, 100 A, and distribution

Types of Equipment

The rectifiers are supplied in four types as regards the form of the main circuit, as described for the 630 A rectifier.

Mechanical Design

A cabinet 600 mm wide, 2200 mm high and 800 mm deep accommodates two rectifiers (fig. 5) or one rectifier and other apparatus. The cabinet has an openable front, so that it can be placed against a wall.

The rectifier consists of three grating units (mains unit, rectifier unit and filter unit). Instrument unit, monitory relay set, sensing unit and trigger pulse device are placed on the hinged front. On the front of the door are placed an operating switch, an ammeter and three signal lamps.

Rectifiers 48 V, 63 A and 40 A

The design of these rectifiers is similar to that of the 100 A rectifier.

Single-Phase Rectifiers 48 V, 6.3—25 A

These rectifiers usually work in unattended exchanges and their equipment has been adapted to this purpose. The block diagram will be seen from fig. 6.

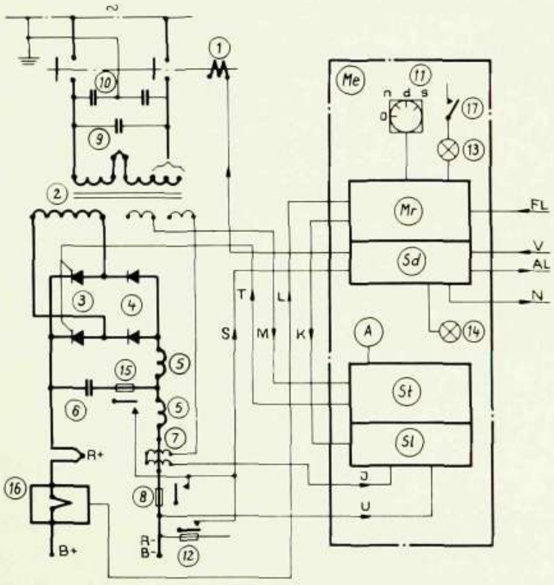


Fig. 6

Block diagram for single-phase rectifier 48 V, 6.3—25 A

1	Contactor
2	Transformer
3	Thyristors
4	Diodes
5	Filter chokes
6	Filter capacitors
7	Measuring transductor
8	Output fuse
9	Voltage surge protection
10	Radio interference suppressor
11	Operating switch positions: n normal operation d operating charge s rapid charge
12	Fuse — monitory circuits
13	Operation lamps "in operation" "charge"
14	Alarm lamps "mains alarm" "fault in rectifier"
15	Filter fuses
16	Device for automatic battery charging
17	Circuit-breaker for signal lamps
Me	Operating unit
Mr	Relay set
Sd	Protection
St	Control unit
SL	Level setting unit
B+,B-	Connection of battery
R+,R-	Connection of distribution
T	Trigger pulses
U	Voltage sensing
I	Current sensing
M	Supply of control circuits
S	Shutdown
K	Preset control levels
AL	Alarm, fault in rectifier
N	Mains alarm
V	Shutdown from D.C. monitor (high distribution voltage)
L	Voltage increase command (automatic battery charging)
FL	Remote-controlled battery charge
A	Ammeter

Fig. 7
Control unit for single-phase thyristor rectifier 48 V, 6.3—25 A
(voltage and current regulator and trigger pulse device)

Main Circuit

The rectifier is connected to the single-phase mains supply via the contactor (1). The primary of the main transformer (2) has tappings for connection to different mains voltages: 110 V, 190 V, 208 V and 220 V. Capacitor (9) provides power factor correction. The rectifier connection consists of two thyristors (3) and two silicon diodes (4) in single-phase bridge (asymmetrical bridge). The smoothing filter consists of two chokes (5) and an electrolytic capacitor bank (6).

Control System

The rectifier contains a constant voltage and a constant current regulator. Regulation is effected by means of change of the trigger phase angle in the thyristors. The voltage is measured with a resistive voltage divider and the current with a measuring transductor (7).

A transistorized control unit in the form of a printed board assembly (fig. 7) comprises a regulator and trigger pulse device. A temperature-compensated zener diode is used as reference voltage. Difference between actual and reference value (error) is fed to the input of a differential amplifier. The amplifier output controls a relaxation oscillator consisting of a capacitor and a double-base diode (unijunction transistor). The latter delivers phase-angle-modulated trigger pulses for turn-on of the thyristors. A bistable flip-flop and separate relaxation oscillator are used for converting the phase-angle-modulated pulse into a pulse train with a frequency of abuot 1 kHz. This pulse shape has proved to be the most advantageous for ensuring reliable turn-on at low power consumption. A derivative feedback is used in the control amplifier to ensure stability of the system. The control unit also has a built-in "walk-in" function. Power supply of the control unit and measuring transductor takes place from separate windings of the main transformer. The control unit functions reliably under heavily varying mains voltage conditions.

Modes of Operation

Three modes of operation can be selected with the operating switch (11): *normal operation*, *operating charge* (the rectifier output is raised to 2.35 V per cell) and *rapid charge* (the output is raised to 2.4—2.7 V per cell). In all positions the rectifier works with automatic voltage and current regulation. Potentiometers for setting of voltage and current control levels are collected on a printed board assembly (level setting unit S1) beside the trigger device.

The rectifier is equipped with a device for automatic battery charging (16). This consists of a reed relay which is passed by current in the battery circuit. The rectifier is connected to operating charge or normal level depending on whether the current to the battery is above or below a preset value. Change to operating charge can also be remotely controlled from a superior exchange.

Protection, Alarms

Fuses with auxiliary contacts are used on the output side of the rectifier (8) for monitory circuits (12) and for filter capacitors (15). Blowing of a fuse disconnects the rectifier. The rectifier has a current limiting device similarly to the three-phase type.

Voltage surge protection is provided by the power factor correction capacitor (9) on the primary side of the main transformer. The radio interference suppressor (10) prevents high frequency voltages, which may be generated on turning on of the thyristors, from extending into the supplying network. Protection against too high a distribution voltage is provided by a separate D.C. voltage monitor, which disconnects the rectifier. Alarm is issued in the event of a fault in a rectifier and of mains failure.

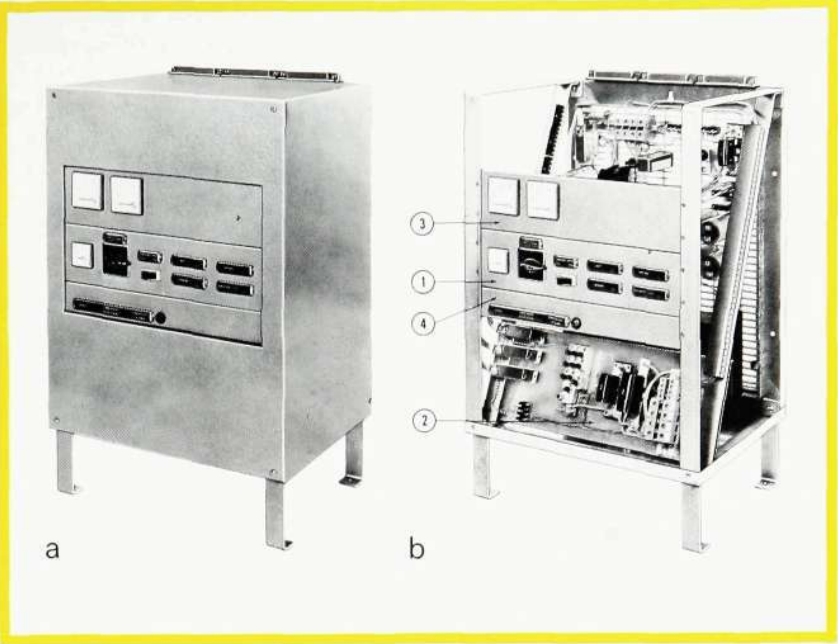


Fig. 8

Power supply equipment with one thyristor rectifier 48 V, 16 A, and distribution

- a With cover
- b With cover removed
- 1 Rectifier operating unit
- 2 Distribution unit
- 3 Instrument unit for distribution
- 4 Voltage control unit for distribution

Mechanical Design

The rectifiers are often supplemented by other equipment to form a complete power plant within the same mechanical unit. The aim in the mechanical design was to permit different plant combinations out of easily assembled units according to special desires.

Fig. 8 shows the complete plant consisting of a 48 V, 16 A rectifier and the following auxiliary units; distribution unit, instrument unit for distribution, voltage control unit for distribution.

The mechanical structure consisting of wall frame, brackets and cover is adapted for wall or floor mounting. For floor mounting floor brackets are required in addition. The main circuit components, placed on a grating, are fastened to the wall frame. Control unit, relay set, operating switch, ammeter and signal lamps are gathered on one mechanical unit — operating unit — which is placed on brackets on the front of the cabinet. The units are interconnected by plug and jack. The equipment casing consists of a removable cover.

The table on the following page contains technical data for the three types described.

Device for Automatic Parallel Operation

This device is used in large rectifier plants with varying loads. The device ensures very rational operation by adapting the number of operating rectifiers to the actual current demand and by distributing the load in a suitable manner. The advantages gained by these means are an essential saving of energy and longer life of the equipment.

Pilot and Step-Connected Rectifiers

Rectifiers used in automatic parallel operation can work in two ways: as pilot or step-connected rectifiers. Only one rectifier at a time works as pilot rectifier while all others work as step-connected. The pilot rectifier remains constantly in circuit and its voltage regulator maintains a constant D.C. voltage in the exchange. At constant voltage the battery current remains constant: all change of load in the telephone exchange then causes a corresponding change of load on the pilot rectifier, which thus follows the variation in load.

A step-connected rectifier is connected into circuit only during the time required by the load. Its connection is controlled by step-in pulses. On the first step-in pulse the rectifier contactor is connected into circuit on the A.C. side; at the same time the rectifier is loaded with a constant current equal to 25 % of the rated current ("first step"). At the next step-in pulse the current increases to 50 % ("second step"), thereafter to 75 % and 100 % respectively of the rated current.

Unloading of a step-connected rectifier takes place in a similar manner in four steps through step-out pulses. When the first step (0.25 $I_=$) is disconnected, the rectifier on the A.C. side is switched out of circuit.

Technical data for thyristor rectifiers

Rated voltage $U_=$ Rated current $I_=$	V A	48 630	48 100	48 16	Remarks
Rectifier connection		4 × three-pulse, singleway (12-phase star with three interphase transformers)	Six-pulse, double-way (asymmetrical three-phase bridge)	Two-pulse, double-way (asymmetrical single-phase bridge)	
Number of trigger pulses per cycle		12	3	2	
Mains voltage	V	380 three-phase	tappings for 380 or 220 three-phase	tappings for 220, 208, 190, 110 single-phase	1)
Permissible mains voltage variations	%	—20 to +10	—20 to +10	—20 to +10	
Mains frequency	Hz	50 or 60	50 or 60	50 or 60	2)
Permissible mains frequency variations	Hz	45—65	45—65	45—65	
Static regulation					
accuracy of regulation					
at load variation	%	1—100	3—100	0—100	
and mains variation + 10 % — 10 %	%	± 0.5	± 0.5	±0.5	
+ 10 % — 15 %	%	± 1	± 0.7	± 0.7	
+ 10 % — 20 %	%	± 2	± 1	± 1	
Dynamic regulation					
transient voltage deviation max.	V	1	1	1	3)
response time max.	ms	25	50	100	4)
Noise voltage					
psophometric value max.	mV	1	1	1	5)
Efficiency and power factor		η cos φ	η cos φ	η cos φ	
at 1/4 rated load	—	0.88 0.78	0.81 0.83	0.80 0.98	6)
,, 2/4 ,, ,,	—	0.89 0.82	0.87 0.83	0.855 0.93	
,, 3/4 ,, ,,	—	0.90 0.82	0.88 0.83	0.87 0.87	
,, 4/4 ,, ,,	—	0.895 0.83	0.87 0.84	0.87 0.80	
Voltage level, normal operation, adjustable between	V	48—52	48—52	43—56	
Voltage level during charge, adjustable between	V	54—58	54—58	53—65	
in the type with increased charging voltage adjustable up to	V	65	65	—	
Current limitation adjustable between	%	10—110	10—110	10—110	
Permissible ambient temperature					
operation	°C	0 to +45	0 to +45	0 to +45	
non-destructive	°C	—10 to +55	—10 to +55	—10 to +55	
Dimensions					
width	mm	800	600	538	
height	mm	2200	900	722	
depth	mm	800	800	398	
Weight	kg	950	270	60	

1) For other mains voltages on request.
2) No switching required.
3) Under conditions of: a) parallel operation with battery the capacity of which in Ah is 4 × rated current $I_=$, b) step change of load with 25 % rated load.
4) Time required for the transient deviation to decrease to 1 %, i.e. to the static regulation band.
5) In parallel operation with battery according to 3a.
6) At nominal input voltage, in warm condition.

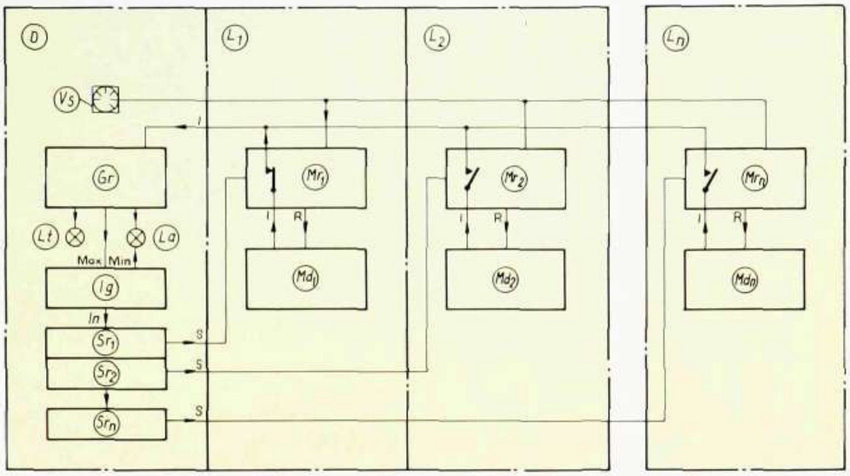


Fig. 9

Block diagram of equipment for automatic parallel operation of rectifiers

D	Distribution rack
L_1	Rectifier – pilot
$L_2 \dots L_n$	" – step-connected
Vs	Selection of pilot rectifier
Gr	Limit relay
Ig	Pulse sender
Sr_1 $Sr_2 \dots Sr_n$	Stepping relay set for rect. 1, 2...n
Mr_1 $Mr_2 \dots Mr_n$	Monitory relay set in rect. 1, 2...n
Md_1 $Md_2 \dots Md_n$	Sensing unit in rect. 1, 2 . . . n
Max., Min.	"Max." and "Min." pulses
In	Step-in and step-out pulses
S	Control of step-connected rectifiers
I	Load sensing in pilot rectifier
R	Preset control levels
La	Alarm lamps "max. load" "limit relay failure"
Lt	Operation lamps "max. pulse" "min. pulse"

Limit Relay and Pulse Sender

The control device for step-connection consists of two transistorized units: a limit relay and a pulse sender (fig. 9). The limit relay (Gr) is connected to the secondary winding of current transformers in the pilot rectifier. The relay supervises the load of this rectifier. When the load exceeds 0.75 $I_{=}$ a "Max." signal is delivered, and when the load falls below 0.25 $I_{=}$ a "Min." signal. Current sensing takes place by means of two differential amplifiers with a reed relay on each output.

The "Max" or "Min" signal starts the pulse sender, which then delivers step-in or step-out pulses at 3 s intervals. The pulses are sent as long as the "Max" or "Min" signal from the limit relay persists. The pulse sender (Ig) consists of a relaxation oscillator and a bistable flip-flop.

Control of Step-Connected Rectifiers

For an exchange with, for example, four rectifiers, of which rectifier (L_1) works as pilot rectifier, the sequence of step-in will be as follows: rectifier (L_2) step 1, 2, 3 ; (L_3) step 1, 2, 3 ; (L_4) step 1, 2, 3, 4 ; (L_3) step 4 ; (L_2) step 4. The fourth step is thus used only when all rectifiers have been loaded to 75 %. Connection of the fourth step takes place in the reverse order in relation to steps 1—3. Step-out takes place in the reverse order to step-in.

Selection of Pilot Rectifier

Any of the rectifiers can be selected as pilot rectifier. The selection is made with a switch on the distribution rack. At the same time the sequence of connection for the step-connected rectifier is determined. If, for example, rectifier (L_3) is selected as pilot rectifier, the sequence of connection will be (L_4), (L_5), . . . , (L_n), (L_1), (L_2). If any of the rectifiers has not been set to "Aut" operation mode or has been disconnected by its protective device, the step-in pulse goes directly to the next rectifier in the chain.

Standby for Pilot Rectifier

If the pilot rectifier drops out, owing to an internal fault, its function is taken over by the next rectifier in the chain. This takes place irrespective of whether the latter has been in operation as step-connected rectifier or not. The loss of the pilot rectifier thus causes no other disturbance than a corresponding reduction of the available power. When the fault in the pilot rectifier has been repaired, it resumes its function as pilot rectifier automatically.

Load on Rectifiers after Mains Filure

On a mains failure all stepping relays release. When the A.C. voltage returns, step-in takes place again with the number of steps corresponding to the actual load. If the standby power set is of limited power, an auxiliary unit can be added which permits only a limited number of steps to be switched into circuit.

Alarms

Alarm is issued when a step-in pulse is sent while all available steps are utilized ("Max load") and in the case of a fault in the limit relay. "Max" and "Min" signals from the limit relay are indicated on lamps on the distribution rack.

Mechanical Design

The equipment for parallel operation with step connection consists of the following units (fig. 10):

- *Limit relay and pulse sender.* These are assembled on printed boards and placed in a relay set in the distribution cabinet.
- *Stepping relay sets.* For every rectifier one stepping relay set is installed, consisting of six relays. Two of the relays indicate the mode of operation of the rectifier (pilot, step-connected, not in automatic parallel operation). The four other relays build a stepping relay chain which controls the step connection. Stepping relay sets are connected to a jack strip in the distribution rack. The jack strip is delivered in units corresponding to four rectifiers. For extension of the exchange the jack strip can be easily supplemented by additional units and the stepping relay sets can be installed as and when required.

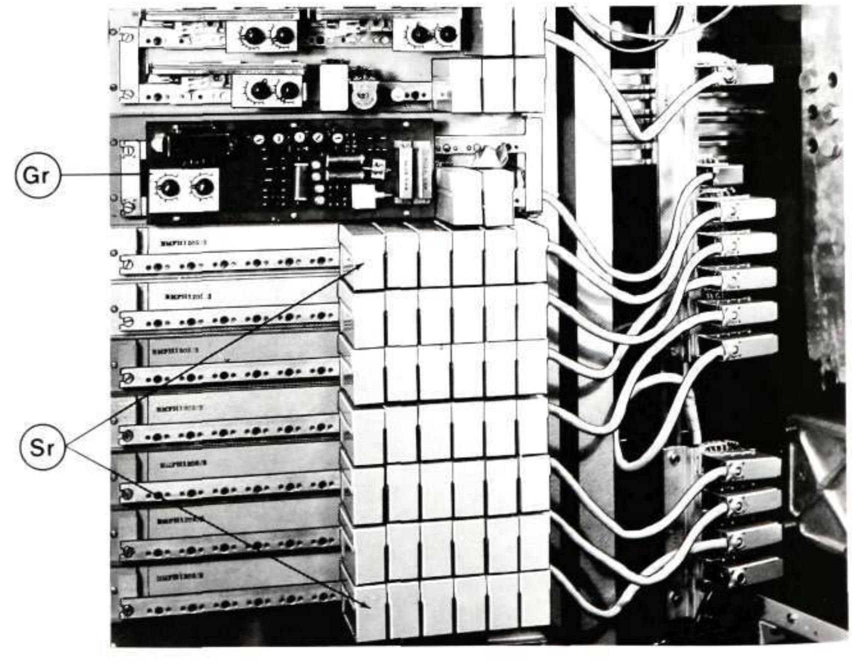


Fig. 10

Equipment for automatic parallel operation of 7 thyristor rectifiers

Gr Limit relay
Sr Stepping relay sets for 7 rectifiers

Automatic Parallel Operation—summary

In comparison with the mode of operation with rectifiers constantly in circuit, parallel operation with step connection offers the following advantages:

- Since the number of operative rectifiers corresponds to the actual load, idle losses are eliminated and the total efficiency of the plant is raised. Under average conditions the saving of energy is of the order of 5 %.

- Step-connected rectifiers are used only during a fraction of the 24 hours; their useful life increases correspondingly.

- In the case of operation with rectifiers constantly in circuit the load distribution is indeterminate and depends on small differences in the output voltage characteristics. In the case of operation with step connection the load distribution is uniquely determined and can be arranged in the most efficient manner.

- All rectifiers are loaded to 75 % before the last step is used. As long as the installed power of the rectifiers exceeds the peak consumption of the exchange by at least 25 %, no rectifier is ever fully loaded. Thermal stresses are reduced, which also contributes to longer life.

The method of step connection requires an extra relay equipment. This is very simple, however, and its cost is quickly paid off through the saving of energy.

Final Remarks

The characteristic features of L M Ericsson's thyristor-controlled rectifiers may be summarized as follows.

They have been designed for the specific demands applying to the power supply of telecommunication plants. They deliver an accurately regulated D.C. voltage at low noise level and low transients. They are adopted to severe ambient conditions such as poor quality commercial power with heavily varying voltage and frequency, frequent mains failures, or large temperature fluctuations. They ensure rational operation in respect of energy consumption, load distribution and freedom from maintenance. An important feature of the rectifiers described is their equipment for supervision and control. This equipment permits automatic operation under all operational conditions, such as recharging of batteries after mains failure, change from primary to standby power supply and vice versa, switching to standby units in the event of an equipment fault etc. The rectifiers are designed for operation in a fully automatic power system, which can be used among other purposes for the supply of unattended exchanges.

References

1. LJUNGBLOM, A.: *L M Ericsson Power Supply Systems for Telecommunication Equipments.* Ericsson Rev. *45*(1968): 4, pp. 142—162.

The Use of Dynamic Programming for Planning of Extensions of Conduits and Main Cable Networks in a Local Exchange Area

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Earlier articles in Ericsson Review and Ericsson Technics have presented principles for long-term planning as regards the division of a multiexchange network into exchange areas, the distribution of traffic between future exchanges, and the structure of the junction network.

The object of this and coming articles is to devote attention to impending extension requirements and to calculate and specify the extensions on the basis of forecasts of the growth of demand having regard to the capacity of existing plant.

The present article shows how economical stages of extension for conduits and main cable networks are determined and how a specification of the extensions to be undertaken year by year is obtained. This is done with a computer using dynamic programming.*

Plannings Methods

For the planning of telephone networks we adopt two procedures, of which the first forms a framework for the second.

- *Cross-sectional studies*, which show the most economical network at a future point of time. A cross-sectional study is generally a long-term plan with the aim of providing a framework for long-term investments and a check that decisions covering short periods are consistent with long-term objectives. This plan is *static* in the sense that it does not recognize the time-value of money and that only limited attention is paid to existing plant.
- *Development studies*, which show the size and the point of time for future extensions having regard to the development of the subscribers' demand and of traffic and existing plant. This plan is *dynamic* in the sense that it recognizes the time-value of money and that it determines the additions to plant in such a way that the sum of the present values of outlays over a given planning period is as small as possible. This plan provides a specification of the extensions to be made every year, 0, 1, 2, ... A dynamic study

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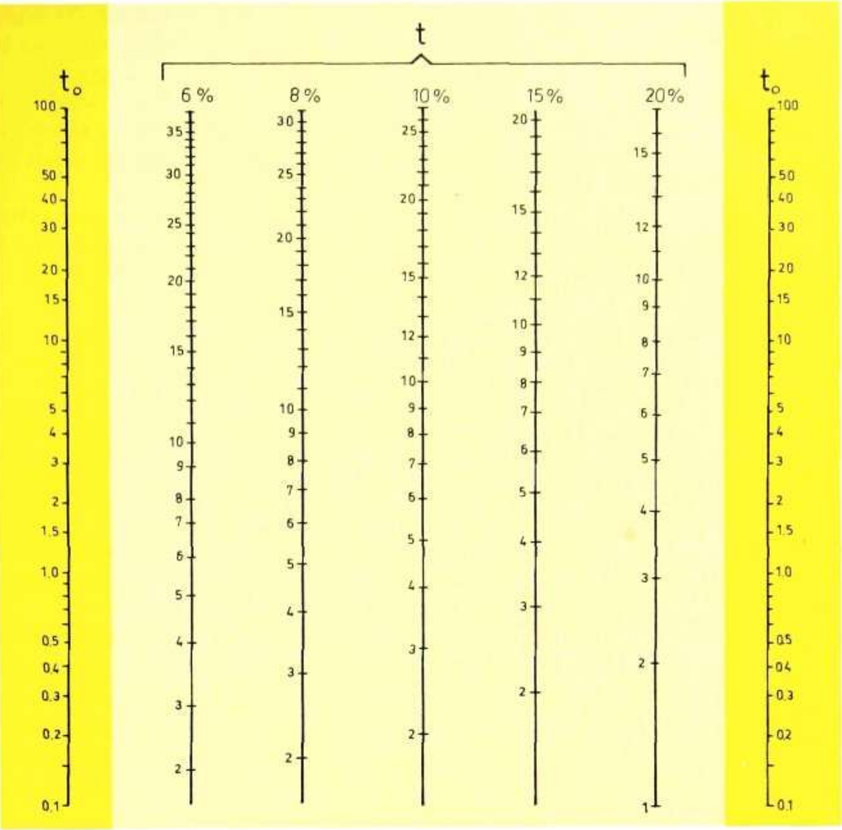
* A revised and extended account of a paper read at "IV Seminario de Telecomunicaciones y Telecontrol", Mexico D.F., in November 1968.

Fig. 1.

Extension period t as function $t_0 = a/bc$ at a rate of interest of 6, 8, 10, 15 and 20 %

a = basic cost for the cable (cost per metre of length)
b = marginal cost (cost per pair-metre)
c = annual growth of demand (pairs per annum)



forms a bridge between the long-term and short-term plans. The short-term plan generally covers a period of 2–5 years and is concrete and detailed. It must specify all material used and contain a time schedule for execution of the work. This plan relates chiefly to the organization of the work and will not be dealt with here.

Retrospect

The principles for extension of plant in economical stages on the assumption of linear growth of demand have been known for a long time (see, for example, Ericsson Review No. 4, 1939). This assumption and the observation that the cost of a cable, for example, can be represented with great accuracy by a linear function

$$a + bn \tag{1}$$

where n is the number of pairs in the cable, implies that the time and size of the stages which yield a minimum present value of future costs can be calculated as a function of the quotient

$$t_0 = \frac{a}{bc} \tag{2}$$

where

a = basic cost for the cable (cost per metre of length)
b = marginal cost (cost per pair-metre)
c = annual growth of demand (pairs per annum)

Fig. 1 shows the *economical extension or provision period*, i.e. the period between two successive extensions, as a function of the quotient a/bc at a rate of interest of 6, 8, 10, 15 and 20 %. The size of the extension stages is obtained by multiplying the extension period by the annual growth of demand c.

The same method can be used if one wishes to establish the stage of extension for a main cable run in which the cables are branched to cross-connection points (cabinets) and tapered down into diminishing numbers of pairs.

The stages for extension of a system of cables of this kind can be obtained from fig. 1 by replacing the growth of demand, c, in eq. (2) by a weighted mean value

$$c_m = \frac{\sum_\nu c_\nu \, l_\nu}{\sum_\nu l_\nu} \tag{3}$$

where

l_ν = length of a cable run ($\nu = 1, 2 \ldots$)
c_ν = growth of demand in a cable run per annum ($\nu = 1, 2 \ldots$)

The growth of demand in a given run, c, is manifestly obtained by adding the growth of demand in all cabinets supplied with cables on that run.

Calculations of this kind provide guidance in establishing the stages of extension for a main cable network, especially as the cost minimum, as in most problems concerning the economic optimum, is flat, and one can therefore vary the extensions within fairly wide limits without changing the costs by more than a per cent or so. For the same reason the requirements of accuracy of the forecast need not be so strict (see fig. 2, called "The case of the obstinate planner").

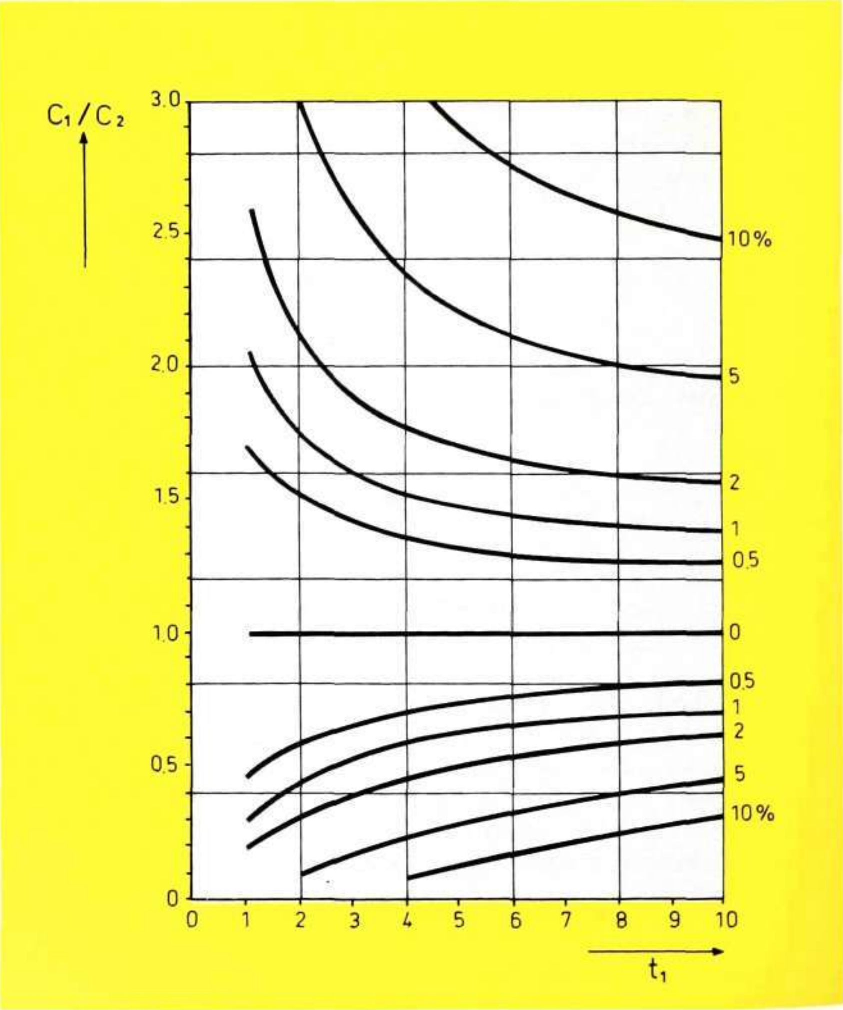


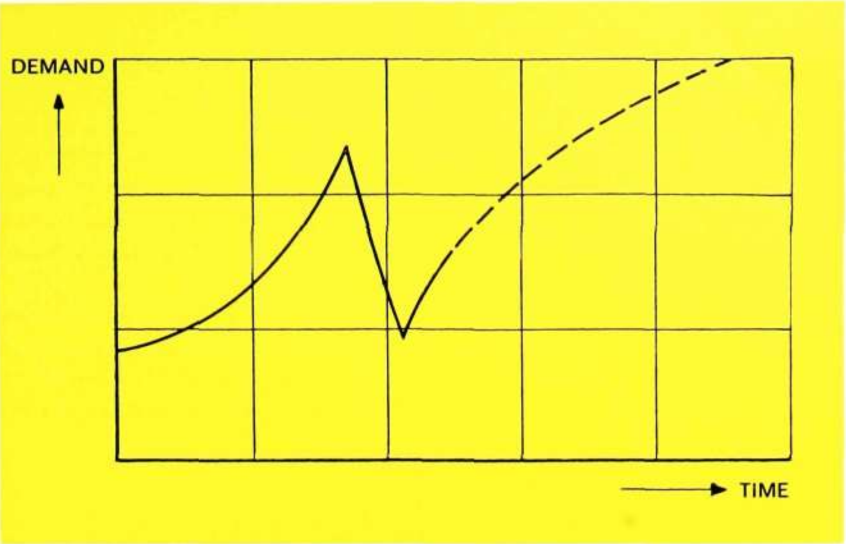
Fig. 2.
"The case of the obstinate planner"

Theoretical example of the requirements which should be placed on the accuracy of the forecast without the cost exceeding the optimal by more than 0.5, 1, 2, 5 and 10 %

Plan horizon $T = \infty$
Rate of interest 10 %
t_1 = extension period for growth of demand c_1 pairs/annum
t_2 = extension period for growth of demand c_2 pairs/annum

The real growth of demand is c_2 pairs/annum but the extension period is nevertheless determined on the basis of another growth of demand c_1 pairs per annum. One sees that the longer the extension periods, the stricter must be the requirements placed on forecasts, which is obviously contrary to what can be attained.

Fig. 3.
Possible development of demand in a cable run



Improvements

Thanks to the development of the computer technique it is possible to improve the calculation of economical stages of extension in two important respects:

☐ The calculation will be exact and one can therefore be sure of attaining the best possible result.

☐ The output from the computer provides a specification of the work to be done year by year, which is of value when ordering materials and for maintaining time schedules in the installation work.

As regards the calculations it is worth observing the following points:

- The development of the demand need not be assumed to be linear. It may be progressive or degressive and in some cases there may be a reduction of the demand for circuits on a cable run (fig. 3).
- Attention is paid to the fact that additions to cabinets do not take place at one time but at different times according to the number of existing and utilized pairs and the growth of the demand.
- The stages of extension are selected having regard to existing standard types of cables and cable runs. The stages obtained from fig. 1, for example, must be rounded off upwards or downwards.
- The stages of extension are determined so that the *sum* of the present values of the costs for cables and conduit is as small as possible.
- It is easy to carry out calculations under different assumptions in respect of the growth of demand, standard types of cables, and rate of interest. Especially as regards the growth of demand this is of significance as it is not generally possible to estimate the growth even fairly exactly within such small areas as a cross-connection area for a longer period than about 5 years. Estimates for longer periods will therefore often be more or less guesses, which however may be of valuable guidance in determining the extensions during the coming years. As soon as the plant approaches saturation in any period, it is time to draw up new calculations on the basis of new and improved forecasts.

The Problem

The methods described in the sequel result in a specification of the additions to be made to conduits and cables in an exchange area at different points of time ($t = 0, 1, 2 \ldots$). They do not, however, embrace the entire subscriber line network but only the part in which cables are laid in conduit and are connected to cabinets or feed points. In the sequel this part of the network will be called the main cable network and, as cabinets and feed points are equivalent from the calculating point of view, we shall speak solely of cabinets.

Through secondary cables connected at distribution points every cabinet supplies a given area called a cross-connection area, and from the distribution points the subscribers are connected to lead-in wires. As already mentioned, a specification of these parts of the network is not included in the calculations.

Requisite Data

The planning of conduit and main cable network as defined above is based on the following data:

- plans of existing and planned conduit runs
- number of free duct-ways in each individual conduit run
- number of cabinet pairs connected from the exchange
- spares at branching points in the runs
- cost of different standard types of ducts and cables
- cost of terminals, i.e. boxes in cabinets and cross-connections
- forecasts of the subscriber development per cabinet
- rate of interest.

Planning Period, Plan Horizon and Extension Periods

The investigation is carried out for a given limited *planning period*, 0–T, where T is the *plan horizon*. The planning period should cover 25–40 years since conduit must usually be constructed to cover the requirements during a long period. The planning period is divided into a number of *calculation intervals* of, for example, 1 year. Up to the plan horizon T a number of *extension periods*

$$0 \rightarrow t_1, t_1 \rightarrow t_2, \ldots, t_{n-1} \rightarrow T \qquad (4)$$

must be determined such that the sum of the present values of the costs of extension of conduit and main cable network is as small as possible. A determination of the extension periods thus implies a determination of the number of extension periods, n, and their length

$$t_1, t_2 - t_1, \ldots, T - t_{n-1} \qquad (5)$$

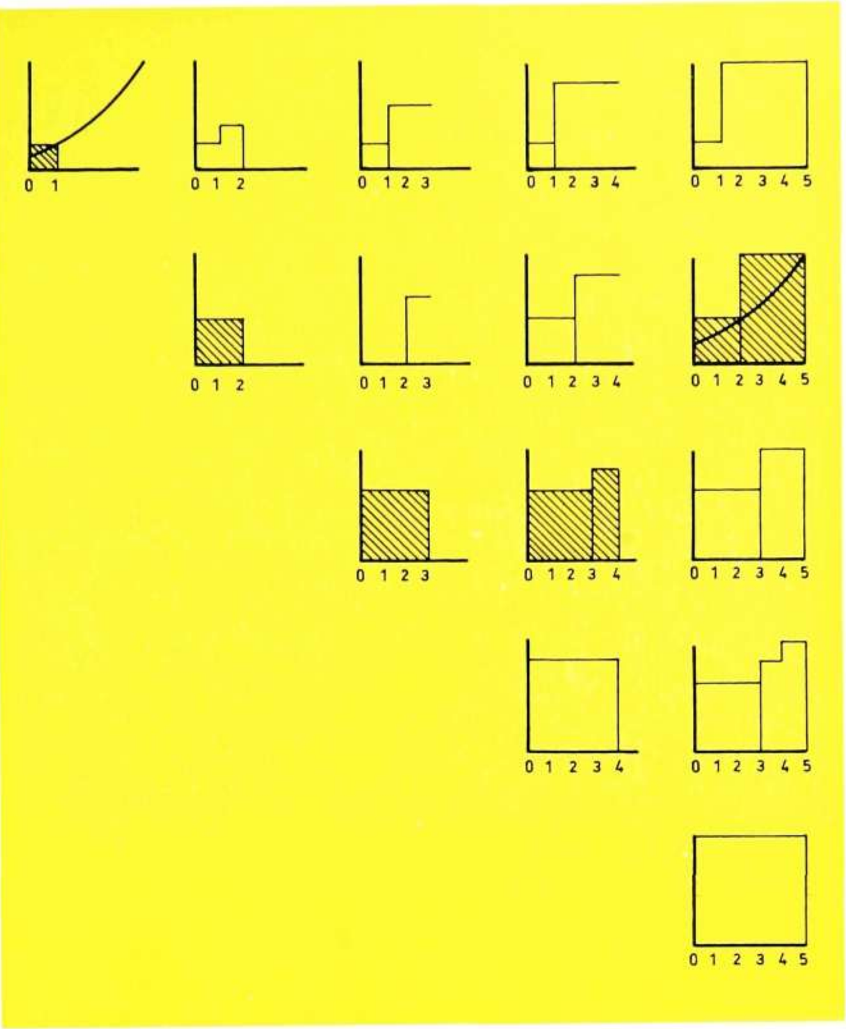
The length of an extension period and forecasts of the subscriber development determine the number of cable pairs to be installed on a cable run as soon as a need for extension arises. These cable pairs are then connected to the cabinets as required during the extension period.

The number of cabinets concerned during an extension period manifestly increases with the length of the period.

Fig. 4.

Illustration of procedure for calculation of economical periods of extension on the basis of eq. (6).

Shaded surfaces correspond to minimum extension or provision costs.



Dynamic Programming

The calculations are carried out on a computer using dynamic programming. The method is an application of the principle of optimality formulated by R. Bellman

> *"Principle of Optimality. An optimal policy has the property that whatever the initial state and initial decision are the remaining decisions must constitute an optimal policy with regard to the state resulting from the first solution"*

and will first be illustrated by a simple case.

Assume that the extension periods for a telephone exchange are to be determined. The costs of an extension consist of a basic cost, administration, travel to installation site, etc., which are independent of the number of installed units, and a cost which is dependent on the number of installed units. The need of lines every year $t = 0, 1, 2, \ldots, T$ is estimated.

The economical extension periods are determined by the following chain of reasoning.

If the plan horizon is 1 year, there is only one way of making the extension, namely for the demand after one year. If the plan horizon is $T = 2$, one can either extend for one year at a time or for two years at a time.

For $T = 3$ years there are four possibilities of extension, but only three additional cases need be examined since, after the preceding calculations, the best method of extending for $T = 2$ has already been decided.

For $T = 4$ years there are eight possibilities of extension, but only four of them need be investigated since one already knows the best method of extension for $T = 2$ and $T = 3$.

Fig. 4 illustrates the calculations for a planning period of $T = 5$ years with calculation interval one year. Mathematically the calculations are described by

$$N(0t) = \min \, [\min_{0 \leq x < t} N(0x) + N(xt)] \qquad (t = 1, 2, \ldots, T) \tag{6}$$

where

$N(0t)$ = present value of extensions during the period 0–t
$N(0x)$ = present value of extensions during the period 0–x
$N(xt)$ = present value of extensions during the period x–t

This method of calculating the stages of extension leads to a great reduction in the required number of calculations compared with examining all theoretical possibilities one by one. This is clearly apparent from the following table.

Number of calculation intervals	Number of calculations	
	Dynamic programming	Theoretical possibilities
10	55	512
20	210	524,288
30	465	2^{29}
40	820	2^{39}

Optimum of Costs for Main Cable Network and Conduits

If the number of duct-ways in the conduit is sufficiently large, or if tunnels or armoured cables are used in the main cable network, the method described above, which is very rapid, can be used with advantage.

But if an extension of the conduits is required during the planning period, the problem becomes more complex. In such case the extensions for main cable network and conduits must be determined such that the sum of the present values of extensions for both these installation units is as small as possible.

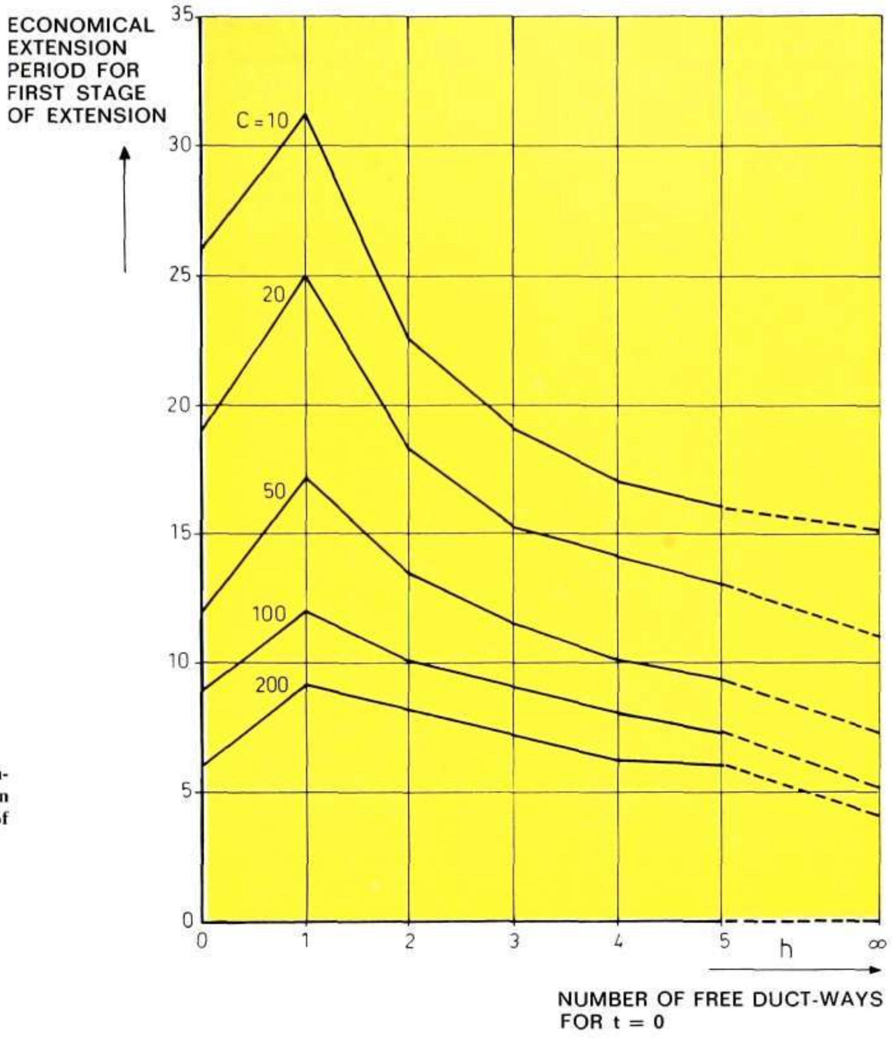


Fig. 5.

Theoretical example of economical extension period for first stage of extension on a cable run as function of the number of free duct-ways *h* in the run

Plan horizon $T = \infty$
Linear growth of demand $c = 10, 20, 50, 100, 200$
Cables and ducts of arbitrary size

If there are few free duct-ways in the network they should manifestly be used in an economic manner. This leads to a certain, sometimes fairly large, increase in the time that one or more extension should cover. This is illustrated in fig. 5 on the simplified assumption that the growth of demand is linear, the plan horizon $T = \infty$, and that cables and ducts are of arbitrary size.

One sees from the figure that if, for example, a single free duct-way exists on a cable run, the extension period must be at least doubled compared with the case of an adequate number of duct-ways.

A suitable increase in the periods of extension for the cables thus leads to an increase in the costs for cables and decrease in the costs for extension of conduit such that the sum of the present values is as small as possible.

To arrive at an economic optimum of the total cost it is advisable to introduce an increment on the basic cost for cables and thence to calculate the time and size of stepwise extensions of main cable network and conduits. On the basis of these figures the total present value of the series of expenditures is calculated. The most economical extension is obtained for the value of the increment which yields the minimum present value.

The table below shows by way of example the result of an investigated network. If no account is taken of conduit, the network, as is seen, must be extended in 11 periods. Taking conduit into account, the number of periods can be reduced to 8. In such case the cost are reduced by about 10 %.

Increment (factor by which the basic cost for cables must be multiplied)	Number of extension periods. Plan horizon 30 years	Present value of cost
1.00	11	559
1.20	9	524
1.40	8	503
1.60	8	503
1.80	7	504

Data Processing

In the planning of conduit run one starts with a plan of existing and planned runs (fig. 6) in which the branching points are numbered 1, 2 . . . and the cabinets (feed points) 101, 102 . . .

The *input data specification* must contain

- Cost of standard cables, standard ducts and terminals
- Rate of interest
- Plan horizon
- Forecast tables for the growth of the demand in cabinets

Example

Cabinet	Year	Need
109	0	180
	5	450
	10	600
	10	510
	20	570
	30	570

- A cable run matrix containing the following data:

Example

Primary point	Secondary point	Length of run m	Pairs connected in cabinet at t=0	Spares at branching pont at t=0	Free duct-ways at t=0
⋮	⋮				
13	11	340		100	2
⋮	⋮	⋮			
10	108	510	0		−2
10	109	150	200		1

The run 10–108 has not been constructed at $t = 0$. Usually one duct-way is reserved for distribution cables and one for cable replacements, hence the figure –2 in the column of free duct-ways. For determination of the number of free duct-ways in the main run (1–2–3–8–, see fig. 6) account is also taken of the fact that a number of duct-ways are required for junction cables, carrier systems etc.

The need can be indicated at arbitrary points of time. The programme interpolates the demand for intermediate years.

The output data specification gives

- The length of extension periods
- A detailed specification of the cables and conduit to be installed every year on different runs.

Example

Main cable network year 0				Terminals	
Run	Length	Number of pairs	Cable cost	Number	Cost
.	.	.	.	.	.
.	.	.	.	.	.
.	.	.	.	.	.
10–109	150	300	3759	300	6000
.	.	.	.	.	.
.	.	.	.	.	.
.	.	.	.	.	.

Conduit. Year 5

Run	Length	Type	Conduit cost
10–108	510	4	35,904

- A summary of the installation costs and present values during the planning periods.

Usually one is content with a detailed specification for the extensions to be made during the first period of extension and a summary survey of the amounts to be invested during the entire planning period. As soon as a new

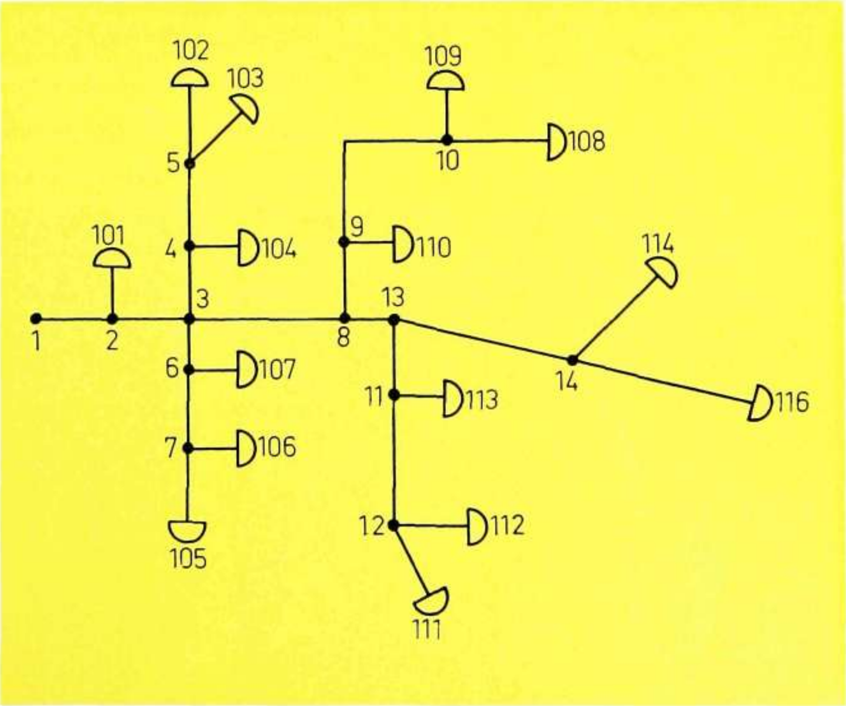


Fig 6
Example of cable run in conduit

need for extension approaches, it is time to make a new calculation for the next stage of extension, using an improved forecast and possibly changed cost data.

If the new forecast shows a very much higher growth of demand than that on which the earlier extension of the conduit was calculated, one should investigate whether it pays to replace small capacity cables by larger cables instead of extending the conduit. This can be done by introducing changes in the input data specification as regards the demand and the pairs connected in the cabinets concerned. A correction for the value of dismantled cable, if any, can thereafter be introduced manually.

In practice one should use at least two tables of the growth of demand, one "optimistic" and one "pessimistic". In drawing up these tables one should take into account that the uncertainty of forecasts grows with time and is greatest for areas where reconstruction and new construction may be expected. Such calculations often yield different results as regards the extensions to be made immediately or during the next few years. The final decision is arrived at through a subjective evaluation of the probability for the various alternative forecasts.

Summary

The present article is intended to show how, through the use of dynamic programming, the calculation of extensions of conduit and main cables within an exchange area can be rationalized. The calculations, which are made on a computer, have the following advantages:

☐ Starting from a given forecast an exact result is obtained. It is easy to carry out calculations under different assumptions as regards the growth of demand, rate of interest, and standard types of cables and conduit.

☐ A detailed specification is obtained of the extensions to be made every year, which is of significance for ordering of materials and for installation programmes.

☐ Finally one obtains a budget of the amounts to be invested every year in installations in the networks, which facilitates the drawing up of financial calculations.

The programming for the computer was done by R. Sjögren.

ERICSSON News

from All Quarters of the World

Stored Programme Controlled Systems Theme at 10th Maintenance Conference

Delegates from the Telephone Administrations of the Scandinavian countries were invited to L M Ericsson's annual Maintenance Conference in Stockholm during the week 2—7 June 1969.

The Conference was the tenth in order—and the fourth with delegates solely from the Scandinavian countries, the last of which took place in 1965.

Some fifty papers were read during the week by visiting Swedish, Danish, Finnish, Norwegian and Icelandic telecommunication experts.

Lively discussions took place on subjects such as maintenance methods, standardization efforts concerning terminology and methods for measurement of service quality, centralized service observation, and the philosophy of alternative routing for the long-distance networks of the Scandinavian countries.

One day was devoted to detailed discussions in separate groups concerning line plant, subscriber, transmission and switching problems.

Special attention was devoted on this occasion to the operation and maintenance of stored programme controlled (SPC) systems, and a visit was made to the AKE Laboratory at the head factory and to the AKE exchange at Tumba, where all operating facilities of the system met with a very great interest and appreciation.

"Data processing of fault information at a large maintenance office" and "Present and future data transmission in Sweden" were two papers which drew particular attention on the last day of the conference.

The 1969 maintenance conference concluded with a visit and dinner at the Museum of Technology. (From left) O. Tómasson, Icelandic P.T.T., P. Aagaard, P.T.T., Copenhagen, H. Freye, LME, and T. Jónsson, Icelandic P.T.T., took the opportunity before the dinner of becoming acquainted with one of the veteran cars of the Museum —a constant object of attraction.

At the traditional closing ceremony at the Museum of Technology the representatives of the participating countries stressed the great value of the conference in providing a regular meeting place for maintenance experts of the administrations and suppliers, and for the exchange of experience and information, a necessity in view of the increasingly rapid rate of development within telecommunications.

Participators at the 1969 Maintenance Conference at Midsommargården.

Order from Australia for Computer Controlled Telephone Exchange

L M Ericsson has received an order from Overseas Telecommunications Commission, Australia, for the delivery of a computer controlled telephone exchange.

It is planned that this exchange, the first of its kind in Australia, will be opened in Sydney at the end of 1970.

The exchange will handle the traffic between international lines and the national Australian telephone network. It will initially be equipped for switching calls on some 200 trunk lines of different kinds. The exchange will also be used for field tests of the new international signalling system No. 6. When the field tests have been completed in 1972, additional capacity can be provided for commercial international telephone traffic.

Parts of the equipment will be manufactured in Australia by L M Ericsson Pty, Ltd, Broadmeadows, near Melbourne.

The first computer controlled telephone exchange supplied by LME was commissioned in Tumba outside Stockholm in the spring of 1968. Orders for the same system have been received for trunk and other exchanges in Rotterdam, Copenhagen, Helsinki and Mexico City.

L M Ericsson's factory at Broadmeadows, Australia.

Success for the DIALOG

Compañia Ericsson Ltda. (CEL) received some time ago an order from the government telephone operating company Empresa de Teléfonos de Bogotá (ETB) for 32,000 DIALOG telephones.

The photograph below, taken in conjunction with the signing of the contract, shows (from left) Mr Valdemar Henriksson, CEL, Dr Ernesto Aya, ETB, and Dr Miguel Mejía, Chairman of the Board of ETB (with the DIALOG used by the Pope during his visit to Colombia last year), and also Mr Jan Nyström, CEL, and Sr Manuel Franco A., ETB.

Large orders for the DIALOG have also been received from Ecuador, Ethiopia and other countries.

LME Sells Headsets Used by Astronauts

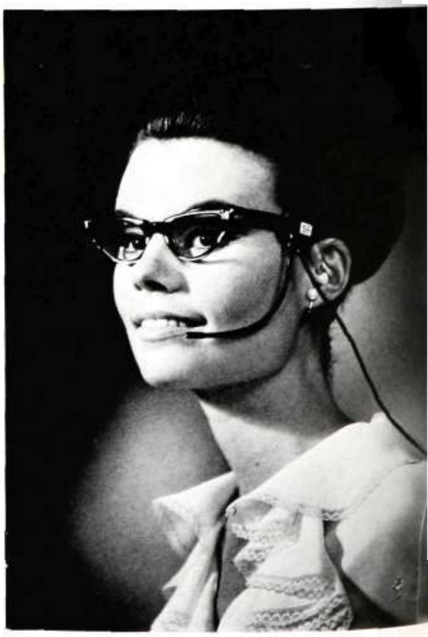
A very light headset made by the company which supplies headsets to the American astronauts is to be sold to telephone administrations and other interested parties by L M Ericsson in large parts of the world.

The company has concluded a longterm agreement with Pacific Plantronics Inc., U.S.A., which develops and manufactures the apparatus, for the sale of the product in large parts of Western Europe, Africa and South America.

The head band of the headset is made of spring steel and covered with nylon fabric. It is easy to adjust and can be used as head band or neck band. Two reproduction elements fitted in an inset replace the carbon granule microphone and the electromagnetic receiver. The inset can be fitted on spectacles. The speech is led from the corner of the mouth through a tube to the microphone inset. The speech level is raised in the built-in amplifier.

The headset weighs only 57 g and is extremely convenient to use. Operators and all who have use of a headset will welcome the new design which, apart from convenience, also provides a very good sound quality.

Plantronics is a large supplier of headsets to Bell System and other American telephone and aviation companies, and also to NASA. The astronauts on the Gemini, Apollo and Mercury projects have used Plantronics headsets.



LME's head factory at Midsommarkransen was recently visited by members of EMBRATEL, Brazil. General Francisco Galvão (left), President of EMBRATEL, and Col. Lourival do Rosário, Technical Director, try out a telephone set from 1878 in the Exhibition Room.

Another visit from Brazil. The Governor of the State of São Paulo, Sr. Roberto de Abreu Sodré, is welcomed by Dr. Marcus Wallenberg, Chairman of the Board of LME. Others (from left): Sr. José Turner, Sr. Antonio C. Branco, Mr. Erik Svedelius, Swedish Consul General in São Paulo, and on far right, Mr. Björn Lundvall, President of the LME Group.

The old telephone set of L M Ericsson type 1892 was in its time an equally great attraction at fairs as the Ericofon is today. The photograph is taken from the Hannover Fair in 1969.

During the International Exhibition "Avtomatizatsiya-69" in Moscow in May, LME's 200 m^2 stand was visited by, among others, Mr. Leonid Brezjnev. He is here seen (right) in conversation with Mr. Björn Jönsson, LME, who demonstrated the representative product programme.

From Ecuador came the Head of the Quito Telephone Administration, Dr. José Sanchez Ibarra. He is here seen, in centre, with (from lef) LME engineers Stig Söderqvist, Lars Mjöberg, Bengt Looström and Hans Hellberg.

New Head of MI Division

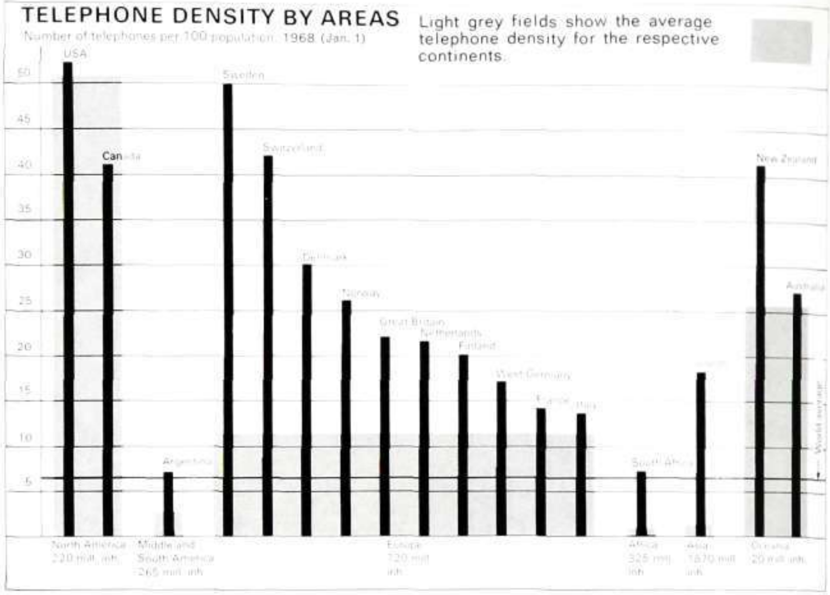
Mr S. Fagerlind

Mr Sven Fagerlind, Technical Director of the LME subsidiary Svenska Radioaktiebolaget, has been appointed new head of L M Ericsson's MI Division as from November 1 this year. In conjunction therewith Mr Fagerlind has been appointed a director of the parent company.

Mr Fagerlind succeeds Mr Hans Sund, who was earlier appointed Head of the Telephone Exchange Division.

Mr Janne Blohm has been appointed Head of the Sales Department of the Long Distance Division in succession to the late Mr Curt Green, and at the same time Chief Engineer.

Rapid Increase in World's Telephones



The total number of telephones in the world at the beginning of 1968 was 222 million, almost twice as many as ten years earlier. Solely during 1967 the number of telephones in the world increased by about 14 millon (see diagram above).

In the U.S.A. and Sweden—countries with a traditionally high telephone density—the increase during the period 1958—67 was 63 %. On some of L M Ericsson's markets the growth was even greater: Brazil 66 %, Colombia 130 %, Finland 81 %, France 100 %, the Netherlands 106 %, Italy 146 % and Mexico 153 %. The increase in some of the developing countries has been still more striking.

Investigations show that the world demand for telecommunications will continue its rapid growth. An increased economic stability in many countries and an improved technical level have created a broad basis for the introduction of the advanced communication equipments of today.

L M Ericsson's new Cable Works at Hudiksvall is now ready to commence work since the second stage comprising 17,000 m² was completed last year. The Cable Works has a total floor area of 32,000 m² and will manufacture telephone cable.

Large Order for Carrier Equipments for the Swedish Telecommunications Administration

The Long Distance Division of L M Ericsson has received a large order for carrier equipment for the Swedish Telecommunications Administration in the face of stiff competition. The order comprises 420 supergroup equipments of type M4, corresponding to 25,200 telephony channels. Delivery is to start at the end of this year and be completed within two years.

First ARF Exchange in Poland

In June L M Ericsson's first ARF automatic telephone exchange was opened in Poland. The exchange is installed at Lodz Zwirki and has a present capacity of 9,000 lines.

P.A.B.X. for Portuguese Tourist Village

At Villa Lara, a tourist village in the province of Algarve in Portugal, an L M Ericsson PABX type AKD 735 will function as public exchange for the tourists in the village. Villa Lara is expanding rapidly, with large building projects in progress, and the Portuguese sales company, Sociedade Ericsson de Portugal Ltda, hopes for a continued confidence in LME products.

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On cover: A mobile telephone station in transit through Bangkok, Thailand.

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L M Ericsson's Toll Ticketing System

K. A. SONE, TELEFONAKTIEBOLAGET L M ERICSSON, STOCKHOLM

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L M Ericsson have developed advanced toll ticketing equipments for automatic specification of calls. A complete ARM network for long distance telephony with toll ticketing has been in operation in Egypt since 1964. Identical toll ticketing equipments were installed in 1967 in Spain for charging of international telex calls. Toll ticketing of trunk calls has been successively introduced in Mexico since 1965. In Mexico data processing is to be centralized, the charging data from a trunk exchange being transmitted at the end of the call on a data link to a centrally located magnetic tape recorder. A major toll ticketing project has started in Brazil as well. The development of trunk traffic in that country will be dealt with in a coming number of Ericsson Review.

The present article presents a brief survey of the principles applied in L M Ericsson's toll ticketing system. Fuller descriptions are available for those who wish to study the system in detail.

Reasons for Introduction of Toll Ticketing

In conjunction with the introduction of subscriber-dialled long distance calls certain administrations have installed toll ticketing equipment for charging of such calls instead, or in supplementation, of multimetering on subscribers' meters. The reasons are many, e.g.

☐ Legal regulations concerning specification of every trunk call.

☐ The subscribers retain the traditional charging method used in the manual service with a ticket for every long distance call.

☐ In some countries the charge for local calls is included in the flat rate and, if toll ticketing is adopted for long distance traffic, no subscribers' meters are required.

☐ Multimetering is at present used for subscriber-dialled international traffic within some European countries. But, as long distance international and also intercontinental traffic becomes converted to automatic operation, the need for toll ticketing increases, both because subscribers undoubtedly wish for a specification of these more expensive calls, and because of the difficulties in rapid pulse transmission which would be required for multimetering on subscriber's meters.

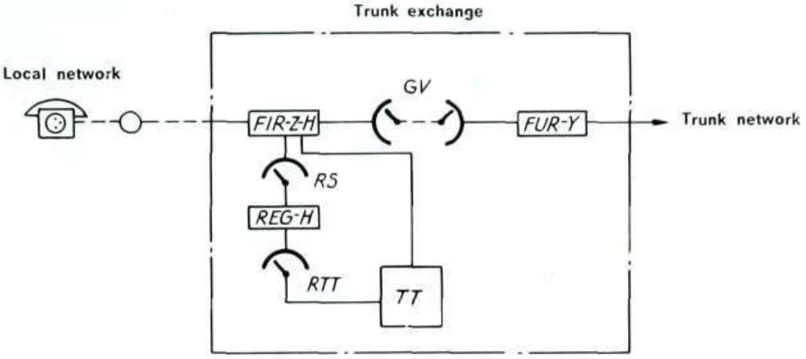
Identification of Calling Subscriber

A condition for toll ticketing is that the calling subscriber's number, the *A* number, can be identified. Equipments for identification and transmssion of

Fig. 1

Toll ticketing equipment at trunk exchange

FIR-Z-H	Line equipment for incoming traffic from local network
GV	Trunk transit stage
FUR-Y	Line equipment for outgoing traffic to trunk network
REG-H	Trunk register
RS	Register finder
TT	Toll ticketing equipment
RTT	Connector between REG and TT



the *A* number have been developed both for L M Ericsson's marker-controlled crossbar systems (*ARF*, *ARK*) and for older non-marker-controlled systems such as the 500-point selector system and step-by-step systems of other makes.

For charging of trunk calls the toll ticketing equipment is centralized to the trunk exchange (fig. 1), so that transmission of the *A* number from the local exchange is necessary. The introduction of *MFC signalling* as register signalling system has made it possible to send the *A* number on the speech path in the same way as the *B* number.

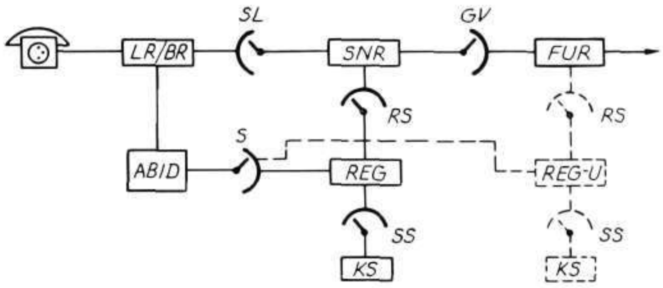
In a marker-controlled system such as *ARF 102* identification takes place when the local register is connected to the subscriber. The marker then always transmits the *A* number to this register provided that it is equipped with a relay set for storage of the *A* number. The code sender must be equipped with a relay set for sending of this number to a trunk register.

In older systems without marker the subscriber is identified by a tone signal via the selector stages (fig. 2). The identification equipment *ABID*, which has a max. capacity of 10,000 subscribers, is connected to the subscriber's individual multiple position, e.g. cut-off relay or subscriber's meter. The exchange

Fig. 2

Connection of identification equipment, ABID

ABID	Equipment for subscriber identification by tone signal
LR/BR	Subscriber's line/cut-off relay
SL	Subscriber selector stage
SNR	Subscriber's cord circuit
REG	Local register
KS	Code sender
SS	Sender-finder
RS	Register finder
S	Finder REG-ABID
GV	Group selector stage
FUR	Line equipment for outgoing traffic
REG-U	Outgoing register



may either be originally provided with a local register *REG* or, if of step-by-step type, may be supplemented by an outgoing register *REG-U* which is connected to the line equipment *FUR* to the trunk exchange.

When the subscriber has dialled a number which requires toll ticketing, the register *REG* connects via the finder *S* to *ABID*. The latter sends a tone signal via *S*, *REG* or *REG-U*, register finder *RS*, cord circuit *SNR* or line equipment *FUR* back through the selector stages to the individual inlet in *ABID*. In the latter the individual wire is run through a translator made up of ferrite cores, which, with the aid of an amplifier, generates the *A* number. After supervision to eliminate the risk of faulty identification, *ABID* transmits the identity to *REG* or *REG-U*, which stores the *A* number and releases *S* and *ABID*. With the aid of the code sender *KS* the *A* number is sent to the trunk exchange.

Applications

The toll ticketing equipment developed for specification of calls can be used:

- for subscriber-dialled national, international or intercontinental telephone or telex connections
- for operator-assisted calls
- for accounting between administrations.

For these various applications the equipment is identical in principle apart from minor variations in the devices used. The following functional survey will therefore deal with the most common applications hitherto, which is charging of trunk calls in the *ARM* system. Other applications will be briefly dealt with later in this article and in a coming article on the telex network in Spain.

Charging of Trunk Calls

General Principles

For charging of trunk calls the toll ticketing equipment, *TT* in fig. 1, is normally centralized to the trunk exchange, terminating there on incoming line equipments from the local network, *FIR-Z-H*, and on the registers for outgoing trunk traffic, *REG-H*. In cooperation with these units *TT* records for every call the numbers of the calling and called subscribers and the times when the call started and ended. The data is fed out at the end of the conversation in tabulated form on punched cards, magnetic tapes etc. Alternatively a data link can be used for transmission to a central magnetic tape recorder.

If required, the *TT* equipment can process the information before feed-out so that the tariff and duration of the conversation are also fed out. For statistical purposes ineffective calls (no answer, busy etc.) can also be recorded, as well as the number of the circuit used. Table 1 shows the output in greater detail.

Table 1. Output from toll ticketing equipment

Basic equipment	No. of digits
1. Calling subscriber's number	10
2. Calling subscriber's category	1
3. Called subscriber's number	10
4. End-of-selection signal (free, busy etc.)	1
5. Time of start of conversation	
— hour, minute, 1/10 minute (tolerance ± 6 s)	5
alternatively	
— hour, minute, second	6
6. Time of end of conversation	5 or 6
7. Date, day and month	4
8. Number of junction circuit (FIR)	2
9. Number of buffer store	1
10. Fault location character	1
11. Class of registration	1
— call with complete information	
— call with incomplete information	
— ineffective call (no answer, busy etc.)	
Additional equipment	
1. Possibility of recording of called subscriber's number on international calls (10 + 6)	16
2. Tariff (00—99)	2
3. Tariff group (day tariff, night tariff)	1
4. Conversation period	
— hours, minutes, 1/10 minutes (± 6 s)	5
alternatively	
— hours, minutes, seconds (± 1 s)	6
alternatively expressed in	
— total minutes	3
5. Additional equipment for international accounting between administrations	
— time for call signal on incoming junction circuit, FIR	5
— number of selected alternative route; together with called number indicates outgoing route	1
6. Additional equipment for operator-assisted traffic	
— class of call (person-to-person, collect calls)	1

For subscribers who desire an immediate notification of the cost of a call, the call specification is fed to a separate card punch or recorder in parallel with or, alternatively, to the regular output device.

An immediate notification of cost can be requested in two ways:

☐ The subscriber's number is given a special subscriber category and all calls from such subscribers (hotels etc.) then receive this service.

☐ The subscriber himself requests an immediate notification of cost by means of a special dialling code.

The toll ticketing equipment is made up of units which serve 100 *FIR-Z-H*. Depending on the recording speed of the output device used, the device can be utilized for up to six *TT* units jointly.

Table 2 shows examples of the possible concentration for different output devices with characteristic output speeds.

Table 2. Example of output devices

Output device	Output speed	Grouping in TT equipment
Card punch	100 cards/minute	Two per 200 circuits
Tape punch	150 characters/s	Two per 200 circuits
Magnetic tape recorder	300 characters/s	Two per 600 circuits
Data modem, 1200 baud	240 characters/s	One per 400 circuits

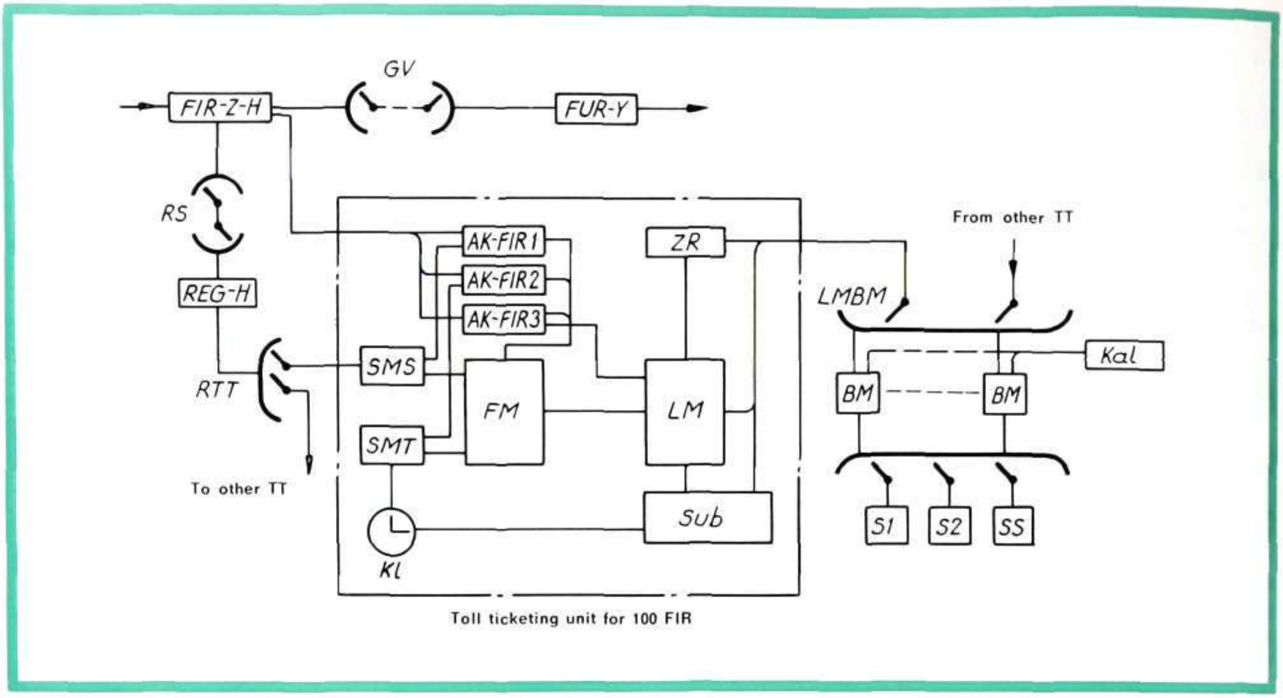


Fig. 3

Toll ticketing equipment, block diagram

SMS	**Write store for A and B numbers**
SMT	**Write store for time of answer**
Kl	**Clock**
AK-FIR 1—3	**Call identifier**
FM	**Ferrite store**
ZR	**Tariff analyser**
LM	**Read store**
Sub	**Calculator for conversation time**
BM	**Buffer store for output device**
Kal	**Calender**
S1, S2	**Regular output devices**
SS	**Output device for immediate call specification**
RTT	**Connectors between REG-H and TT**
LMBM	**Connectors between 100-line group and BM**

The *TT* equipment for 100 *FIR-Z-H* shown in fig. 3 has a ferrite core store, *FM*, with a memory word of 150 or 180 bits per *FIR-Z-H* for storage of *A* and *B* numbers and time of answer during the conversation. The memory word is addressed from *FIR* by a call to three identifiers *AK-FIR* 1—3. A normal trunk call results in three classes of call from *FIR-Z-H* to the *TT* equipment:

a) Call to *AK-FIR* 1 for recording of *A* and *B* numbers in ferrite core store.

b) Call to *AK-FIR* 2 for recording of time of answer in ferrite core store.

c) Call to *AK-FIR* 3 for recording of time of clearing. This call starts read-out of information a) and b) from the ferrite store, processing of the information and feed-out to the output device.

Recording of Calling and Called Numbers

After seizure from the local network *REG-H* receives the calling and called numbers and, when required, also the calling subscriber's category code *REG-H* controls the setting up of the connection to the called subscriber and then signals to *FIR-Z-H* for recording of the *A* and *B* numbers in *TT*. *FIR-Z-H* calls *AK-FIR* 1, which identifies and serves one calling *FIR-Z-H* at a time. When *FIR-Z-H* has been identified, *AK-FIR* 1 acknowledges the call. *REG-H* receives the acknowledgement signal from *FIR-Z-H* and *RS*, connects via *RTT* to *SMS* and transmits in 2-out-of-5 code the *A* number (max. 10 digits), *A* category (1 digit), and *B* number (max. 10 digits, alternatively max. 16 digits if an international call is to be charged) to *SMS*, which temporarily stores the information for matching to the ferrite store *FM*. *SMS* calls the gate circuits of *FM*, which provide access to the ferrite store for one of the above-mentioned three classes of call a—c at a time. *FM* with the aid of *AK-FIR* 1, addresses the word in the ferrite store which corresponds to the selected calling *FIR-Z-H*. The information in *SMS* is then written into the addressed memory word with coincident currents. 2-out-of-5 code is used also in *FM*. Check bits are also written in for service supervision. At the end of the write-in *FM* delivers an acknowledgement signal to *SMS*, which releases *FM* and repeats the acknowledgement to *AK-FIR* 1, *FIR-Z-H* and *REG-H*. *REG-H* disconnects *RTT* and *SMS*. As *REG-H* has completed its task of setting up the connection to the *B* subscriber, the register as well is disconnected. *FIR-Z-H* then cuts off the call to *AK-FIR* 1, which becomes free.

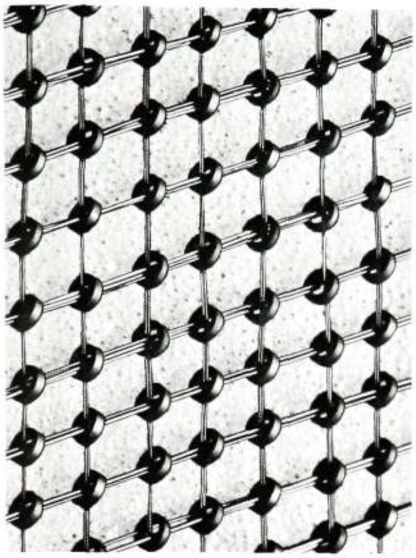


Fig. 4

Detail of memory matrix of toll ticketing equipment. The outside diameter of the ferrite rings is 2 mm.

Recording of Time of Answer

When the *B* subscriber answers, the answer signal is conveyed backwards over the set-up speech path and stored in *FIR-Z-H*. *FIR-Z-H* then calls *AK-FIR* 2 and the call is identified as in *AK-FIR* 1 above. *AK-FIR* 2 seizes *SMT*, which stores the time indicated by the equipment clock. The time is transmitted by means of 5 digits in self-checking code (2 out-of-*n*) for the hour (2 digits), minute (2 digits) and tenths of a minute (1 digit). This code is also used for storage of the time in *FM*. *SMT* calls the gate circuits of *FM* which, via *AK-FIR* 2, steer the recording of the time in the ferrite store to the word corresponding to the calling *FIR-Z-H*. The recording takes place in the same way as for write-in of *A* and *B* numbers. After write-in *FM* acknowledge to *SMT*, *AK-FIR* 2 and *FIR-Z-H*, which breaks the connection to *AK-FIR* 2. A call from another *FIR-Z-H* can then be served.

Recording of Time of Clearing

When the calling subscriber hangs up, *FIR-Z-H* receives a clearing signal from the local network and clears the connection forwards to the *B* side. *FIR-Z-H* also calls *AK-FIR* 3 in the toll ticketing equipment (fig. 3), which identifies the call and seizes the read store *LM*. The gate circuits of *FM* are called from *LM* and the word corresponding to the calling *FIR-Z-H* in the ferrite store is addressed via *AK-FIR* 3. All information stored in the memory word during the conversation is read out, transferred to *LM* and stored. The number of the calling *FIR* is transmitted from *AK-FIR* 3 to *LM* simultaneously with the read-out from *FM*. When *LM* has stored this information, an acknowledgement is sent via *AK-FIR* 3 to the calling *FIR-Z-H*, which disconnects the call to *AK-FIR* 3. An indication that *FIR-Z-H* is free is then signalled to the local network. The read-out operation in the ferrite store is given priority over calls from *SMS* and *SMT* in order not to delay the indication that *FIR-Z-H* is free.

The conversation time is calculated by the calculator *Sub*. The time of clearing (hour, minute, 1/10 minute) is transmitted from the clock to *Sub* in conjunction with the seizure of *LM*. The time of answer is received by *Sub* from *LM* after read-out from *FM*. The duration of the conversation is obtained by subtraction of the time of answer from the time of clearing. The conversation time is indicated in hours, minutes and tenths of a minute or, if so desired, in total minutes. *Sub* can also be programmed so that conversations shorter than about 12 seconds are not recorded. In certain applications the duration of the conversation is not calculated until invoicing takes place. In such case *Sub* in the toll ticketing equipment is replaced by a store which records the time of end of conversation.

The tariff is calculated in the tariff analyser *ZR* and may be dependent on the number and category of the calling subscriber and on the called number (at the most the 6 first digits). Day and night tariffs can be programmed depending on the time of answer. The tariff is indicated by two digits (100 tariffs) and indication of day or night tariff. If the tariff is instead to be calculated at the time of invoicing, a tariff analyser is not installed in the toll ticketing equipment.

Output of Call Specification

When the processing of the information in *LM* is complete the buffer store *BM* is called, the function of which is to store the information during the time of waiting for and feed-out to the output device. A free *BM* is connected to *LM* via the connected *LMBM*, and the information in *LM* and, where relevant, *ZR* and *Sub* is transferred to *BM*. *LM* and *LMBM* then release.

BM records the date from the calender (day, month). The calender, which is controlled from the clock, is made up on a 4-year basis and thus takes leap years into account.

The calls can be classified in *BM* for facilitation of the subsequent data processing of the output. The following classes are indicated:

- Call with complete information
- Call with incomplete information
- Ineffective calls (no answer, busy etc.).

After processing in *BM* a free output device is selected and connected to *BM* and the information is fed out. The buffer store then releases.

Output Devices

To determine which type of output device *TT* should be provided with, it is necessary to consider the entire procedure from feed-out from the buffer stores of the toll ticketing equipment up to the print-out of the subscriber's bill.

The main factors which affect the choice of output device are the quantity of data and how they are to be processed in conjunction with the making out of the bill. The geographical situation of the *TT* equipment in relation to the point of invoicing is also of significance.

In the case of a few, relatively small toll ticketing equipments with small quantities of data, output on punched card machines or tape punches may be suitable and provides a reasonable handling procedure both at the telephone exchange and for transfer to and invoicing in a computer. In the case of punched cards, moreover, if the number of cards is small, the invoicing can be done manually and with simple sorting machines. With growing traffic, however, the handling of cards and tape at the telephone exchange becomes difficult owing to the frequent changes of card and tape when using many output devices; it also involves voluminous transport, and conversion to magnetic tape at the invoicing point prior to computer processing is often necessary.

In the case of large quantities of data in the *TT* equipments, therefore, it is desirable from the service aspect at the telephone exchange to select output devices with larger storage capacity, such as a magnetic tape recorder, which may be remotely situated and connected via a data link. Magnetic tape data are edited by a driver unit in data blocks with the necessary check bits and block intervals and the code for direct input to a computer without previous conversion.

The buffer stores of the *TT* equipment have a standardized interface to the output devices. Matching to output devices of different makes and types is done, if necessary, with a driver unit specially adapted to the purpose, which is connected between buffer store and output devices and edits the output as desired. The change from, for example, punched cards to magnetic tape or data transmission equipment when the traffic grows can be effected by replacement of driver units and output devices.

The toll ticketing equipment are grouped with the possibility of access to two output devices (fig. 5). It must be ensured that sufficient traffic-carrying capacity is maintained with only one of these devices in operation, as occurs for example during overhaul of an output device. The output of call specifications is distributed between the output devices.

Apart from the two regular output devices *BM* has access to an output device for output of call specifications requiring immediate notification of cost.

Fig. 5

Grouping of toll ticketing equipments

FIR-Z	**Line equipment**
TT	**Toll ticketing equipment for 100 line equipments**
BM	**Buffer store**
S1, S2	**Regular output devices**
SS	**Output device for immediate call specification**

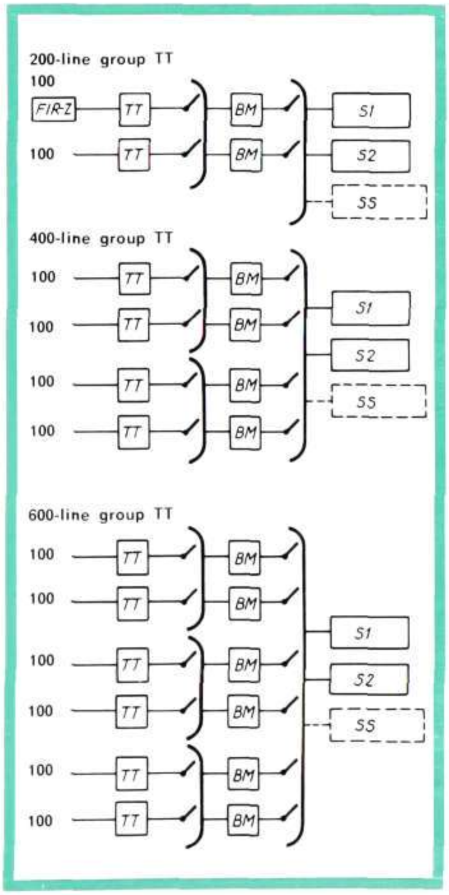


Fig. 6
Toll ticketing rack at Victoria trunk exchange, Mexico City

Fig. 7
Incremental magnetic tape recorder and associated rack-mounted electronic control equipment

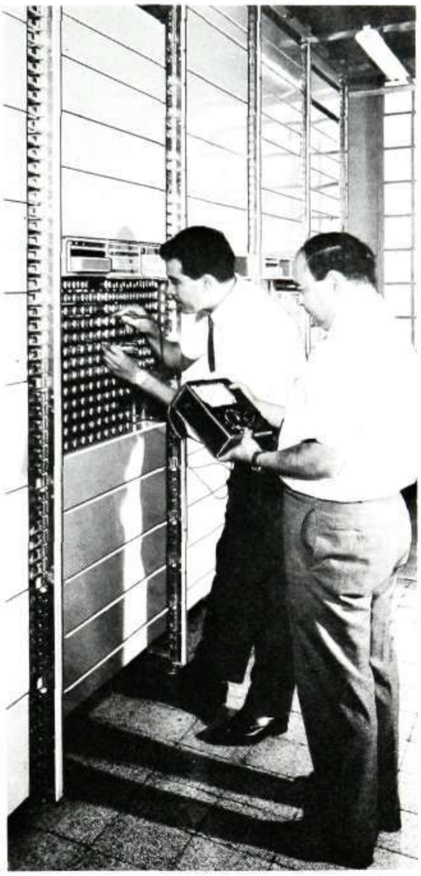


Fig. 6

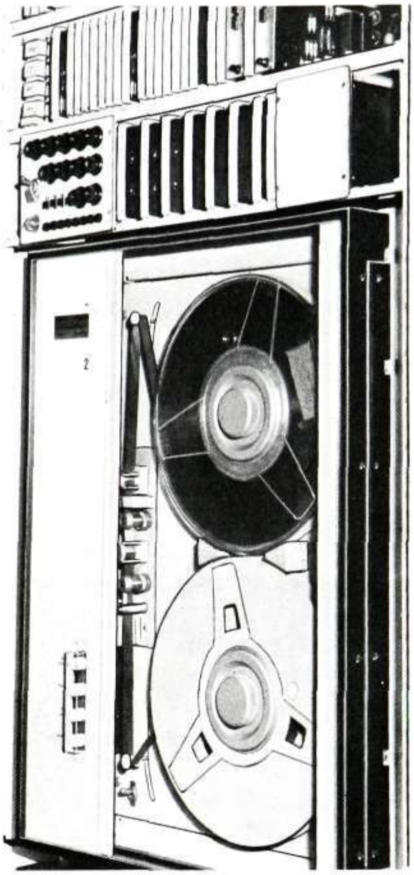


Fig. 7

Supervision of Toll Ticketing Equipment

A metering equipment must operate with great reliability, and disturbances of operation must be quickly discovered and delimited. Self-checking codes have therefore been used for transmission of data through the toll ticketing equipment; strictly centralized units in the system, such as clock, buffer stores and output devices have been duplicated.

For faults which affect single calls an automatic alarm is issued, and information indication of the nature of the fault, and the units concerned are recorded by the output devices of the equipment.

For a fault in central units within the 100-line group an alarm is issued, as well as a fault signal to all *FIR* line equipments concerned. If there is a large number of lines and several 100-line groups, the fault signal is used for blocking the lines concerned against traffic. The signal can also be used for redirection of the calls to an operator or for allowing the calls to pass without charging.

The alarm and supervisory functions of the equipment are adapted for connection to the central service supervision system of the telephone exchange.

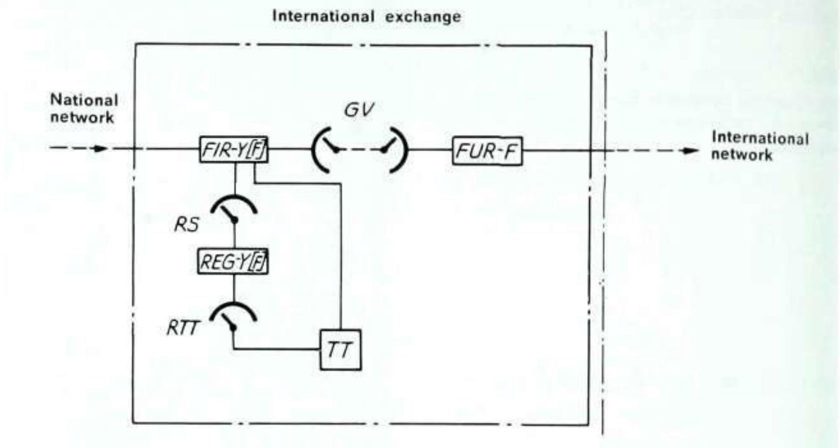
Components and Mechanical Construction

The toll ticketing equipment is made up of a ferrite core store, with electronic components in the peripheral circuits of the store, and of L M Ericsson's telephone relays. The racks are of type *BDH*, height 2900 mm, the equipment units being connected by plug and jack.

Fig. 8

Toll ticketing equipment at international exchange

FIR-Y[F]	**Incoming line equipment from national network**
GV	**International transit stage**
FUR-F	**Outgoing line equipment to international network**
REG-Y[F]	**Outgoing international register**



Toll ticketing equipment for, for example, 200 junction circuits *FIR* is mounted in 7—9 racks. The number varies with the necessary traffic-carrying capacity.

Driver units for magnetic tape recorder or data transmission equipments are fully electronic and placed with the output devices in racks of type *BDE*, height 2900 mm. A rack of this kind accommodates, for example, 2 tape recorders with driver units, which can serve *TT* equipments for up to 600 *FIR*.

Two wall-mounted pendulum clocks common to all 100-line groups in the exchange are used as pulse transmitters for timing. The pendulum clock pulses are distributed to the various 100-line groups, in which the time is indicated via duplicated relay chains.

Other Applications

International Traffic

A form of metering of increasing interest is a combination of toll-ticketing for solely international traffic and an existing system for multimetering of national calls.

The toll ticketing equipment is installed only at the international exchange in association with an incoming line equipment *FIR-Y[F]* from the national network and outgoing international register *REG-Y[F]* (fig. 8). For matching to the international numbering scheme the called number capacity of the toll ticketing equipment is in this case max. 16 digits. The operation of the equipment is as earlier described.

Since complete equipment for identification of calling subscriber and transmission of the *A* number via the national network to the international exchange is usually lacking, considerable additional equipment may be needed for these purposes. The method to be chosen depends upon the existing situation, which must be studied from case to case. The earlier described identification equipments combined with *MFC* signalling, however, provide a satisfactory technical solution. With low international traffic it may be advisable to have an identification operator deal with the transmission of the *A* number to the *TT* equipment. This reduces the investment on additional equipment but involves the expenses of operators.

Operator-Assisted Traffic, TSP

For person-to-person calls which are to be charged only if the desired person is reached, and for collect calls which are to be paid by the called subscriber after his consent, the toll ticketing equipment is used in combination with special operator equipments *TSP* (traffic service position), see fig. 9.

The *TSP* procedure is briefly as follows:

The dialling subscriber marks by a special access code that *TSP* assistance is desired, after which the connection is routed through a special cord circuit group, *SNR-TSP*, and associated register, *REG-TSP*, with connection to the toll ticketing equipment *TT-TSP*. *REG-TSP* receives the *A* and *B* subscribers' numbers from the calling exchange and takes over the control of the connection to the *B* subscriber. When the connection has been set up to the *B* subscriber, *REG-TSP* transmits the *A* and *B* numbers to *TT*, where they are stored in the ferrite store's word for that *SNR-TSP*. *REG-TSP* then releases. The operator's equipment *OPR-TSP* is then connected to *SNR*. The operator receives verbal advice from *A* concerning the desired service and on receipt of the answer asks *B* wether the connection is to be established. If so, the operator starts charging by transmitting a signal to *KM-TSP* and also indicates the class of call to *KM-TSP*. She then leaves the connection. In cooperation with *SNR-TSP*, *KM-TSP* transmits the class of call to *TT-TSP*, which stores it together with the time for start of charging in the ferrite store word for *SNR-TSP*. *KM-TSP* then releases. The class of call is recorded since it affects the tariff. At the end of the conversation *SNR-TSP* calls the toll ticketing equipment for indication of end of conversation, after which the call specification is fed out in the normal way. If the exchange also has toll ticketing equipment for fully automatic traffic, the output devices can be grouped jointly for these equipments and *TT-TSP*.

International Accounting

Accounting between administrations for international traffic can be arranged in accordance with C.C.I.T.T.'s recommendations by installation of a variant of toll ticketing equipment in the international exchange (fig. 10).

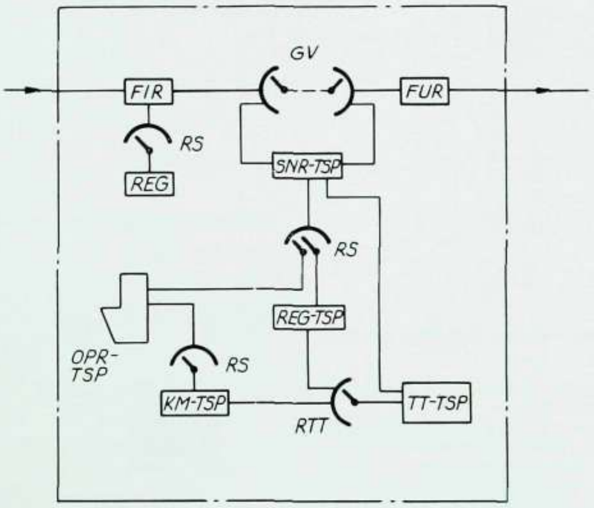


Fig. 9

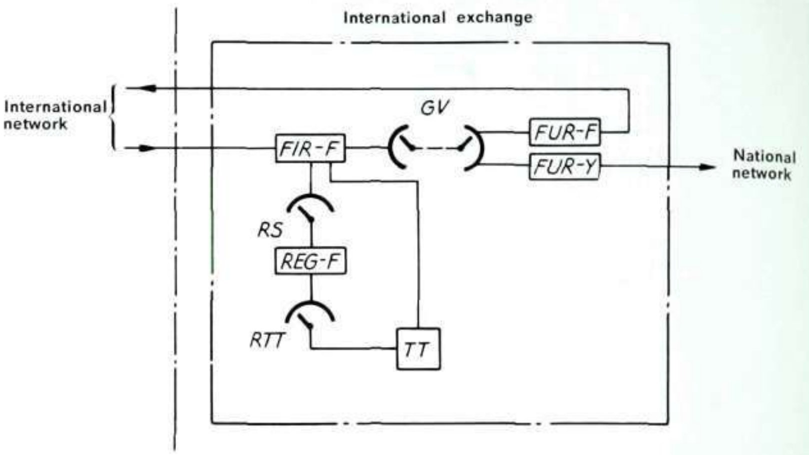
Toll ticketing of operator-assisted traffic, TSP

REG	**Incoming register**
SNR-TSP	**Cord circuit with operator's equipment and toll ticketing connection**
REG-TSP	***Outgoing register***
ROP-TSP	**Operator's equipment**
KM-TSP	**Receiver of code from OPR-TSP**
TT-TSP	**Toll ticketing equipment**

Fig. 10

Toll ticketing equipment for accounting at international exchange

FIR-F	Line equipment for incoming traffic from international network
GV	International transit stage
FUR-F	Line equipment for outgoing traffic to international network
FUR-Y	*Line equipment for terminating traffic* in national network
REG-F	Incoming international register



The equipment is connected to incoming line equipments *FIR-F* and register *REG-F* from the international network and records data of transited and terminating traffic.

The *A* subscriber's number need not be recorded in this case, but the called international and, if nessesary, national area codes are recorded, as well as data of incoming circuit and selected outgoing route. The times of incoming calling signal, answer and clearing are also recorded. The time af calling signal is recorded because occupation times on ineffective calls (no answer etc.) are of interest, as the ratio between conversation times and occupation times provides a measure of the effective utilization of the network.

The received digits and data concerning outgoing route are transmitted from *REG-F*, when the selector stages *GV* have been through-connected, and are recorded in the store of the toll ticketing equipment together with the time of the calling signal. Recording of the time of answer and feed-out of the specification after clearing take place in the normal way.

Data Collection System for Toll Ticketing

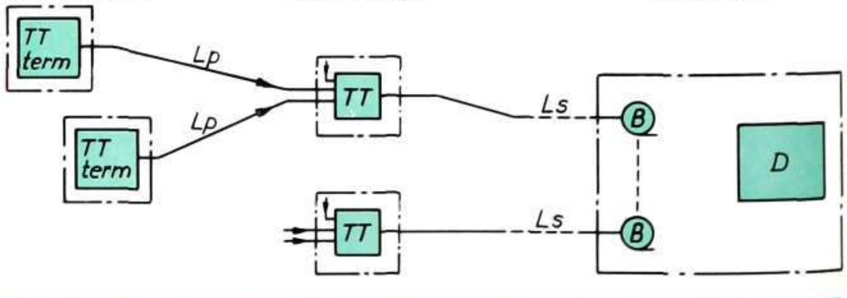
General

In large national networks it is often important to make use of a central data processing equipment for the preparation of telephone bills jointly for the

Fig. 11

Data collection system for toll ticketing, general survey

TT term	Terminal equipment for transmission of primary data
Lp	Permanent circuit for multi frequency transmission of primary data
TT	*Toll ticketing equipment*
Ls	Permanent carrier circuit for 1200 baud transmission of call specifications
B	Magnetic tape recorder
D	Computer for preparation of bills



entire country or for large parts of the country. For collection of data from the toll ticketing equipments a system has been developed in which *call specifications* from *TT* are fed out via data transmission links to magnetic tape recorders at the invoicing point. This saves transport of punched cards, tapes etc., and the recording output devices of the toll ticketing equipment are centralized, which is of benefit from the maintenance point of view.

The data collection system also includes toll ticketing terminals for transmission of *primary call data* from small exchanges such as group centres and terminal exchanges to toll ticketing equipments at a higher level in the network. Fig. 11 shows a general survey of the data collection system, which is briefly described below.

Collection of Call Specifications

From toll ticketing equipments at a number of trunk exchanges, *NC1-NCn* in fig. 12, calls specifications are fed out at the end of conversation and sent in the form of a data block per call on permanent data links (one telephony channel per link) to a trunk exchange *DC*, which is also data collection centre. The number of characters in the data block is fixed for each application and is normally about 50. The appearance of a data block will be seen in fig. 13.

For the data transmission L M Ericsson's duplex 1200-baud series modem with associated control units is used on both sides of the circuit.

In *DC* the data blocks are recorded via a matching unit with tape editing, *DE-B*, in a magnetic tape recorder of incremental type. Every data link has its own tape recorder.

The data transmission is checked with character and block parity bits and controlled by signals in the supervisory channel of the data link. In the event of a transmission fault the data block is repeated a number of times before the circuit is considered unusable. In this state, or on break of the data link, an alternative route is automatically connected by *FIR-DT* and *KS* at *NC* via the trunk network to *FUR-DT*, modem and tape recorder at *DC*, after which

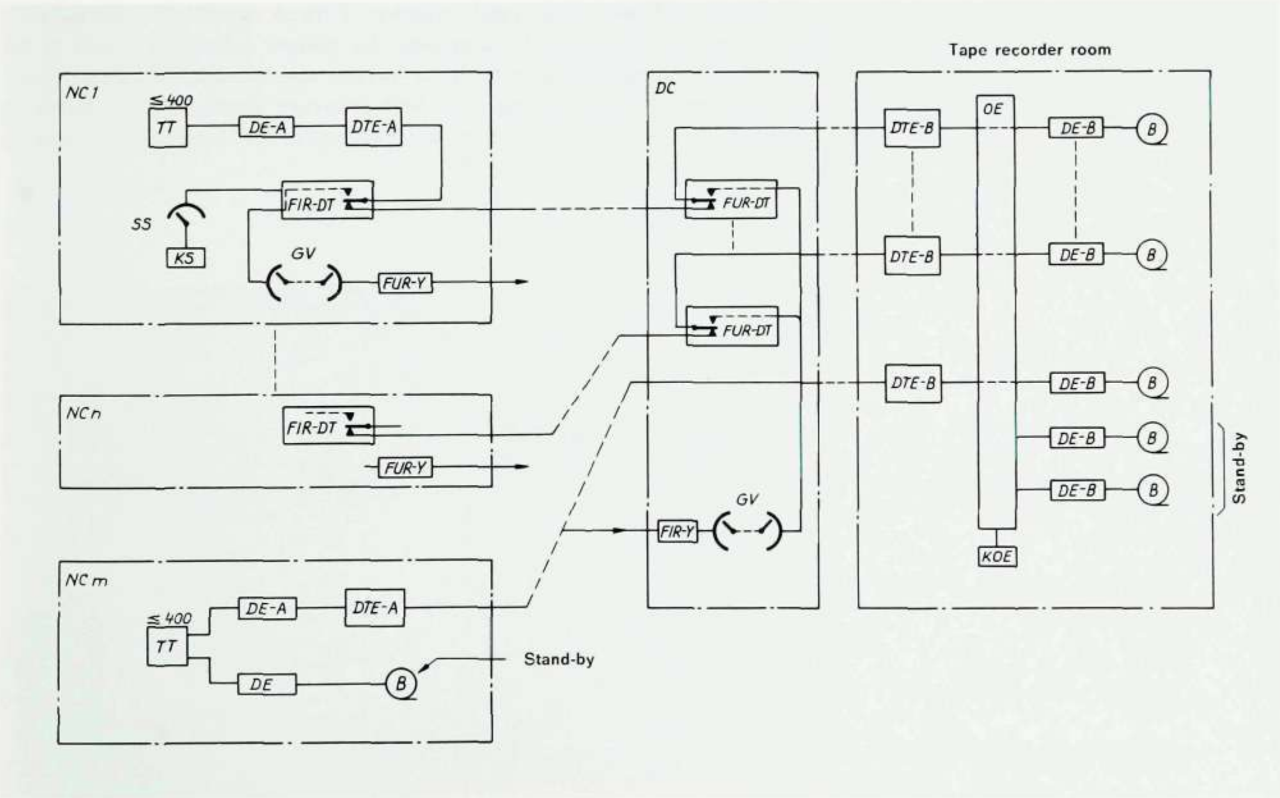


Fig. 12

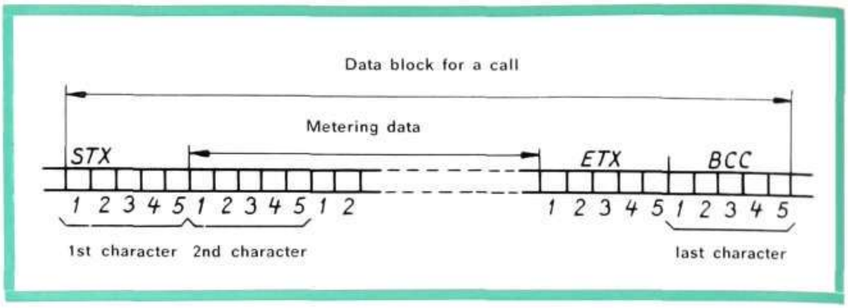
Data collection system for toll ticketing, collection of call specifications

NC 1-n	**Trunk exchanges, e.g. zone centres**	
DC	**Trunk exchange and data collection centre, possibly district centre**	
NC m	**Trunk exchange without alternative route to DC**	
TT	**Toll ticketing equipment**	
DE-A	**Matching unit between TT and data transmission equipment**	
DTE-A, B	**Series modem and control unit**	
FIR-DT	**Line equipment for alternative route**	
FUR-DT	**Line equipment for alternative route**	
OE	**Equipment for switching between magnetic tape recorders**	
KOE	**Control logic for OE**	
DE-B	**Equipment for matching between DTE-B and magnetic tape recorder**	
DE	**Matching unit between TT and magnetic tape recorder**	
B	**Magnetic tape recorder**	
KS	**Code sender**	**Regular exchange equipments**
SS	**Sender-finder**	
GV	**Trunk group selector stage**	
FUR-Y	**Outgoing line equipment to trunk network**	
FIR-Y	**Incoming line equipment from *trunk network***	

Fig. 13

Metering data for a call

STX	Start of text character
ETX	End of text character
BCC	Block check character
1—5	Bit positions per character: 1—4 = binary character, 5 = character parity bit



the data transmission restarts. For setting up of the alternative route *FUR-DT* has been allotted a call number which is automatically generated by *FIR-DT* in cooperation with *KS* in accordance with the signalling principles of the trunk network concerned. During the setting-up time the toll ticketing equipment temporarily stores any call data in order that no data shall be lost.

The permanent circuit is continuously supervised by *FIR-DT* and *FUR-DT*. When the circuit becomes usable again, return to it takes place automatically and the alternative route is disconnected.

As already mentioned, every data link has a specific tape recorder at *DC*. On disconnection of the latter, e.g. for change of tape, a common stand-by tape recorder is automatically connected to the data link via an electronic switching equipment *OE*. When the regular tape recorder is in operation again, return to it takes place automatically. The switching unit *OE* is dimensioned for connection of up to 20 data links.

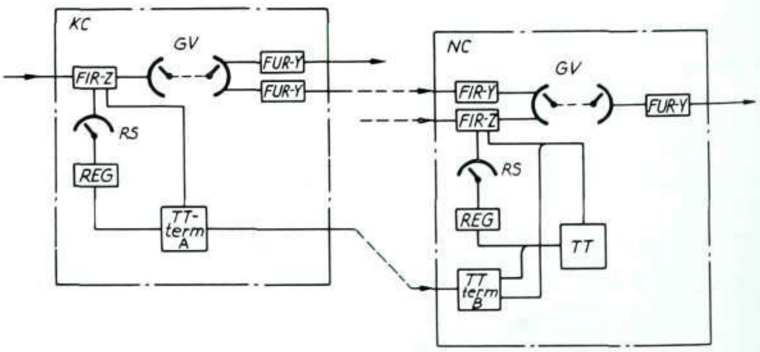
Collection of Primary Call Data

For small exchanges with small number of trunk circuits the toll ticketing function can be centralized by arranging for several exchanges jointly to use one toll ticketing equipment at a higher level in the network. The latter equipment may be connected to the data link described above. Fig. 14 shows an example of the procedure, in which a group centre *KC* uses the toll ticketing equipment *TT* at the zone centre *NC*.

Fig. 14

Data collection system for toll ticketing, example of collection of primary call data

KC	Group centre
NC	Zone centre
FIR-Z	Incoming line equipment from local network, charging point
RS	Register finder
REG	Register
GV	Group selector stage
FUR-Y	Outgoing line equipment to trunk network
TT term	
A, B	Terminal equipments for transmission of primary call data
TT	Toll ticketing equipment



Every incoming line equipment *FIR-Z* from the local network at *KC* is allotted a memory word in the *TT* equipment at *NC*.

With the aid of the toll ticketing terminal *A*, which has connection to *FIR-Z* and a register at *KC*, the metering data are transmitted on a permanent junction circuit to toll ticketing *B* and *NC*. The transmission is effected by pulsed multifrequency signalling at a speed of about 10 digits per second.

For every call the following three blocks of primary data are transmitted:

a) Calling and called subscribers' numbers and *FIR-Z* number. The block is sent when *REG* at *KC* has set up the connection to the *B* subscriber.

b) Answer signal and *FIR-Z* number. The block is sent when the *B* subscriber answers.

c) Clearing signal and *FIR-Z* number. The block is sent at the end of the conversation.

Toll ticketing terminal *B* checks the received block and steers it to the desired inlet in the *TT* equipment, guided by the *FIR-Z* number. Every block is acknowledged by a tone signal to terminal *A*.

Toll ticketing terminal *B* has the same signal configuration towards *TT* as *FIR-Z* and *REG* at *NC*, so that the output of call specifications is done in the same way as earlier described.

TT terminal *A* has the same connections to *FIR-Z* and *REG* as a toll ticketing equipment. Provision has therefore been made in the system for replacement of *TT* terminal *B* by a normal toll ticketing equipment when the traffic grows.

About four transmission links are required for fifty *FIR-Z* at *KC*.

New Dial

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UDC 621.395.636.1
LME 8223

The conventional dial is still the subscriber's main signalling device, but as shown by an article in Ericsson Review No. 1, 1969, pushbutton dialling will become more and more popular. The reasons for this are partly the quicker and more convenient keying procedure, partly the increased number of signal codes, which enable new facilities to be offered to the public. But pushbutton dialling adds to the cost of the telephone instrument and requires additional equipment in the exchange. Subscribers who do not need new facilities do not wish to pay for them either. Besides, it will take a long time for telephone administrations to add the necessary equipment at the exchange, since, among other things, pushbutton dialling requires register control. There are, however, already register-controlled systems for high-speed dialling (20 pulses/sec). Through field tests it has been established that, in comparison with a normal dial (10 pulses/sec), the time needed for pushbutton dialling is reduced by one-half and for high-speed dialling (20 pulses/sec) by one-thrid. The difference between pushbutton and high-speed dialling is thus rather small. High-speed dialling is cheaper and, in many cases, a sound alternative. For a long time to come there will be a great demand for dial telephones. L M Ericsson have therefore developed both a keyset for telephones with voice-frequency code signalling and a new dial that can be adapted for up to 20 pulses/sec.

Technical Background to the New Dial Design

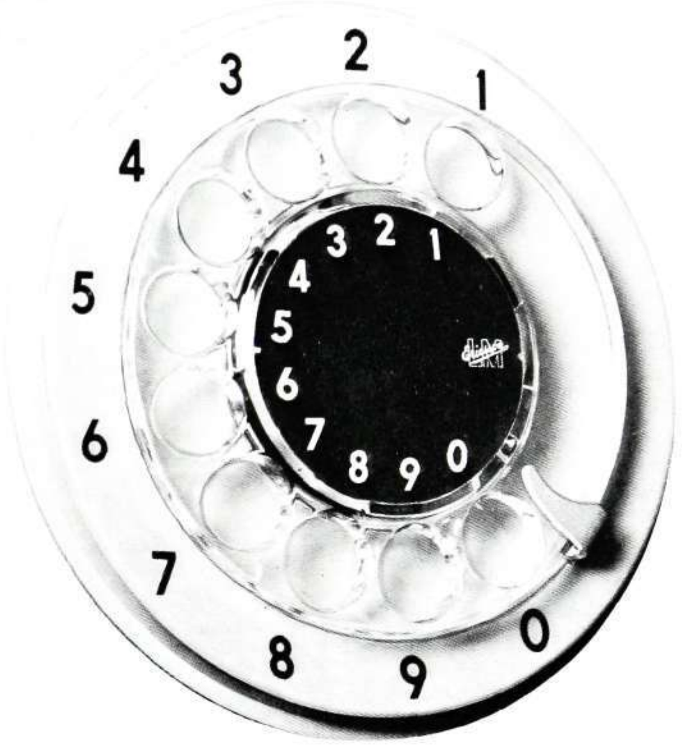
A prerequisite for correct dialling is a dial of high quality and reliability, needing little maintenance in long-time use. In the design of the new dial attention has been paid to the fact that the dial must be able to work with old step-by-step type telephone systems and must also be adaptable to future types of exchanges. As the dial pulses in some telephone systems are repeated several times without pulse correction, strict requirements must be placed on the dial pulses so as not to jeopardize the correct setting-up of calls.

L M Ericsson are marketing telephone instruments all over the world, which must operate satisfactorily for a long time in various environments and under different operating conditions. From these various considerations the following conclusions may be drawn concerning the demands to be placed on a modern dial:

☐ Correct dial speed and pulse ratio for correct connection of calls even under difficult conditions.

☐ Possibility of adapting dial speed and pulse ratio to suit different types of exchange.

Fig. 1
Dial type RGA 750



☐ Long interdigit pause (the time between two pulse trains) to permit the dial to work with old exchanges.

☐ Small contact bounce to permit working with modern electronic exchanges.

☐ Long service life and little maintenance.

☐ Faultless operation even in severe climates.

Operation and Mechanical Design of Dial

The requirements of exactness in pulsing, long service life and resistance to environmental factors place great demands on the pulsing system and mechanical design of the dial.

Extensive theoretical and practical studies of the pulsing system, gears, choice of material and finishing treatments were made before the design principles were laid down. This, in combination with detailed and long-time tests, has resulted in a dial of great exactness and long service life.

The dial consists of a mechanism containing motor spring, gear unit, pulsing unit, contact springset and governor. The cover plate is screwed to the mechanism and the finger-wheel snaps onto a hub connected to the central gear. The rear of the dial is protected by the casing.

Dials are available for speeds of 10, 16 or 20 Hz. By using different pulsing gears, optional make-break ratios are obtainable.

A detailed description of the various parts (fig. 2), their operation and characteristics is given below.

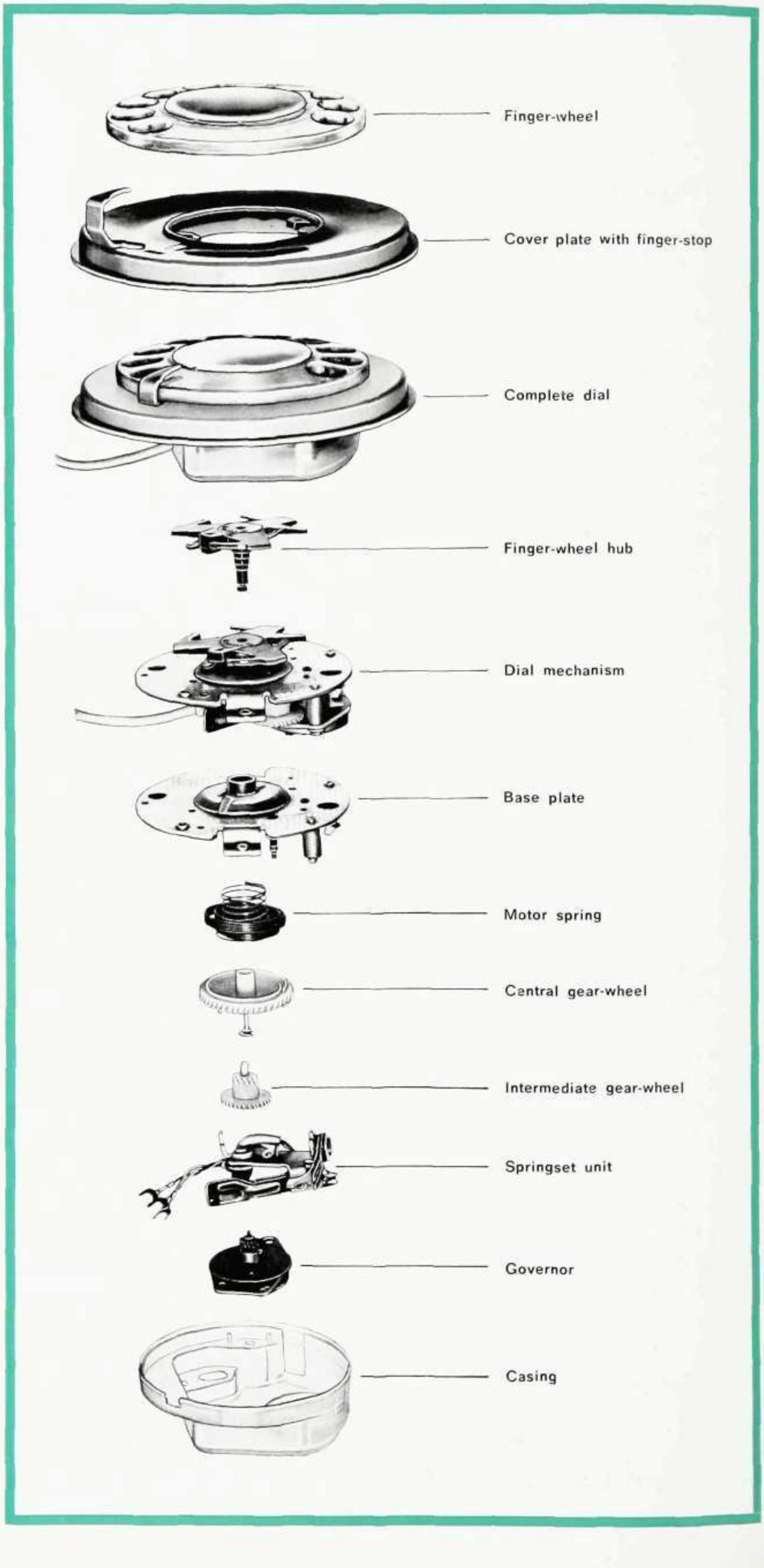
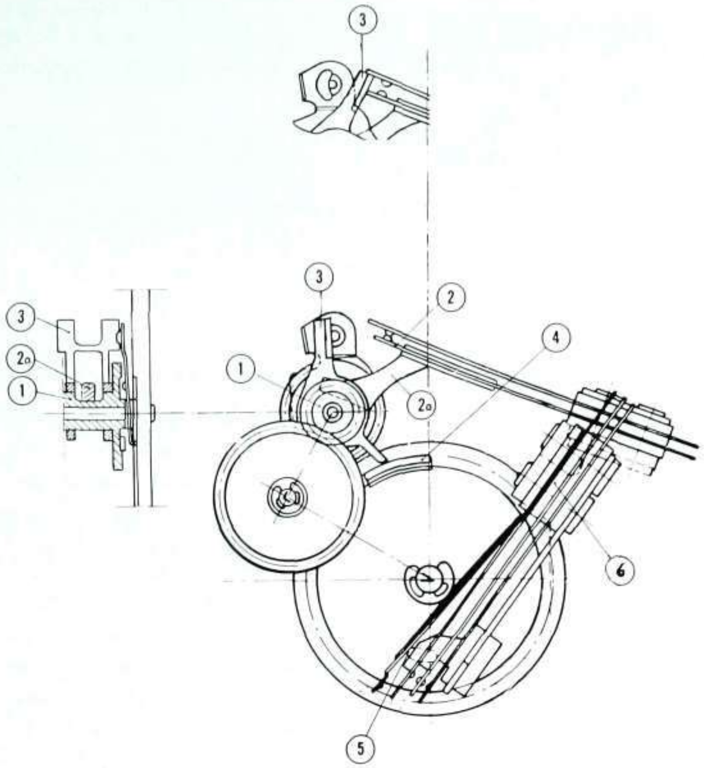


Fig. 2
Main components of the dial

Fig. 3
Pulsing unit with the governor removed



Pulsing Units

The pulsing unit (fig. 3) is a single-cam system, which means that all pulses are produced by a single pulsing cam. The pulsing unit consists of two eccentrics, one of which is divided into two, each operating its pulsing spring. When the dial is rotated, the pulsing gear (1) is turned anticlockwise and the lower pulsing spring (2) is operated via the lifting stud (2a) which is moulded to the spring and rests against the middle eccentric of the pulsing gear. The upper pulsing spring moves in step with the lower. The relative movement thus arising between the pulsing contacts cleans the contacts and ensures reliable contact performance. During the return movement of the dial, the pulsing gear rotates clockwise and the eccentric arm (3), which is mounted on the outer eccentrics, follows the movement. When the lower pulsing spring is raised, the eccentric arm below the upper pulsing spring is turned and thus produces a pulse when the lower pulsing spring is lowered again. After the last pulse the eccentric arm is pushed aside via a boss (4) on the central gear. This guarantees that the correct number of pulses is sent out.

Another boss (5) on the central gear operates the short-circuiting springset (6) during the return movement of the dial, thus removing the short-circuit on the transmission circuit of the telephone instrument. The time sequence between the last pulse in a train and the removal of the short-circuit on the transmission circuit is determined by the position of the bosses on the central gear in relation to each other and is thus easy to maintain.

A pulsing system like the one described offers considerable technical advantages, such as:

☐ Uniformity of pulses, as a single cam generates all pulses. The pulse ratio is not affected by play in bearings as is the case with certain dials, in which the pulsing device is placed on the central shaft (10-cam system).

☐ Constant dial speed, as the gear ratio between the pulsing device and governor is low and the exactness of the gear has very little influence on the speed of the pulsing device.

☐ Extreme reliability of contacts, as the considerable sliding of the pulsing contacts cleans the contacts before the pulse train is sent out.

☐ Small contact bounce, as the movement of the pulsing springs is forcibly controlled.

Governor

The requirements on the governor may be summarized as follows:

☐ The governor must be insensitive to change of torque. The reason for this is partly that, during the return movement, the motor spring does not give a constant torque and partly that the friction losses in motor spring, bearing and gear vary according to climate, temperature and wear.

☐ The governor must be insensitive to changed coefficient of friction between governor stud and governor cup. The coefficient of friction will change according to climate, temperature and physical variations of the material used for the governor studs and cups.

To meet these exceptional demands, a governor of so-called drive-bar type (fig. 4) has been chosen for this new dial. In principle, the drive-bar governor differs from an ordinary centrifugal governor through its use of a drive-bar that drives the governor weights ahead of it. If an attempt is made to speed up such a governor, the force on the governor studs will increase, which increases the speed regulating capacity of the governor. The drive-bar governor can be made entirely independent of variations in the applied torque, so that the dial speed can be kept within very narrow limits. This enhances the reliability of dialling. It sometimes happens that the return of the dial is by mistake speeded up with the fingertip, which results in too high dial speed and connection to a wrong number if the exchange equipment cannot follow. The construction we have chosen does not permit forced return, and thus one source of subscribers'

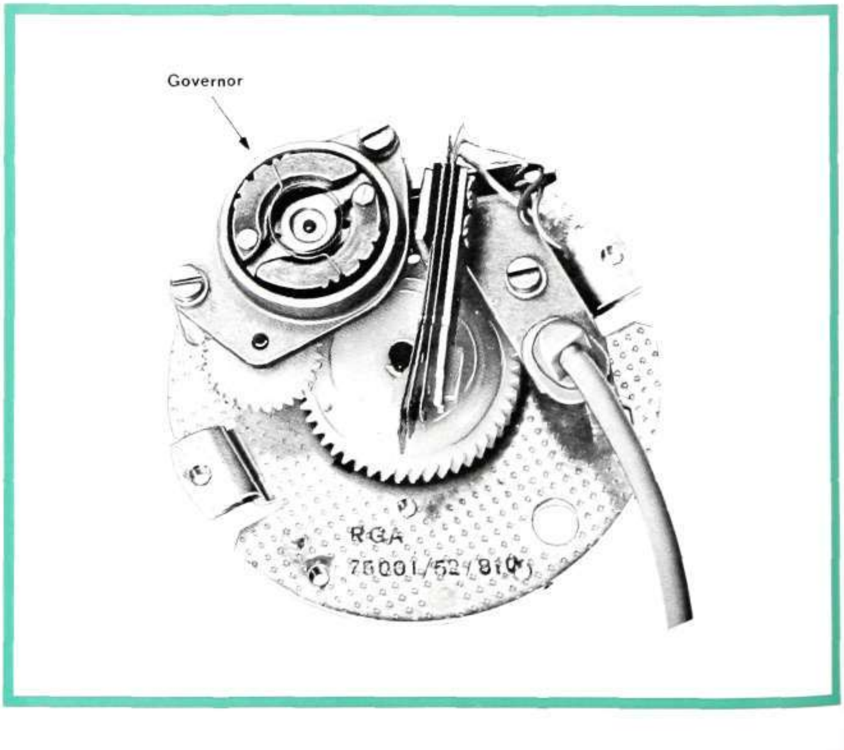


Fig. 4

Dial mechanism with governor

The drive-bar in the centre of the governor drives the governor weights during rotation of the dial

faults is eliminated. The governor is made as a separate unit, placed so as to be easily accessible for inspection and adjustment. The governor unit can easily be replaced if another dial speed is required.

When the dial has been mounted in the telephone, the governor lies under the dial mechanism. This means that worn particles cannot get into the gear or the contact springset and cause trouble.

Gear System

The gears have oblique involute teeth. Oblique teeth have a greater mechanical strength and are quieter in operation than straight teeth.

Some of the gear-wheels are made of formaldehyde and the others of polyamide. This combination of materials ensures the least possible wear. Only initial lubrication of the gear is needed.

Springset Unit

The springset unit in the dial consists of pulsing springset and a short-circuiting springset. The springs have twin contacts of well proven silver-copper alloy, which in combination with good contact slide and good contact pressure provides a highly reliable contact function.

The insulators between the contact springs are phenolic mouldings and have excellent insulating properties.

Motor Spring

The motor spring is a 3-coil helical spring. Being placed under the central gear-wheel, it is protected against dust, water, etc. This position also prevents unintentional changing of the bias of the spring when replacing the cover plate or finger-wheel.

Bearings

The combination of materials in all bearings is steel against plastic. The bearings are dimensioned for high wear resistance and large variations of temperature and humidity. Extensive long-time tests have shown that the bearings need only be initially lubricated.

Clutch Spring

The clutch spring is placed on the governor shaft. Owing to the large gear ratio between the central gear-wheel and the governor, the spring is well protected against overload.

Finger-Wheel

The finger-wheel is a transparent acrylic moulding. It snaps onto the finger-wheel hub, which eliminates the risk of cracking of the plastic. The finger-wheel hub is of resilient plastic, which protects the central bearing against overload.

Casing

The casing is made of plastic and forms a seal with the edge of the cover plate and the sleeve protecting the dial cable against strain. The casing also encloses the governor cup and prevents worn-off particles from getting into contacts in the telephone set.

Properties

Extensive long-time tests have been made in order to establish the properties of the dial. Concurrently with the design of the dial, modern test equipment has been developed with which realistic functional and environmental tests have been carried out.

Unless otherwise stated, the properties of the dials described below apply to a normal environment, i.e. 20° C ± 2° C and 30—60 % relative humidity.

The *mechanical stability* of the dial is very good, as the fitting of the dial mechanism and outer parts cannot affect the function of the dial.

The *electric strength* of the insulation between live parts and between live parts and frame is $\geq$ 500 V DC instantaneous.

The *insulation resistance* between the leads and frame at 500 V DC during 1 min. is above 1000 Mohms measured after 4 days of normalization at 20° C and about 50 % relative humidity. Even after 7 days of testing at 40° C and 90—95 % relative humidity the insulation resistance is above 100 Mohms when measured 1 hour after completion of the test.

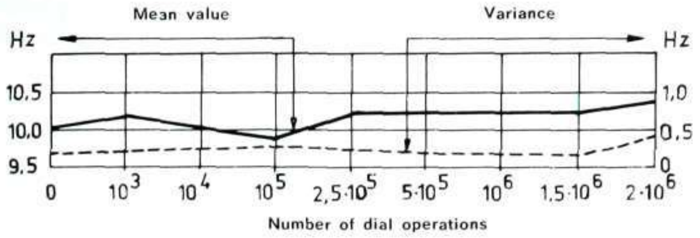
The *torque* is less than 60 mNm when the dial is rotated to the finger-stop. This corresponds to a force of $\approx$ 1.9 N (190 g) in the finger-hole.

Short-circuiting of the transmission circuit of the telephone during transmission of the pulse train is necessary in order that the pulse shape shall not be affected and to obtain the lowest possible line resistance during the pulse train. The removal of the short-circuit must not take place too early, as – with a fast-working telephone system – this might cause an extra pulse from the pulsing relay at the public exchange. After the last pulse the pulsing relay operates via the subscriber's line with the telephone impedance short-circuited. On removal of the short-circuit the telephone impedance causes an instantaneous reduction of the current and the pulsing relay delivers an extra pulse if it has not had time to be sufficiently magnetized. The dial has therefore been designed so that the short-circuit ends as late as possible, which gives about 90 ms between the end of the last pulse and the connection of the telephone impedance with a normal dial (10 pulses/sec) and about 45 ms with a fast dial (20 pulses/sec).

Fig. 5
Dial speed

———— **Mean value**
Left hand scale

– – – – **Variance**
Right hand scale



The *reliability of pulsing* is determined by the interdigit pause, dial speed and pulse ratio:

- The *interdigit pause* is defined as the time between two pulse trains. It consists partly of the time of rotation, which is variable depending on the dialler, and partly on the design of the pulsing mechanism. The latter time is 320 ms and the variable time is estimated at 200–500 ms, so that the total interdigit pause will be at least 500 ms.

- The *pulse period*, defined as the length of each period in ms, is on delivery (10 Hz) 100 ms ± 7 ms and after 2×10^6 dial operations within 100 ms ± 15 ms. The variation of dial speed during the life of the dial will be seen from fig. 5.

- The *pulse ratio*, defined as the ratio of the pulse to the total pulse period, is either 50 ± 3 %, 60 ± 3 % or 67 ± 3 %, and holds good during the whole service life of the dial (2×10^6 operations). See fig. 6.

Ruggedness has been attained through the fact that outer parts such as finger-wheel, cover plate, finger-stop, number ring and finger-wheel hub are made of materials with good resistance to scratching, cosmetics and ordinary detergents, and also to sunlight.

Humidity tests show that the dial works within the stated limits after:

a) Damp heat long-term exposure test, IEC 68-2-3 test C, severity class V (40° C, 90–95 % R.H., 21 days)

b) Accelerated damp heat test, IEC 68-2-4 test D, severity class IV (6 days with total of 6 cycles, 16 h, 55° C, 80–100 % R.H., with condensation).

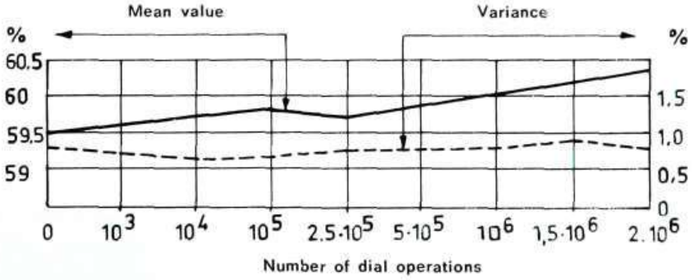


Fig. 6
Pulse ratio

———— **Mean value**
Left hand scale

– – – – **Variance**
Right hand scale

Summary

From the above remarks it will be apparent that the goals set up have been met:

- The chosen design provides long life and high reliability of dialling with small maintenance. The sliding of the pulsing contacts during rotation of the dial ensures self-cleaning of the contacts and improved contact performance during pulsing.

- Thanks to the drive-bar governor the user can only to a small extent affect the dial speed and so jeopardize the reliability of dialling.

- Dial speed and pulse ratio can be simply adapted to old and new telephone systems.

- Through the combination of separate mechanism with special cover plate and finger-wheel the dial can be used in practically all existing wall and desk instruments of any make.

Transmission and Signalling Conditions in the Planning of Local Telephone Networks

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The intention of this article is to describe primarily how, by a simple graphical method, an examination can be made of how the final choice of telephone sets, subscribers' lines, junction circuits and switching equipment is affected by their transmission and signalling characteristics, taking into account the reference equivalents recommended by the C.C.I.T.T.

The concept of reference equivalents is dealt with from different aspects, and the economic consequences of the division of reference equivalents among different units of the local exchange network are also considered without going into details of their calculation.

Good speech intelligibility is the decisive condition for satisfactory conversation on a telephone connection.

Much research has been devoted to establishing standards for the sending and receiving systems. A special working group within C.C.I.T.T. is working on these problems and maintains contact with telephone administrations and other organizations which are coducting their own research within this field. The recommendations are published by I.T.U. (International Telecommunication Union).[1]

Another special working group within C.C.I.T.T., called GAS 2, of which the author was a member, has worked for a number of years on a handbook on "Local telephone networks", which was recently published. This handbook presents a detailed account of the transmission and signalling conditions, among other factors, for local telephone networks.

Reference Equivalents

General

According to C.C.I.T.T. Recommendation P11, Red Book No. V. bis, the maximum nominal reference equivalents for a country are:

sending system $SRE = 20.8$ dB
receiving system $RRE = 12.2$ dB.

The national circuits from the international exchange up to the local networks, for a country of average size (max. 1000—1500 km length of transmission from the international exchange), may have at most three links.

Fig. 1

Distribution of equivalents for an international call in a country of average size

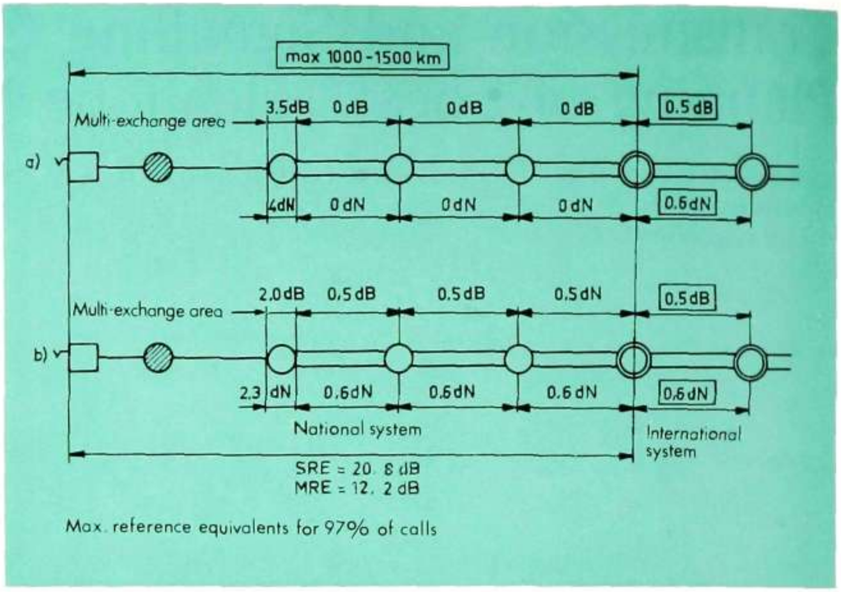


Fig. 1 shows two possibilities for the distribution of the reference equivalent. In both cases a total reference equivalent of 3.5 dB is obtained on the 4-wire links up to the local exchange area.*

The part of the reference equivalent which can be used for the local network is thus:

sending system	17.3 dB
receiving system	8.7 dB.

Alternative Routing via Separate Tandem Stages for the Local Traffic

The distribution of the reference equivalents when separate tandem stages are introduced will be seen from fig. 2 and can be calculated according to the formulae below.

By using separate tandem stages the distribution of the reference equivalents on the junction lines for local traffic is not dependent on the limits for international connections, as mentioned earlier, but only on the fact that the reference equivalents between any two subscribers on local calls should not exceed 30—36 dB.

The following relations apply:

Local traffic

$$x_i + z_{ij} + x_j \leq 30\text{—}36 \text{ dB}$$

x_i, x_j	is the highest reference equivalent for a subscriber's line with telephone set for sending or receiving (when x_i is the sending value x_j should be the receiving value, and vice versa).
z_{ij}	is the reference equivalent of the junction circuits between two exchanges (*i* and *j*).

---

* For alternative b) in fig. 1 the sending and receiving equivalents can be increased by 0.5 dB for every 4-wire link eliminated. For a local network connected to an international exchange, for example, the reference equivalent may be increased by 1.5 dB.

$$\left.\begin{array}{l} x_i + y_i \\ x_j + y_j \end{array}\right\} \leq \left\{\begin{array}{l} 17.3 \text{ dB in sending direction} \\ 8.7 \text{ dB in receiving direction} \end{array}\right.$$

x_i, x_j is the highest reference equivalent for a subscriber's line with telephone set for sending or receiving.

y_i, y_j is the reference equivalent of the junction circuits between the local exchange and the trunk exchange.

The choice of subscriber's cable and telephone set has a direct influence on the choice of junction circuits, and it is an iterative process to find the combination which minimizes the total cost of the subscriber's and junction networks, using the reference equivalents available.

Alternative Routing via Tandem Stage Common to Trunk and Local Traffic

When the local traffic between the exchanges is low, it may be advisable economically to use one (or more) tandem stages for joint routing of the trunk and local traffic.

The distribution of the reference equivalents will be seen from fig. 3.

The same equations apply as in the former case.

Desirable Reference Equivalent Levels within the Network

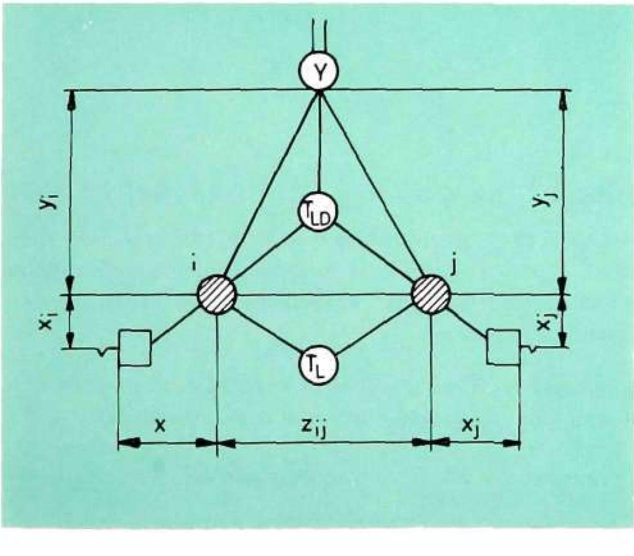
In order that the intelligibility on a call between two subscribers shall be satisfactory, it is desirable that the total reference equivalents for the network are within given limits. Through investigations made by telephone administrations and telephone equipment manufacturers it has been found that, at low levels (high *RE*), the subscribers have difficulty in conducting a satisfactory conversation. At high levels (low *RE*) disadvantages have also been noted. Among other things the risk of crosstalk and overloading of amplifiers on the line increases.

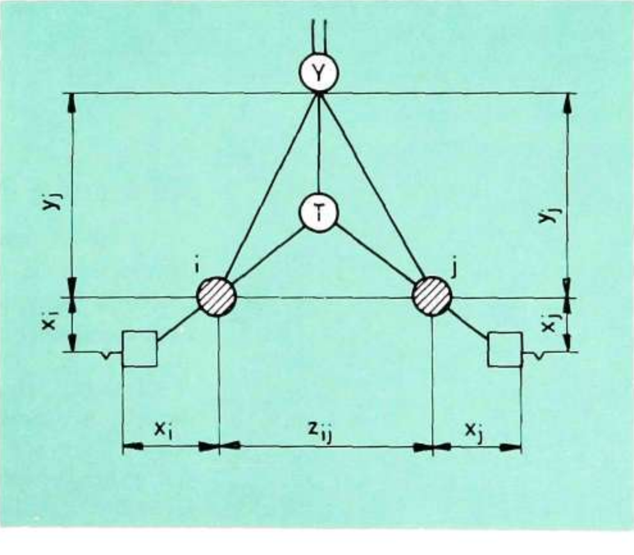
Fig. 2 (left)

Distribution of reference equivalents with separate tandem stages for local and trunk traffic

Fig. 3 (right)

Distribution of reference equivalents with single tandem stage for combined local and trunk traffic





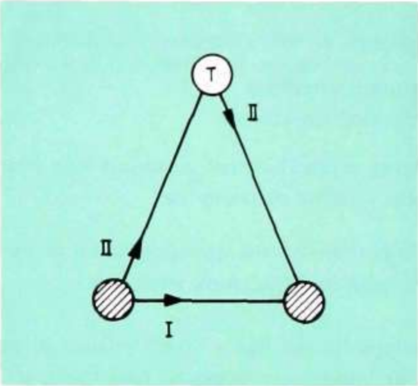


Fig. 4

Alternative routing between two exchanges belonging to the same tandem area

I Direct route (1st choice)
II Alternative route (2nd choice)

It has been found that a reference equivalent range of 0 to + 30 dB yields satisfactory results,[1] which it has been possible to attain by simple means through the now generally existing telephone sets with automatic attenuation regulation.

This attenuation regulating effect is illustrated in figs. 6 and 7, which are commented on under "Subscriber's Telephone Set" on page 145.

New C.C.I.T.T. Recommendation for Determination of the Reference Equivalent of a Cable per Km

In determining the reference equivalent of unloaded cables of small conductor diameter, it has been found that the image attenuation at 800 Hz, which is usually stated in cable specifications, does not yield realistic results. Many administrations, after carrying out investigations of their own, have decided that higher frequencies should be used. Within C.C.I.T.T. a proposal has now been introduced as to how the reference equivalent, q/km, should be calculated. The method is described in detail in C.C.I.T.T.'s handbook "Local Telephone Networks", Chapter V, Annex 3. The section showing how the corrected value should be calculated for different cable diameters is quoted below.

> "The experience of many Administrations shows that the reference equivalent q of a subscriber's line (homogeneous line in unloaded cable) may be represented with sufficient accuracey for network planning requirements by the following type of formula:
>
> $$q = K \cdot \alpha_{800}$$
>
> where α_{800} is the image attenuation of the line at 800 Hz.
>
> K is a constant independent of the length of the subscriber line but dependent to some extent on the diameter d of the conductors.
>
> Administrations which do not have results of reference equivalent measurements carried out in their networks can use the values of K obtained by formula
>
> $$K = 0.875 \cdot d^{-0.25}$$
>
> The following table gives the values of K obtained by this formula in respect of a few d values in current use.

d (mm)	0.32	0.4	0.5	0.6	0.65	0.7	0.8	1
K . . .	1.17	1.10	1.04	1	0.98	0.96	0.93	0.87"

Alternative Routing Principles in a Multi-Exchange Area

For the planning of a network of several exchanges different routing alternatives must be studied. These are directly dependent on the facilities of the telephone exchanges and tandem stages used in the network in respect of alternative routing and signalling system.

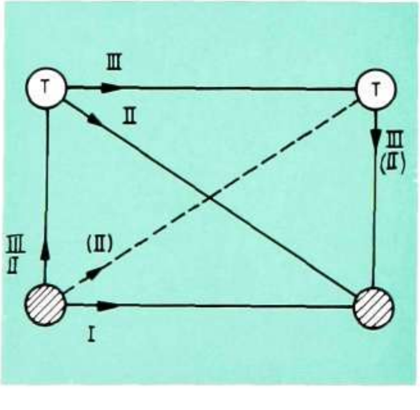
An earlier article in Ericsson Review[4] contains a detailed account of how the most economical structure of a junction network is calculated.

The fundamental principles for alternative routing can be most clearly described by figs. 4 and 5.

Fig. 5

Alternative routing between two exchanges belonging to separate tandem areas

I Direct route (1st choise)
II Alternative route (2nd choice) (Under certain circumstances this routing can be directed over the second tandem stage.)
III Alternative route (3rd choice)



Transmission Properties of the Various Elements in a Multi-Exchange Network

General

A multi-exchange network may suitably be divided into the following elements:

- Subscriber's telephone set
- Subscriber's line
- Local exchanges and tandem stages
- Junction circuits for trunk and local traffic.

Subscriber's Telephone Set

Great advances have been made in recent years in the design of telephone sets. The transmission properties of the receiver and, particularly, of the microphone have been continuously improved.

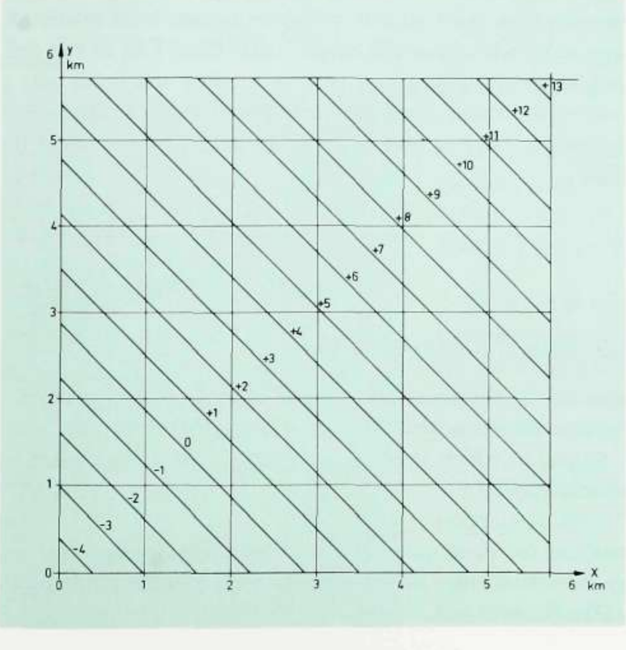
There are now telephone sets with automatic atteuation regulation which prevent unpleasantly speech levels for subscribers with short line. The improved microphone and receiver characteristics can the be utilized without risk, so that subscribers with long lines have better transmission conditions. The result is that the variations of level are less dependent on the length of the subscriber's line within an exchange area.

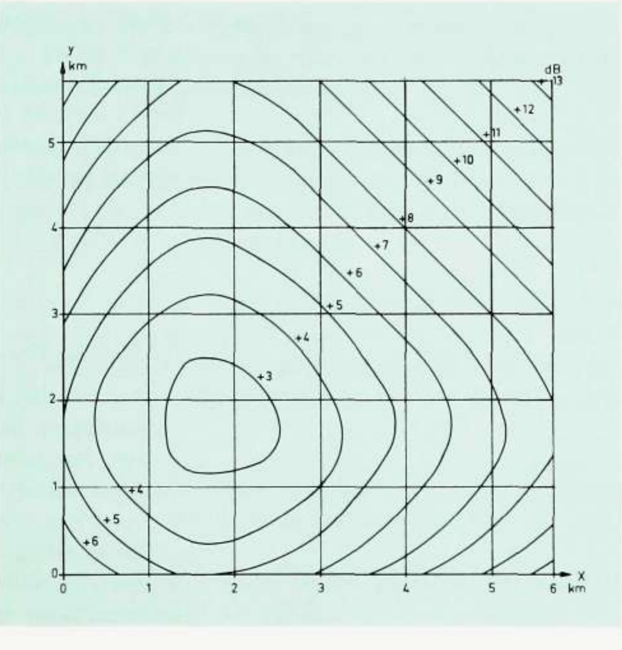
The regulating effect is clearly seen in figs. 6 and 7, which show level topograms from which the total *RE* between two subscribers anywhere in the network can be directly read.

The level topogram has been calculated for a specific diameter af subscriber's cable. The topogram shows the total *RE* between two subscribers within a single exchange area. On a connection between subscribers within different

Fig. 6 (left)
RE level topogram
(telephone set without attenuation regulation)

Fig. 7 (right)
RE level topogram
(telephone set with automatic attenuation regulation)





areas the *RE* for the junction circuit must be added to the value of the topogram.

The reference equivalent has been calculated according to the following formula:

$$RE_{tot} = (x + y)\,q + SRE_x + RRE_y$$

where x = sending subscriber's line in km

y = receiving subscriber's line in km

q = RE/km of the subscriber's line

SRE_x = sending reference equivalent of the telephone set at x km

RRE_y = receiving reference equivalent of the telephone set at y km

The level topograms shown in figs. 6 and 7 relate to a telephone set with linear characteristics both for microphone and receiver. The regulating effect (fig. 7) has been equal for the microphone (sending system) and the receiver (receiving system).

The transmission characteristics of the telephone set have a decisive influence on the extent to which the sending and receiving reference equivalents recommended by C.C.I.T.T. can be allowed on subscriber and junction lines. A telephone set with good transmission characteristics may therefore result in a reduction of the costs for subscriber and junction lines.

Subscribers' Lines

The commonest types of subscribers' lines today consist of unloaded 0.4 or 0.5 mm cable. 0.32 mm cables have been introduced in certain very densely populated cities.

Using the principle recently proposed by C.C.I.T.T. for correction of the image attenuation at 800 Hz, which is normally stated in cable specifications, the method of calculation of *RE* for cables can be established and used in an unambiguous manner.

Since the attenuation of an unloaded cable, which is the usual choice for subscribers' lines, increases with the frequency, frequency distortion arises. On converssation over long subscriber lines this might cause distortion of the character of the speaker's voice. To counteract this, in modern telephone sets a certain amount of pre-emphasis has often been attained in the frequency characteristic of the microphone. A rise of 8—12 dB between 300 and 3400 Hz appears to be satisfactory.

Local Exchanges and Tandem Stages

The insertion loss added by the local exchange is often included in the *RE* indicated for telephone sets, since this loss chiefly derives from the feed system. For tandem stages, in which there is no feed, an additional insertion loss of 0.5 dB is often calculated.

The signalling conditions for local exchanges are dependent on the telephone system used and may in certain cases be the decisive factor in the planning of multi-exchange networks.

The following signalling values are permissible with L M Ericsson's common control systems:

• Maximum loop resistance for subscriber's line including telephone set	1800 ohms
• Maximum loop resistance for junction circuits (DC signalling without extra voltage)	2000 ohms
• Maximum loop resistance for junction circuits (DC line signalling with extra voltage)	approx. 3600 ohms

Junction Circuits for Trunk and Local Traffic

Through the introduction of modern signalling methods, which have raised the permissible loop resistance, and of modern telephone sets, which through improved transmission characteristics have raised the available RE, it has become possible to use, for example, 0.5 mm cables on long-distance junction circuits.

A contributory factor is the modern and economical loading equipments. Loading is probably the commonest method at present of reducing the cost of the junction network. It also eliminates the frequency distortion since the attenuation is practically constant within the 300—3400 Hz frequency band.

There are other methods as well of achieving satisfactory and economical junction circuits, such as

- two-wire amplifiers
- carrier system on twin cable (e.g. PCM)
- coaxial cables
- radio links
- negative impedance repeaters.

Junction Cable Network Relative to Subscribers' Cable Network

As the number of exchanges in a multi-exchange area grows, it is abvious that, of the total originated traffic from subscribers, an increasing portion is directed over the junction network between the exchanges.

The number of pair-km of junction cables in such a network therefore grows rapidly with the number of exchanges in the area. At the same time it is normal that the exchange areas will be reduced in size as a consequence, among other things, of the growing subscriber density.

The growth of the ratio (F) between "total pair-km junction lines" and "total pair-km subscriber lines" with the number of exchanges (n) has been studied for an idealized case in which the subscriber density in the area has been assumed to be uniformly distributed. The originated traffic per subscriber has been taken as parameter (fig. 8).

The function has proved to be in close confirmity with several cases in practice in which there have been varying subscriber densities within the area.

With 50—70 exchanges the junction lines will attain the same total length as the subscriber lines.

Fig. 8

Ratio (F) between Total pair-km junction circuits and Total pair-km subscribers' lines in a multi-exchange network with (n) exchanges

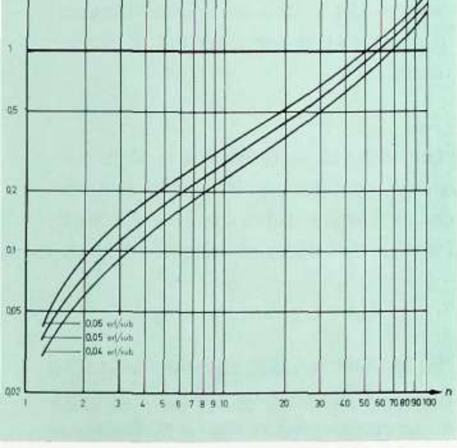


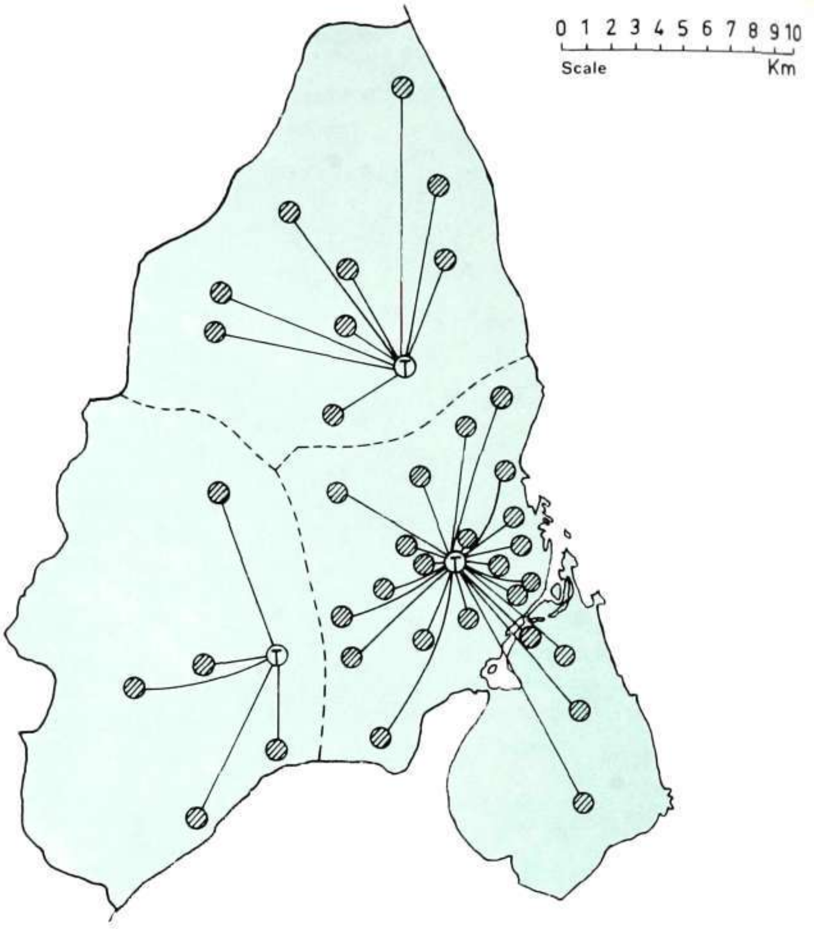
Fig. 9

Local exchange network with 3 tandem areas

Ⓣ Tandem exchange (total 3)

▨ Local exchange (total 40)

– – – Boundary of tandem area



If we instead consider the relation between the costs for the corresponding cable networks (excluding repeaters and selector inlets for the junction lines), cost equality is attained at about 20—30 exchanges in the network.

Including the costs for repeaters and selector inlets, cost equality comes appreciably earlier, which means that the savings on the junction network that can be achieved through the introduction of alternative routing may result in a significant reduction of the total cost of line plant in a multi-exchange area.

The economical significance of the junction network in large multi-exchange areas results in the fact that the tandem exchanges in the peripheral tandem areas are shifted towards the centre. This is clearly apparent from fig. 9, showing a local exchange network with three tandem areas.

It is interesting to note, however, that this central shift of the tandem exchanges may be virtually eliminated through the introduction of carrier systems on the junction circuits between the tandem exchanges, since the cost for such systems is only to a slight extent dependent on the distance between the exchanges.

Under these assumptions the tandem exchange will be centrally situated within every tandem area and savings can be made on the cost for junction circuits between the tandem exchange and the terminal exchange (fig. 9).

Calculation of the Reference Equivalents by a Graphical Method

The reference equivalents for the various parts of the network can be simply calculated by means of nomogram as shown in fig. 10.

For the sake of simplicity the figure shows only the sending system of the telephone set, and furthermore only one dimension of subscriber's cable has been included. In practice the nomogram is made up both for sending and receiving *RE* for the telephone set. All types of cables used for subscriber lines are also drawn in the nomogram (fig. 12).

The nomogram shows the *RE* on the *y*-axis and the loop resistance for the subscriber's line on the *x*-axis.

The national sending reference equivalent, *SRE*, has been established by C.C.I.T.T. at max. 20.8 dB and constitutes the upper limit of the nomogram (fig. 10).

As appears from fig. 1, 3.5 dB is reserved for the 4-wire trunk network. The remaining *RE*, 17.3 dB, constitutes the upper limit for the local network (generally 2-wire circuits).

The *SRE** of the telephone set is generally indicated as function of the loop resistance and excluding the contribution to the *RE* of the actual subscriber's line. By reducing the *SRE* of the telephone set from the 17.3 dB level and in-

---

* In the nomogram, to describe the worst case, the reference equivalent of the telephone set including manufacturing tolerance must be used as *SRE*.

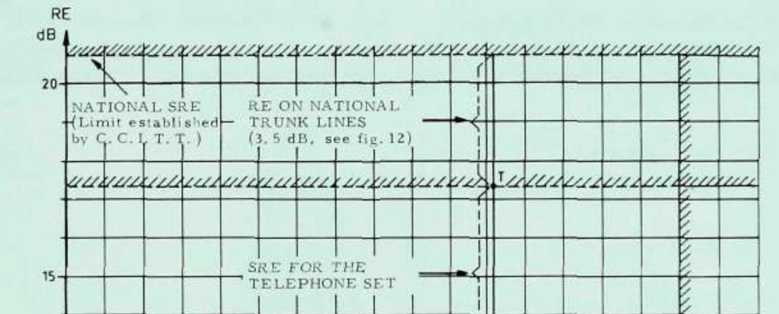


Fig. 10

Nomogram for calculation of the reference equivalents in a local exchange network

serting the *RE* for the subscriber's line on the basis of the 0-line (x-axis) of the nomogram, one obtains an area between the *SRE* of the telephone set and the *RE* of the subscriber's line which constitutes the remaining *RE*. This remaining *RE* may be used for junction lines and tandem stages, if any, between the local exchange and the trunk exchange in the network.

By simultaneously drawing on the nomogram alternative cable dimensions for subscribers' lines one can study the most suitable choice of subscribers' and junction cable dimensions which do not exceed the stipulated *RE*.

The receiving reference equivalent (*RRE*) of the telephone set is inserted analogously, proceeding from its upper limit, 8.7 dB. It should be noted that the *RRE* generally has negative values, so that the curve will lie above the 8.7 dB line.

The loop resistance limit is dependent on the switching system and is marked on the nomogram.

Example of Calculation

General Data of the Telephone Network

The method of calculating the distribution of the reference equivalents (*RE*) in a multi-exchange area and of establishing from them the dimensions of subscriber lines, junction and toll circuits will be shown by an example taken from reality.

The earlier described graphical method will be used. The data of the reference equivalents of telephone sets and subscriber lines applying to this case have been drawn on the nomogram.

Fig. 11 a
Multi-exchange area (Beirut, Lebanon)

- ◎ Trunk exchange
- ○ Local exchange
- - - - Boundary of local exchange area

Fig. 11 b
Example of calculation (Beirut, Lebanon)

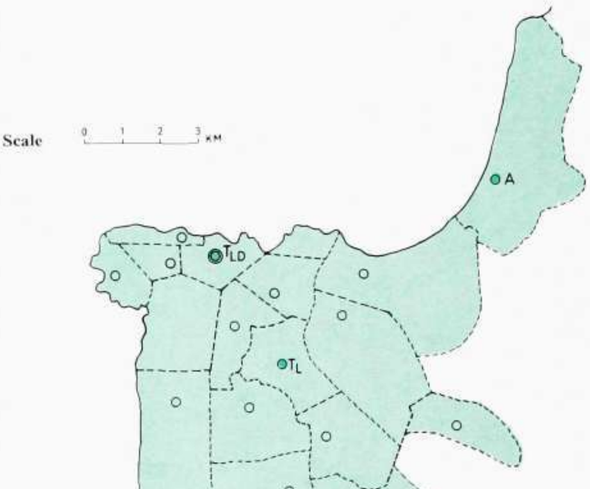


Fig. 11a

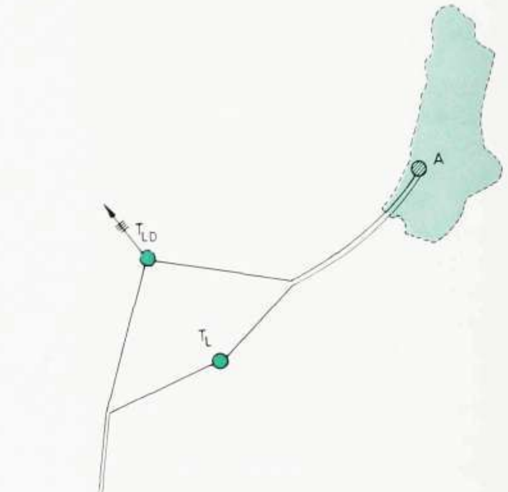


Fig. 11b

For a multi-exchange area a forecast has been drawn up of the expected subscriber growth. On the basis of this forecast the economical exchange locations and areas have been established as seen in fig. 11. According to the forecast there will be 200,000 subscribers within the main exchange area, which has been divided into about 20 local exchange areas.

It is found that the minimum cost is obtained by having separate tandem stages for the trunk traffic (toll) and the purely local traffic. The tandem stage for the trunk (toll) traffic, T_{LD}, was in this case situated in the same exchange as the 4-wire trunk exchange. The tandem stage for the local traffic, T_L, has a central situation in the network.

The routing principles in this case are thus described by figs. 2 and 4.

A transmission calculation is carried out for all exchanges in the network, but we shall show only the calculation for exchanges A and K, which moreover represent the most remote subscribers in the network.

Otherwise the following conditions apply:

Telephone exchanges:	Alternative routing possibilities. Maximum loop resistance on subscribers' lines is 1800 ohms, of which 1600 ohms refer to the subscribers' lines. Maximum loope resistance on junction and toll circuits is normally 2000 ohms but, with an additional voltage, can be raised to 3600 ohms.
Telephone sets:	L M Ericsson's DIALOG *6/DLG* with automatic attenuation regulation.
Cables:	Subscribers' cables with 0.4 mm conductor diameter are planned throughout the network. The cables have a capacitance of 38 nF/km. The cables for junction and toll circuits must be loaded in order to reduce the attenuation and so the cost of the network. Loading coils with 74 mH at 1850 metres spacing.
Subscribers' line length:	In both exchange areas A and K, the maximum length of subscribers' lines is 4.0 km.

Calculation of RE on Junction Lines for Trunk Traffic (Toll Lines)

The calculation of the reference equivalent and loop resistance on the toll lines is shown in the table below for a number of different coductor diameters. The cables have medium loading, 74 mH with 1850 m spacing, whereby an essential reduction of the *RE*/km (*q*) is obtained without any limitation of the transmitted frequency band (300—3400 Hz). This loading gives a cut-off frequency of 4300 Hz. Thus the maximum transmitted frequency of the speech band (3400 Hz) does not exceed 0.8 times the cut-of frequency.

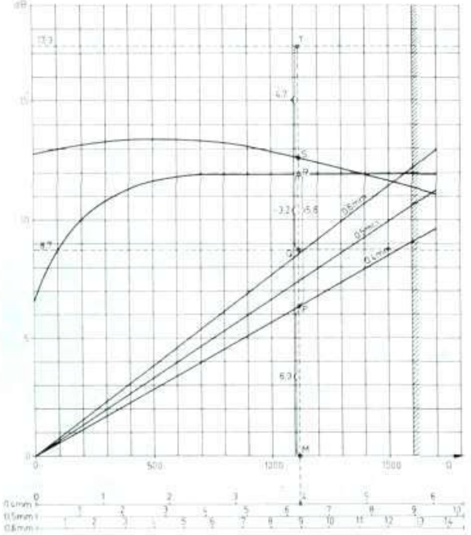


Fig. 12

Nomogram for calculation of local exchange network with RE for telephone set and subscriber lines

	Distance km	Cable diameter mm	RE/km dB/km	RE dB	Resistance/km ohms/km	Resistance ohms
I	9.84	0.5	0.78	7.68	181.3	1784
		0.6	0.55	5.41	127.3	1253
		0.7*	0.41	4.03	94.3	928
II	12.40	0.5	0.78	9.67	181.3	2248
		0.6	0.55	6.82	127.3	1579
		0.7*	0.41	5.08	94.3	1169

I: *Exchange A — Trunk exchange*
II: *Exchange K — Trunk exchange*

* We now easily find from this table that a loaded 0.7 mm cable fulfils our requirements and should therefore be chosen.

The maximum reference equivalents which can be permitted in our case between the local exchange and the trunk exchange are represented by the distance *P—R* in the nomogram (fig. 12) and is 5.6 dB. This value includes the loss in the tandem stage T_{LD}, which is 0.5 dB. The remaining *RE* for the actual toll lines will be 5.1 dB.

Calculation of RE on Junction Lines for Local Traffic

The calculation of the reference equivalent and loop resistance on the junction lines is shown in the table below. The cables have the same loading as in the toll line case.

According to the recommendations in C.C.I.T.T.'s handbook "Local Telephone Networks" the *RE* between two local exchanges must not exceed 12—19 dB. A maximum value of 15 dB has been suggested in our case.

The maximum loop resistance may be 2000 ohms with normal DC line signalling. Using an extra voltage the loop resistance may amount to 3600 ohms.

	Distance km	Cable diameter mm	RE/km dB/km	RE dB	Resistance/km ohms/km	Resistance ohms
I	10.63	0.5	0.78	8.29	181.3	1927
		0.6*	0.55	5.85	127.3	1353
		0.7	0.41	4.36	94.3	1002
II	12.54	0.5	0.78	9.78	181.3	2274
		0.6*	0.55	6.90	127.3	1596
		0.7	0.41	5.14	94.3	1183
III	22.24	0.5	0.78	(17.35)	181.3	(4032)
		0.6*	0.55	12.23	127.3	2831
		0.7	0.41	9.12	94.3	2097

I: Exchange A — Tandem stage T_L
II: Exchange K — Tandem stage T_L
III: Exchange A — Exchange K

The values within brackets in the table exceed the stipulated limits.

Both with an alternativ route via T_L and with a direct route between exchanges *A* and *K* the total *RE* would exceed the maximum stipulated 15 dB if 0.5 mm cable were to be used. In the case of the direct route the loop resistance would also be too high.

The most economical case that fulfils the requirements is 0.6 mm cable and has been marked in the table with an asterisk.

Since in our case the lines follow the same duct route, a common cable can be used for the direct and for the alternative routes.

The total attenuation between exchanges *A* and *K* will be:

Direct route:	12.23 dB
Alternative route:	$5.85 + 0.50\ (T_L) + 6.90 = 13.25$ dB

Calculation of Maximum Total RE for Local Calls

The nomogram in fig. 12 can also be used for calculating the total *RE*. With reference to the formula in fig. 2 we calculate *RE*:

x_i + 4,7 dB *SRE* (4 km), distance *S—T* in the nomogram
+ 6.3 dB Sub.line, *RE* (4 km), distance *M—P* in the nomogram
+ 11.0 dB Total

z_{ij} + 13.3 dB See under preceding heading

y_j — 3.2 dB *RRE* (4 km), distance *Q—R* in the nomogram
+ 6.3 dB Sub.line *RE* (4 km), distance *M—P* in the nomogram
+ 3.1 dB Total

The total *RE* between two subscribers in areas *A* and *K* may thus amount to a maximum of $11.0 + 13.3 + 3.1 = 27.4$ dB, which is below the stipulated maximum of 33 dB in the calculation. (The C.C.I.T.T. handbook "Local Telephone Networks" suggests that the maximum value should be within the range 30—36 dB.)

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Electronic Equipment for Generation of Ringing Signals and Tones

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UDC 621.382:621.395.38
LME 8329 751

Equipments for generation of ringing signals and tones have hitherto been based on rotary generators and cam-disc interrupters. In recent years L M Ericsson have developed and introduced an electronic (static) signalling equipment in which both generation and interruption take place with the aid of semiconductors. The new equipment requires no maintenance whatsoever. This article describes its principle of operation and advantages over previous equipments.

L M Ericsson's previous signalling equipments (e.g. types *BKL 15, 16, 17* and *BKL 137*) are based on rotary generators and cam-disc interrupters. In recent years the Power Laboratory has been working on the development of an electronic equipment requiring no maintenance and free from wear. These properties are of special significance for unattended exchanges, for example, which are becoming increasingly common.

As a first step in the effort to achieve a maintenance-free signalling equipment, static generators were introduced for the ringing voltage and tone voltage (signalling equipment *BKL 138*). Recently a fully static equipment has been developed in which the interruption of signals is also done electronically, i.e. by means of semiconductor contacts. The new equipment, which is supplied in three types—*BKL 251, 253* and *254*—is presented below.

General

In the design of the signalling equipment attention has been paid to the need for considerable variation in the number of necessary signals, depending on the type and size of the exchange and the country in which the exchange is installed. Public exchanges use a smaller number of signals than private branch exchanges. In the latter there are separate signals for internal calls and external incoming calls. Small public exchanges in most European countries have the lowest number of signals, which are also of simple character. Similar exchanges in countries with the British Post Office system often have a larger number of more complicated signals.

Apart from the ordinary 425 Hz tones, special signals of different types are used in different cases:

1. Modulated 425 Hz tone
2. Crackling tone
3. Ticking tone
4. Recently introduced international information tone consisting of three frequencies, 950, 1400 and 1800 Hz
5. D.C. signals.

In large exchanges interrupted ringing signals and ringing tones are divided into several groups displaced in time in order better to utilize the power of the signal generators.

Large private branch exchanges require the largest number of signals, both time-displaced and special signals for internal use.

Typical signals for exchanges of different types will be seen from table 1.

Table 1. Signals for different types of exchange. Time in seconds.

▥ **On**
— **Off**

Signal designation	Signal name	Signal character		
		Public exchange common type	Public exchange in B. P. O. country	P. A. B. X.
TON 1	Busy tone	0,25 0,25	0,75 0,75	0,33 0,33
TON 2	Dialling tone	425 Hz	0,02 0,02 crackling tone 50 Hz	425 Hz
TON 3^1	Ringing tone	1,2 4,65	0,4 0,4 425/50 Hz 0,2 2,0	1,2 4,65
TON 3^2	Ringing tone	1,2 4,65	0,4 0,4 425/50 Hz 0,2 2,0	1,2 4,65
TON 3^3	Ringing tone	1,2 4,65	425/50 Hz 0,4 0,4 2,0 0,2	
TON 4	Intrusion tone	0,17 0,5 0,17 0,17		ticking tone 0,33 0,33
TON 7	Interception tone	0,2 0,2 0,2 0,6 0,2 0,2 0,2 0,2	6,0 1,0	0,2 0,2 0,2 0,6 0,2 0,2 0,2 0,2
TON 10	Progress tone		ticking tone 0,5 0,5	
TON 12	Second dialling tone			0,32 0,32 0,01
TON 13	*First ringing tone*	425 Hz	425/50 Hz	425 Hz
TON 14	End-of-period tone		0,25 2,0	
TON 17	Coinbox tone		0,2 0,2	
TON 22	Seizure tone			0,25 0,25 ticking tone 0,25 0,25 1,0
RG	First ringing* signal	25 Hz	25 Hz	25 Hz
RG_i^1	Calling signal*	1,2 4,65	0,4 0,4 0,2 2,0	1,2 4,65
RG_i^2	Calling signal*	1,2 4,65	0,4 0,4 0,2 2,0	1,2 4,65
RG_i^3	Calling signal	1,2 4,65	0,4 0,4 2,0 0,2	
RG_{iF}	Incoming external call			0,33 0,33 0,33 5,0
RG 22	Ring-back signal			0,33 0,33

* **Internal calls in private branch exchanges.**

Operation

The static signalling equipment consists of the following main parts: ringing and tone generator, interrupter, relay unit, control unit and distribution unit. The block diagram of the unit will be seen in fig. 1.

The voltages from the ringing and tone generator are interrupted in the interrupter unit and extended to the distribution unit via the relay unit. The supervisory circuits in the control unit sense the most important signals in the distribution unit. In the event of a fault in any of these signals, the main equipment is automatically disconnected within 10 s, the standby equipment is brought into operation and an alarm is issued.

Table 2 presents data for the three types of signalling equipments.

Table 2

Type	Applications	Standby equip- ment	Max. number of signals	Number of sub- scribers	Ringing generator output
BKL 251	Large public exchanges. Public exchanges in countries with B.P.O. system. P.A.B.X.	Yes	5 ringing signals (1 continuous, 4 interrupted) 12 tones (including modulated) or 10 tones and 1 D.C. pulse	Max. 10,000 (for P.A.B.X. max. 8,000)	100 VA
BKL 253	Medium-sized and small public exchanges	Yes	2 ringing signals (1 continuous, 1 interrupted) 9 tones	Max. 4,000	100 VA
				Max. 1,000	25 VA
BKL 254	Medium-sized and small public exchanges	No	Same as for *BKL 253*		

Generators

Ringing Voltage Generator

The ringing voltage generator is a thyristor inverter fed with D.C. voltage and delivering a sinusoidal output voltage of 90 V at a frequency of 25 Hz. The generator is made in two sizes, 25 VA and 100 VA nominal output. The block diagram will be seen from fig. 2.

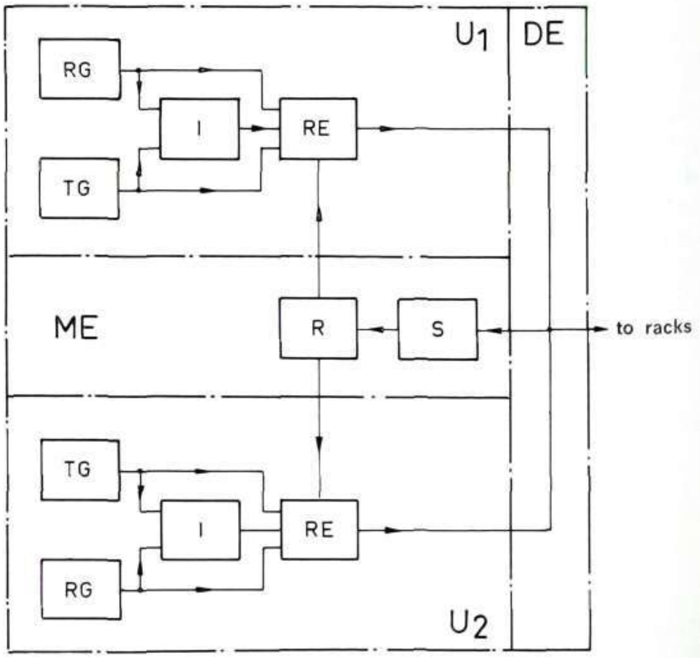


Fig. 1

Block diagram for static signalling equipments BKL 251 and 253

U_1	**Main equipment**
U_2	**Standby equipment**
RG	**Ringing voltage generator**
TG	**425 Hz tone generator**
I	**Interrupter**
RE	**Relay unit**
DE	**Distribution unit**
ME	**Control unit**
S	**Supervisory circuits**
R	**Relay unit in control unit**

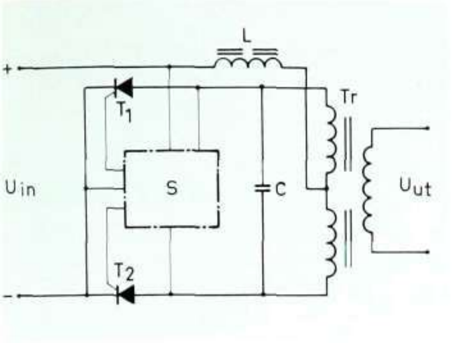


Fig. 2
Block diagram for ringing voltage generator

L	**Choke**
TR	**Transformer**
C	**Capacitor**
T_1, T_2	**Thyristors**
S	**Control circuit**
U_{in}	**Input voltage**
U_{ut}	**Output voltage**

The main components of the generator are the choke *L*, transformer *TR*, capacitor *C*, thyristors T_1 and T_2 and control circuit *S*. The sinusoidal voltage is generated through the fact that the magnetizing inductance in the transformer *TR* and the capacitor *C* constitutes a resonant circuit tuned to 25 Hz. Energy is supplied to the resonant circuit via the thyristors, which conduct alternately. The capacitor *C* also functions as commutating capacitor, i.e. it turns off the thyristors alternately. This is effected by applying the capacitor voltage in the reverse direction across the conducting thyristor at the moment when the second thyristor is fired.

The choke *L* separates the oscillating circuit from the D.C. source, i.e. takes up the voltage difference between them. In this way the choke functions also as smoothing filter for the D.C. source. The firing voltage for the thyristors is supplied by the control circuit *S*.

The inverter is of so called self-oscillating type and is characterized by simple circuitry and low distortion and can withstand sudden changes of load including short-circuiting. A thermal automatic circuit-breaker on the input protects the generator against lengthy overloads.

The mechanical design of the 100 VA ringing voltage generator will be seen from fig. 3. The generator is placed at the bottom of the signalling equipment and plugged into the jack field in the distribution unit. The 25 VA and 100 VA ringing voltage generators have the same base plate and method of attachment. Replacement of a smaller by a larger size of generator as the exchange expands is therefore very simple.

Tone Generator 425 Hz

The generator, which delivers voltage for continuous and interrupted tones, consists of an *LC* oscillator and a power amplifier class B. The generator has two outputs, one 2×25 V for the tone contacts in the interrupter and one with three voltage tappings on the transformer (2, 6 and 10 dBu) for continuous tone. The max. output power is 1 VA. The generator is made up as a printed board assembly and placed on an electronics shelf with the boards for the interrupter.

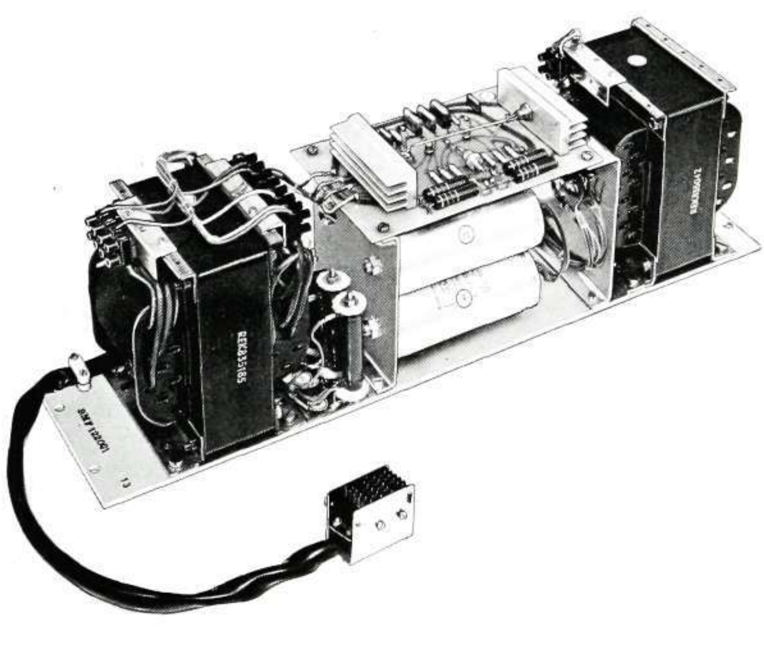


Fig. 3
Ringing voltage generator 100 VA, 25 Hz

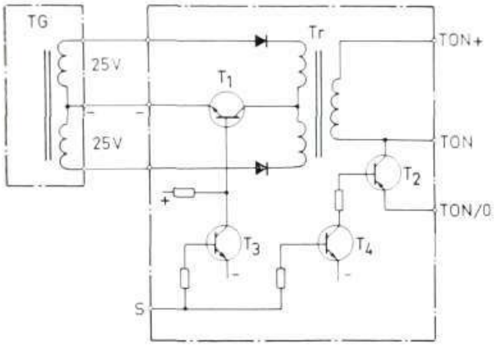


Fig. 4

Circuit diagram for the tone contacts

TG	**Tone generator**
Tr	**Output transformer**
T_1	**Interrupter transistor**
T_2	**Short-circuiting transistor**
TON +	**Tone contact output connected to the positive terminal in the distribution unit of the signalling equipment**
TON	**Signal output**
TON/0	**Tone contact output connected to the return wire**
S	**Control input**

Crackling Tone Generator

This generator, which is used for generation of dialling tone in B.P.O. countries, consists of a relaxation oscillator with unijunction transistor and a power amplifier.

Ticking Tone Generator

The principle of this generator is the same as for the crackling tone generator. The two generators together constitute a printed board assembly, which is placed on the electronics shelf.

Interrupter

The interrupter consists of electronic contacts for ringing, tone and D.C. voltages, and timing circuits for their control. The circuits are made on printed boards and placed on the electronics shelf. The power is supplied by a transistorized series regulator.

Contact for Interruption of Tones

The tone contact has two functions, to interrupt the tone voltage and to short-circuit the signal output during the silent period. The short-circuit takes place to the positive bus-bar in the telephony racks via the separate return wire to each rack. The purpose of the short-circuit is to eliminate crosstalk and the occurrence of noise voltages on the subscribers' circuits caused by the signals in adjacent circuits. The circuit diagram of the tone contact is shown in fig. 4.

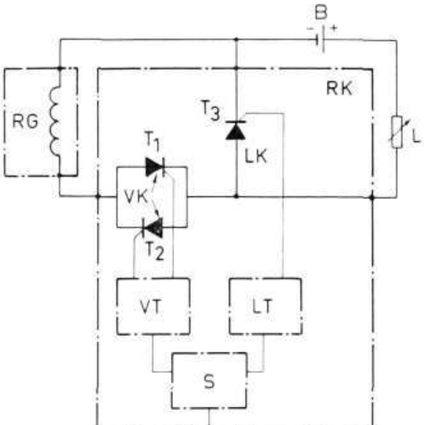
Interruption is effected by means of the transistor T_1. At a control voltage close to negative ("0" signal) on the control input *S*, a base current is applied to T_1, which interconnects the output transformer *Tr* and the output of the tone generator *TG*. At a control voltage close to positive ("1" signal) the transistor T_3 conducts and T_1 is cut off, so opening the circuit for the tone voltage. At the same time a base current is applied to T_2 from T_4 and the signal output is short-circuited to the return wire.

The secondary winding of transformer *Tr* has tappings for 2, 6 and 10 dBu output voltage. Each tone contact can be individually strapped to one of these voltages.

Fig. 5

Block diagram for ringing contact

RG	**Ringing voltage generator**
RK	**Ringing contact**
T_1-T_3	**Thyristors**
B	**Battery**
L	**Load**
VK	**A.C. contact**
LK	**D.C. contact**
VT	**Firing circuit for VK**
LT	**Firing circuit for LK**
S	**Control circuit**
U_S	**Control voltage from timing circuit**



Contact for Interruption of Ringing Signals

Interrupted ringing signals consist of a combination of D.C. and A.C. voltage. During ringing the two voltages are in series across the load. In the silent period the A.C. voltage is disconnected from the load, while the D.C. voltage remains connected. The ringing contact consists of an A.C. contact and a D.C. contact. The A.C. contact conducts during ringing, the D.C. in the silent period. The block diagram is shown in fig. 5.

The A.C. contact *VK* consists of thyristors T_1 and T_2, the D.C. contact *LK* of thyristor T_3. The firing voltage for the thyristors is supplied by the firing circuits *VT* and *LT*, which are alternately activated by the control circuits *S*. Blocking oscillators are used as firing circuits.

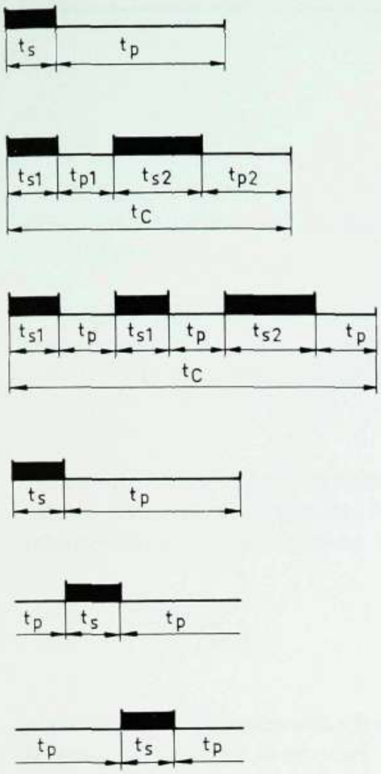


Fig. 6

Signal types according to time character

t_s	**Time when signal sent**
t_p	**Time for silent interval**
t_C	**Time for a signal cycle**

Contact for D.C. Signals

This contact is used for special purposes such as feed of lamps and relays. The contact consists of a power transistor controlled by the timing circuit via an amplifier stage.

Timing Circuits

All timing circuits in the interrupter are based on relaxation oscillators with unijunction transistors and bistable flip-flops. The configuration of the timing circuits depends on the time character of the signals controlled by them. According to the time character the signals have been divided into four types as shown in fig. 6.

Type A Signal with *one* on period and *one* off period.

Type B Signal with two different on and two different off periods.

Type C Signal with two different on periods t_{s1} and t_{s2} and one off period t_p. A signal cycle may include more than two signals. t_{s1}, for example, may be repeated several times within one cycle. The signal may alternatively contain one on period and two off periods.

Type D Signals in three (or possibly two) time-displaced groups according to type A or type C.

Timing circuits for time character type A consist of a relaxation oscillator and a bistable flip-flop. Block diagram and waveform are shown in fig. 7.

For time character types B and C a combination of two timing circuits is required. The timing circuit which controls the contact is controlled by another timing circuit. The timing circuit in fig. 7 can be converted into a controlled timing circuit if a transistor is added in the relaxation oscillator and a second trigger input in the bistable flip-flop.

For time character type D with three time-displaced groups a corresponding series connection of three timing circuits is required.

Change of times is done by changing the charging resistor in the relaxation oscillators.

The timing circuits are characterized by the following properties:

1. Simple change of time with a large time range.
2. Stability to variations of temperature and voltage.
3. Long-time stability.
4. Few components.

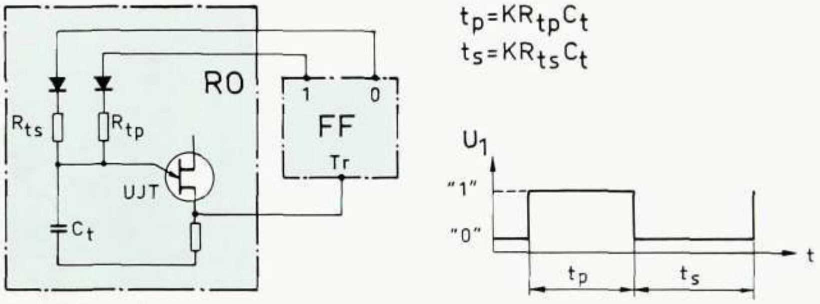


Fig. 7

Timing circuit for signal type A, block diagram and wave form on output

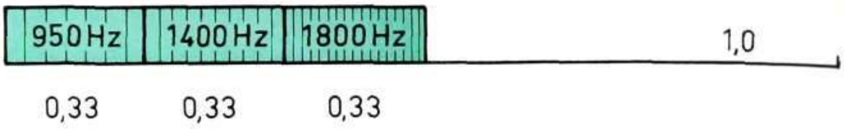
RO	**Relaxation oscillator**
FF	**Bistable flip-flop**
UJT	**Unijunction transistor**
U_1	**Voltage on output 1 of the flip-flop**
Tr	**Trigger input**

Fig. 8

Signal character for international information tone

▥ On
—— Off

Time in seconds



Generation of Special Signals

International Information Tone

The tone consists of three signals of different frequencies. The character is shown in fig. 8.

Generation of signals takes place in accordance with the block diagram in fig. 9. Three tone generators and three tone contacts are used. The contacts are controlled by a timing circuit combination for time character D.

Modulated 425/50 Hz

The 425 Hz voltage is obtained from the tone generator, the 50 Hz voltage from a RC sine wave oscillator. Modulation is effected by applying the 425 Hz voltage to an amplifier, the supply voltage of which changes with the modulation frequency.

Control Unit

The control unit consists of circuits for signal supervision, operation of main and standby equipment, and alarms. It also includes a test unit for manual supervision of the signals. The control unit is shown in fig. 10.

Signal Supervision

The supervision of interrupted signals is done by sensing the change from on to off state, this change zeroing a linearly increasing voltage. If no change occurs, the voltage continues to increase and attains a threshold value at which a relay is actuated. As a result the standby equipment is switched on and an alarm signal is issued.

As a rule busy tone and interrupted ringing signals are supervised, but facilities exist also for supervision of continuous ringing signals. At most two tones and three ringing signals can be supervised.

Control and Alarm Functions

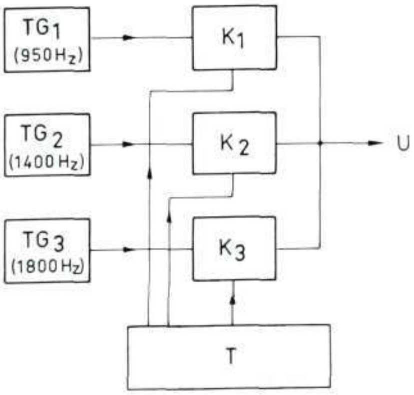
The push-buttons for controls and lamps for indication of state are placed on the front of the control unit. The standby equipment can be switched on manually with a push-button or automatically actuated by the signal supervision circuit. The equipment can also be tested in the idle condition without signals being transmitted to the distribution unit. The test unit is described later in this article.

A minor alarm signal is issued when the standby equipment is brought into operation and in case of blowing of a fuse. The major alarm signal is issued for a persistent signal fault after connection of the standby equipment. In *BKL 254* a major alarm signal is sent immediately after a signal fault.

Fig. 9

Generation of international information tone, block diagram

$TG_1 - TG_3$	**Tone generators**
$K_1 - K_3$	**Tone contacts**
T	**Timing circuit**
U	**Output signal**

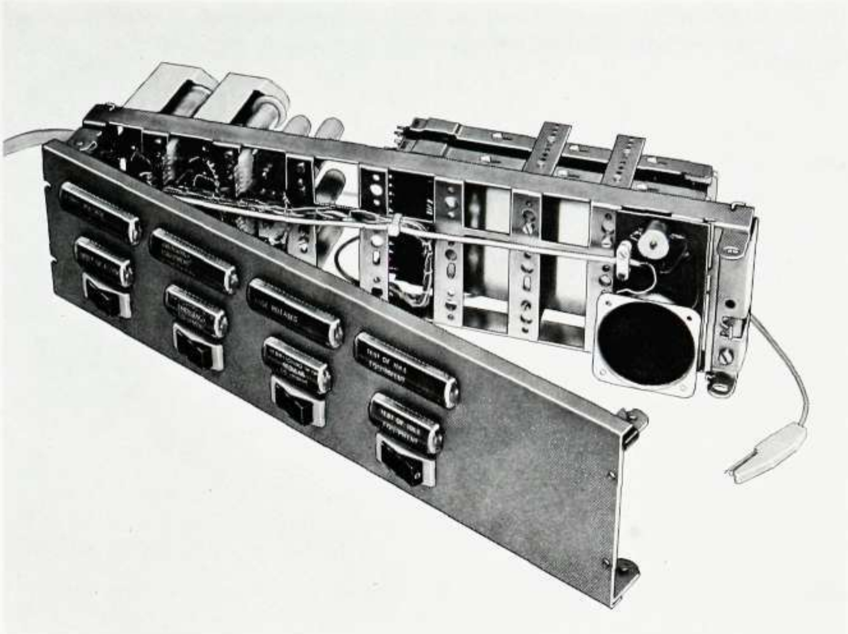


Mechanical Structure

The signal equipment consists of standard modular units placed in wall or floor cabinets for power supply.

Every unit is separately secured in the cabinet with screws. All incoming and outgoing lines terminate on the distribution unit terminal block. The other units plug into the distribution unit.

Fig. 10
Control unit for BKL 251 and BKL 253



The wall cabinet types *BKL 251* and *BKL 254* are shown in figs. 11 and 12.

At the bottom of the cabinet are the ringing voltage generators and the distribution unit. On the door are placed the electronics shelves, relay units and control unit. Space is also provided for an additional unit, e.g. *MRG* equipment.

BKL 251 contains:

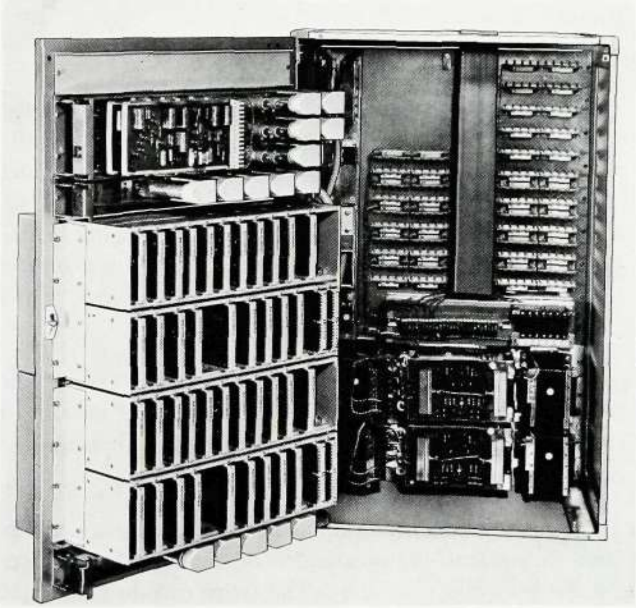
2 electronics shelves, 4-module, i.e. double shelf
2 ringing voltage generators
2 relay units

BKL 253 contains:

2 electronics shelves, 2-module (single shelf)
2 ringing voltage generators
2 relay units

Fig. 11 (left)
Signalling equipment BKL 251

Fig. 12 (right)
Signalling equipment BKL 254



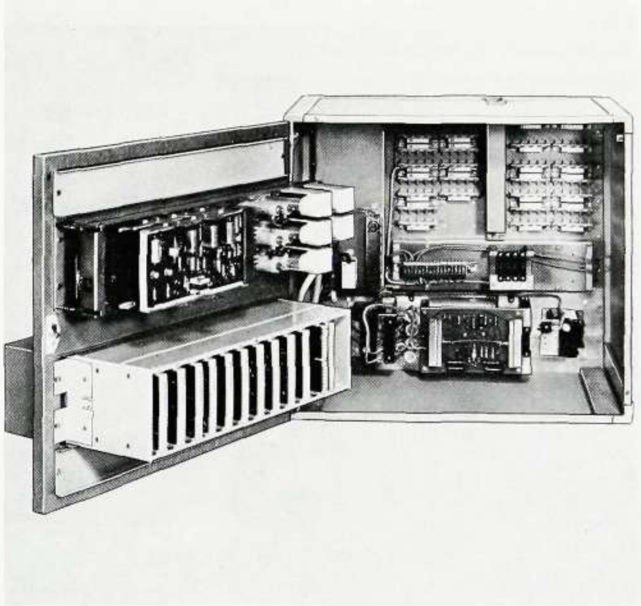
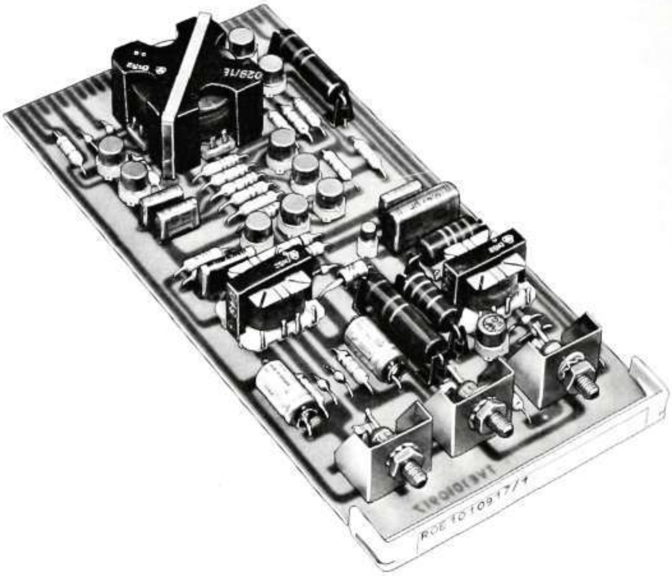


Fig. 13
Printed board assembly with tone and ringing contacts



BKL 254 contains:

1 electronics shelf, 2-module
1 ringing voltage generator

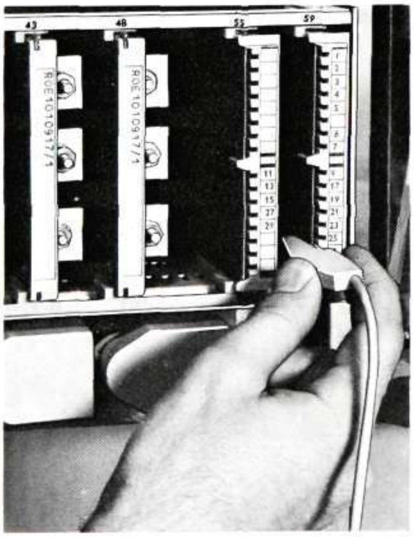
The electronics circuits have been grouped on printed board assemblies, each board forming a functional unit. By way of example the following combinations are built on a board of type *ROE 101*.

1. Two contacts with associated timing circuits for time character type A.
2. Tone contact with timing circuits for time character type B or C.
3. Three timing circuits for time character D.
4. One tone contact and one ringing contact (for *TON 3* and *RG$_i$*, which usually have the same time character)

This method of construction simplifies the wiring of the electronics shelf and is very compact.

The printed board assembly with tone and ringing contacts is shown in fig. 13.

Fig. 14
Test of signals on electronics shelf



Tests and Fault Tracing

The signalling equipment is delivered in separate units with associated printed board assemblies. The units and boards are tested separately. Assembly at the exchange is simple ; testing of the assembled units consists solely of a functional check. The signals are checked with the earlier mentioned test unit. This consists of a loudspeaker for check of tones, a buzzer for check of ringing signals and a special plug for insertion in the jacks on a special test board on the electronics shelf (fig. 14). Each jack is connected to a terminal block in the distribution unit and has the same number as the terminal block.

The equipment can also be tested in idle condition. When the "Test of idle equipment" button is pressed, the standby equipment starts without the signals being connected to the distribution. They can, however, be monitored on the test board jacks on the electronics shelf.

In the event of a fault in the signalling equipment, fault tracing is done by switching over the two equipment (automatically or manually) and connecting the faulty equipment as idle equipment. The latter can then be tested

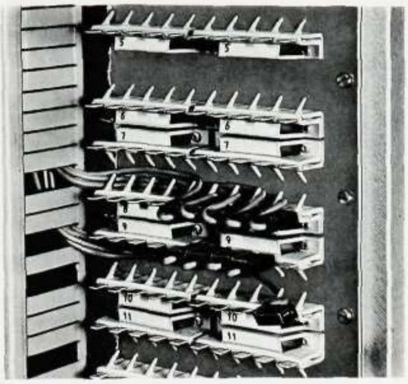


Fig. 15

Detail of distribution unit

The flat sleeve termination allows simple separation of individual telephony suites and location of faults

by the previously described method without disturbing operation. Replacement of boards and units in the idle equipment can also be done without disturbance of operation.

The design of the distribution unit permits rapid and simple fault tracing in the event of short-circuiting in the telephony equipment. The distribution unit contains a new type of terminal block with flat sleeve terminations. Every telephony suite which requires a tone or ringing signal is connected by sleeve plugs individually to the respective block terminal (fig. 15). The plugs can be easily withdrawn and a single suite can therefore be simply separated and the fault located.

Technical Data

System voltages: 24, 36, 48 and 60 V D.C.

Ringing Signals

Voltage: adjustable to 70, 90 or 105 V (at no load and nominal input voltage)
Frequency: 25 Hz (other frequencies on request)
Voltage drop: between no load and full load max. 20 %
Equivalent disturbing voltage*: max. 0 dBu (0.775 V) measured in accordance with C.C.I.T.T. "Directives".

Generator output: 1. 25 VA (cf. table 2)
2. 100 VA ,, ,, ,,

For exchanges with more than 4000 subscribers the ringing signals are distributed in two or three time-displaced groups.

The ringing contacts are considerably overdimensioned and can carry a continuous load of 3 A. The ringing signal outputs are protected against short-circuiting by 1 A automatic circuit-breakers. In the event of a short-circuit in external circuits the ringing signal is not disconnected but merely attenuated by a series resistor connected in parallel with the blown fuse.

Tones with Sinusoidal Output Voltage

Voltage: adjustable to 2, 6 or 10 dBu (1, 1.5, 2.5 V) at no load. Adjustment is done on the associated printed boards. At delivery the voltage is set to 6 dBu.

425 Hz Signals

Generator output: 1 VA
Distortion: max. 5 %
Max. load on a signal output terminal: 250 mA
Voltage drop between no load and max. load on a signal output terminal: max. 1.2 dB.

International Information Tone

Output: 150 mW
Distortion: max. 3 %
Voltage drop between no load and full load: max. 1 dB

Modulated Signals (425/50 Hz)

Modulator output: 350 W

Other Tones (Ticking Tone, Crackling Tone)

Output voltage: adjustable to 1.5 and 15 V at full load (2.4 Ω resp. 60 Ω)

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* This value includes two weighting factors for each frequency, one psophometrical and one which takes into account the mode of coupling between the disturbing line and the disturbed one.

D.C. Signals

The output signal from the D.C. contact is an interrupted positive polarity. Max. current output: 0.5 A

On and Off Periods

Longest possible period: 10 s

Shortest period: 10 ms

Period tolerance: ± 10 % (± 3 % on request)

Tone outputs with off periods longer than 250 ms are short-circuited to a separate return wire during the off period in order to avoid crosstalk. The short-circuiting impedance is max. 1 Ω.

All tone output terminals are short-circuitproof.

Input Current

Max. 4 A (equipment for 48 V system voltage)

Mechanical Data

(Wall cabinet type)

	BKL 251	*BKL 253*	*BKL 254*
Height mm	840	600	480
Width mm	530	530	530
Depth mm	485	485	485
Approximate weight kg (with *RG* generator 100 VA)	75	52	35

Summary

Characteristic features of signal equipments *BKL 251*, *253* and *254*.

1. Great flexibility.
2. High reliability.
3. No need for maintenance.
4. Tone signal levels can be altered individually.
5. Signal periods can be easily altered.
6. Special signals and short-duration signals can be better produced than in electromechanical equipments.
7. Simple testing and fault tracing.
8. The standby equipment can be tested and its units replaced without disturbance of normal operation.
9. The initial power can be low and easily raised when the exchange is extended.
10. The number of signals can be easily increased.

The advantages of the electronic signalling equipment are particularly marked in the following cases:

a) For use at unattended exchanges where high reliability and freedom from maintenance are of particularly great importance.

b) For future international standardization of signals the equipment offers the means of simple alteration of signal character and periods.

LME Receives Orders from Brazil Totalling 90 Million Kronor

L M Ericsson, Brazil, has received orders for long-distance and local switching equipment to a total value of 90 million kronor. The largest individual orders came from Companhia Riograndense de Telecomunicações (CRT) for local exchange equipment for 20,000 subscriber lines and from TELEPAR, the telephone authority in the State of Paraná, which ordered trunk exchange equipment for 1480 lines.

Large orders have also been placed by EMBRATEL, the federal telecommunications administration, for trunk exchange equipment totalling 3200 lines for Rio de Janeiro, Vitória, Campos and Belém, and from Companhia Telefônica Brasileira (CTB), Brazil's largest telephone operating company, for extension of the existing exchanges in São Paulo.

In recent years Brazil has become one of LME's larger markets, the sales in 1968 amounting to some 110 million kronor. Last year Ericsson do Brasil enlarged its factory near São Paulo and the Group now has some 2800 employees on manufacture, sales and installation work in Brazil.

L M Ericsson's factory at São José dos Campos, Brazil, with its 33,000 sq.m. floor area, is the largest telephone factory in Latin America.

EDB's Training Department 10 Years

During the 10 years since the Training Department was established at Ericsson do Brasil, it has reached a very high level, with the emphasis on telecommunications technique. Continuous cooperation has been established with universities and the Department constantly arranges courses and lectures.

Since 1959 it has held 55 courses on telecommunications and similar subject fields, attended by more than 400 technicians, of whom 116 from the Ericsson Group. The total number of hours of training during the 10-year period is 73,500, and the largest number during one year, 1968, was 23,000.

The Department itself prepares the training material and has a special group which makes translations from Swedish, English and French to Portuguese.

The classrooms are flexible in order to be adaptable to the number of pupils, the maximum member being 60. All modern aids, such as TV, tape recorders etc. are available.

Production Control System for Sandvikens Jernverk

L M Ericsson has received an order from Sandvikens Jernverk for a large production control system to a value of some 3 million kronor. The system is built up around a process computer UAC 1610 made by L M Ericsson. To the computer are connected via four data concentrators some 60 terminals and 20 typewriters. The terminals consist of keyboards, digit indicators, push-buttons and signal lamps for two-way communication between the computer and operating personnel. All equipment has been designed and will be manufactured by L M Ericsson.

The work on the project is to be carried out in close cooperation between Sandviken and L M Ericsson; the system will be put into service during 1971.

The new system permits improved production planning, better control and quicker reorganization within the individual production stages, and will therefore bring considerable gains in the production process.

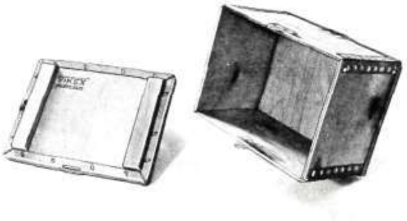
VIKEX — New Transport Packaging

L M Ericsson was the first enterprise in Sweden to introduce this year a new type of transport packaging, folding cases of birch plywood made in one piece.

The idea of the VIKEX case, as the new packaging is called, came from two LME engineers, Ivar Johansson and Arne Ekberg.

The suppliers, Bröderna Nordgren, Alfta, Sweden, have worked on the development of the packaging jointly with L M Ericsson during the past year. This year 130,000 cases are to be delivered and in 1971 around 350,000, i.e. LME's approximate annual requirement of standard packaging for export.

The VIKEX case is made of birch plywood with fittings of electro-galvanized steel. This plywood proved to have superior properties compared with other materials. It is also cheaper and withstands moisture and transport better than the material in previosly used cases. The thinner walls (6 mm as against 18 mm in wooden cases) and the absence of laths makes the case less bulky, the weight of the standard case, for example, being reduced by more than half.


Prototype of the VIKEX case with runners (called PALLVIKEX).

The VIKEX case is made in some 20 sizes, some of which have runners for greater ease in mechanical handling. The largest case at present has outside dimensions of 1060×1100××1150 mm and, packed, weighs 600 kg gross.

The development work has included practical transport tests. Deliveries have been made to, among other countries, Lebanon and Panama, where LME personnel have checked and reported how the packaging and goods have stood up to the long transport. The tests were satisfactory —one case was demolished on one of the shipments, but the products were found to be entirely undamaged.

The new packaging has attracted a great interest among several Swedish companies, including Astra and Electrolux, and also internationally.

L M Ericsson's Fire Alarm System for Swedish Ships

L M Ericsson Telemateriel AB has concluded an agreement with the Götaverken Group and the Uddevalla Yard for the delivery of automatic fire alarm equipments for ships.

The background to the agreement is the rationalization of engine-room operation, increasing numbers of ships now having unattended engine-rooms. Without human supervision in the engine-rooms there must be a very rapid automatic fire alarm. L M Ericsson's system with smoke and thermal detectors within the same central equipment, or even the same section, is extremely well adapted for this purpose.

The latest ship with L M Ericsson fire alarm equipment, m/s Veni, was recently launched by Götaverken; with a displacement of 227,000 tons she is the largest ship hitherto built in Scandinavia. Her furnishings and engine-room are protected by some 30 smoke detectors and 200 thermal detectors.

LME engineers, Ivar Johansson (left) and Arne Ekberg with a folded VIKEX case.

Svenska Radio AB delivers mobile radio equipments for police motor-cycles among other purposes. The cycles are equipped in Stockholm, and recently the second delivery of some 30 cycles was collected. An interesting feature is that the control apparatus of the radio station is recessed in the petrol tank and that microphone and headset are built into the helmet.

The Brazilian Minister of Communications, Sr. Carlos Furtade de Simas, recently visited the head factory. He is here seen (left) talking to Mr Björn Lundvall, head of the Ericsson Group (right), and Mr Gunnar Vikberg, President of LME's subsidiary Ericsson do Brasil.

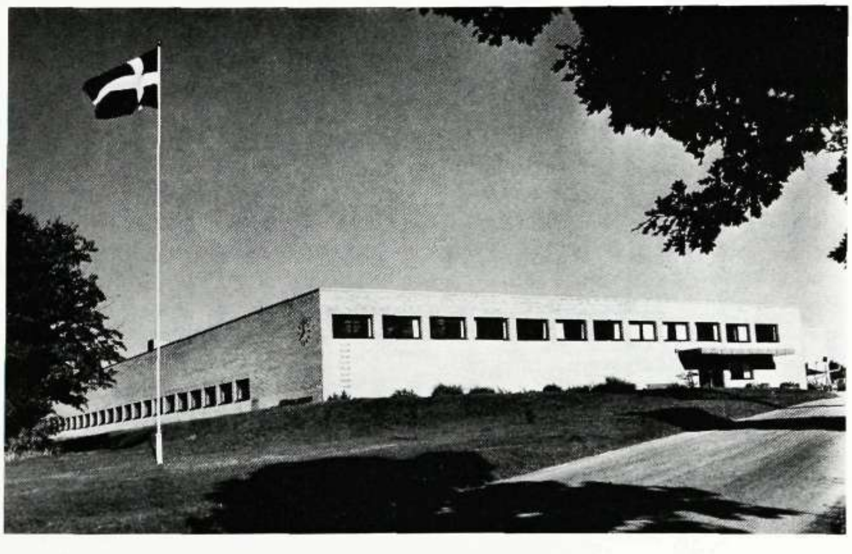
During the Zambia Trade Fair at Lusaka L M Ericsson had an exhibition of its products in the Swedish Pavilion.

The photograph shows at the LME stand (from right) President Kenneth Kaunda, Zambia, and President Milton Obote, Uganda, who opened the Fair. With them are Messrs. L. Engström and K. Lindkvist, Swedish commercial representatives at Lusaka and Nairobi.

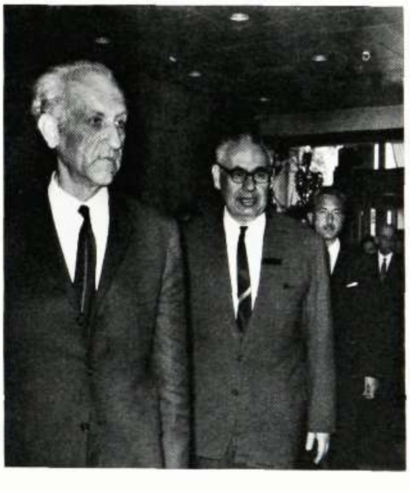
The Swedish Crown Prince Carl Gustaf (left) visited the International Aviation Exhibition in Paris last summer. Here he is seen with (from right) Lars-Olof Larsson and Hans Eckersand from LME's MI Division, who demonstrated radar, electro-optics and communication systems.

Tlalnepantla, an industrial suburb of Mexico City, is to be the site of LME's new factory and offices. The photograph shows the Mexican architect Carlos Diener (third from left) with LME engineers Harold Mohlström and Karl-Erik Eriksson discussing a drawing of the building. A point of interest is that the street has been christened Calle L. M. Ericsson —as far is known the first time that LM Ericsson has given its name to a street abroad.

At Vedeby near Karlskrona is the L M Ericsson factory which delivers the greater part of the Group's requirement of enamelled wire. The factory also makes telephone cords, among other purposes for the telephone sets made at LME's Karlskrona factory.



A delegation from the Yugoslavian National Assembly visited L M Ericsson at Midsommarkransen during their week's visit to Sweden in June. The photograph shows the arrival of the delegation headed by the Speaker, Mr Popovič, and Ambassador, Mr Latinovič.



Appointment

Eric Ledin

Mr Eric Ledin has been nominated director of the company in conjunction with his appointment as from September 1, 1969, to assist the head of the Telecommunication Group, Mr F. Sundkvist, on questions concerning sales in Sweden.

Mr Ledin will continue as head of the Swedish Sales Department within the Telephone Exchange Division.

Olaf Gustafson In Memoriam

Olaf Gustafson

The message of Olaf Gustafson's death on July 9, 1969, came completely unexpectedly. At the time of his retirement in 1968 he was head of LME's activities in Colombia.

Olaf Gustafson was born in Norway and graduated from the Trondheim Institute of Technology in 1939. Both before and after his engineering course he was associated with the Norwegian Telecommunications Administration. During the war he served in the British army as major in the Signal Corps.

In 1951 he left the Norwegian Telecommunications Adminstration to join L M Ericsson. After a brief period of training in Sweden he was taken on by our company in Colombia in July 1951. Three years later he was head of L M Ericsson's activities in Colombia.

During the period in which Olaf Gustafson was in charge of the work in Colombia, our activities greatly expanded. L M Ericsson consolidated its position as the leading supplier of telecommunications equipment to Colombia.

Olaf Gustafson had a very great working capacity. His devotion to his work in the company's interests went before all else. He did not shrink from the troublesome problems which occasionally arose, but dealt with them with good judgement and a presistent energy.

Olaf Gustafson was a keen athlete during the whole of his life—he realized the importance of good physical condition in order to deal with his exacting work.

Apart from his family, with whom he had unusually close relations, Olaf left many friends in Latin America, Norway and Sweden. His consideration and friedliness had both a strength and an intensity. Peace to his memory. *Arne Stein*

Ericsson Technics

Ericsson Technics Nos. 1 and 2, 1969, have been issued and contain two papers each.

The first in No. 1, "Methods for Optimizing Alternative Routing Networks" by B. Wallström, presents a method of calculation for use in data processing of large networks with arbitrary groupings of the switching equipment.

The authors of the second article, "PLUTO, a Data Management Software System" are S. Sam-Sandberg and E. Ödmansson. They describe a disc-storage-oriented register organization system PLUTO and its use for creation of an integrated data bank for Telefonaktiebolaget L M Ericsson.

Ericsson Technics No. 2 starts with a paper by A. Cunnington, "Constraints on Real-Time Computer Systems". He investigates a problem which arose in the development of the L M Ericsson process computer system UAC 1600. The problem is how to allocate priorities to the various control programmes for the peripheral units in order to obtain optimal real-time processing while respecting the time constraints imposed both by the peripheral units themselves and possibly by the process. His paper indicates a numerical solution to the general case of real-time constraints and presents algorithms for arranging the various system routines in hierarchical order, checking that all time constraints are respected and calculating how much of the time of the system is occupied totally and by each control programme. Examples show how the method was applied in the particular case of UAC 1601.

Finally, in "A Lowpass to Bandpass Transformation for Passive and Active RC Filters" by B. T. Henoch a lowpass to bandpass transformation of the form $y = s + \omega^2{}_0/s + 2\omega_0$ is derived for dimensionless transmission functions of RC networks. The derived bandpass transformation is also presented in a generalized form applicable to distributed RC networks.

Engineer in Kenya Christens Baby after L M Ericsson

Ericsson Band in Nairobi, Kenya, is presumably the only child in the world to have been christened after a manufacturer of telecommunications equipment.

The boy's father, Mr Joash Abdallah Mujenyi Band of the East African Posts and Telecommunications Corporation in Kenya, states in a letter that L M Ericsson had acted "godfather" to a recently born Kenyan.

The father had participated on L M Ericsson's international training courses at the main factory in Stockholm last spring.

Mr Band, a 22-year-old technician, was one of several East Africans selected by SIDA (Swedish International Development Authority) for special training in telephone switching technique.

The extreme friedliness shown to him by the staff of the Ericsson Training Centre during his period of study in Sweden was the reason why he called his son after the company, says Mr Band.

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AB Rifa, *161 30 Bromma 11*, tel: (08) 26 26 10, tgm: elrifa, telex: 10308, "ELRIFA STH"

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L M Ericsson Data AB, *171 88 Solna*, tel: (08) 83 07 00, tgm: ericdata, telex: 1093 "ERICDATA STH"

L M Ericsson Telemateriel AB, *135 01 Stockholm-Tyresö 1*, Fack, tel: (08) 712 00 00 tgm: ellem, telex: 1275, "1275 TELERGA S"

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· AFRICA ·

Egypt (UAR)

Telefonaktiebolaget L M Ericsson, Technical office Egypt Branch *Cairo* P.O.B. 2084, tel: (02) 46581, tgm: elleme

Ethiopia, Sudan

Telefonaktiebolaget L M Ericsson, Technical office, *Addis Ababa*, P.O.B. 3366, tel: (01) 49 260, tgm: ericsson, telex: 210 90 "MOSFIRM ADDIS"

Kenya, Tanzania, Uganda

Telefonaktiebolaget L M Ericsson, Technical office, *Nairobi*, P.O.B. 9063, tel: (02) 271 06, tgm: ellem, telex: 22304, "ERICSSON NRB"

Libya

L M Ericsson Technical Office, *Tripoli*, P.O.B. 3002, tgm: ericsson

Malawi

Ericsson Telephone Sales Corporation AB, *Blantyre*, P.O.B. 431, tgm: ericofon

Morocco

Société Marocaine des Téléphones Ericsson *Casablanca*, 87, Rue Karatchi, tel: 788 75, tgm: ericsson

South Africa, Southwest Africa, Botswana, Lesotho, Swaziland

L M Ericsson Telephone Co. (Pty.) Ltd, *Johannesburg*, P.O.B. 4728, tel: 836 7771, tgm: ericofon

Tunisia

Telefonaktiebolaget L M Ericsson, Technical office, *Tunis*, Boite Postale 780, tel: (01) 240520, tgm: ericsson, telex: 695, "ERICSSON TUNIS".

Zambia

Ericsson Telephone Sales Corporation AB *Lusaka*, P.O.B. 2762, tel: (146) 772 90, tgm: ericofon

Ndola, P.O.B. 2256, tel: (143) 3885, tgm: ericofon

· AMERICA ·

Argentine

Cia Ericsson S.A.C.I. *Buenos Aires* Casilla de Correo 3550, tel: 332071, tgm: ericsson, telex: 0122196, "CATEL BA"

Cia Argentina de Teléfonos S.A. *Buenos Aires*, Belgrano 894, tel: 332076, tgm: catel, telex: 0122196, "CATEL BA"

Cia Entrerriana de Teléfonos S.A. *Buenos Aires*, Belgrano 894, tel: 332076, tgm: catel, telex: 0122196, "CATEL BA"

Industrias Eléctricas de Quilmes S.A. *Quilmes FNGR*, 12 de Octubre 1090, tel: 203 2775, tgm: indelquibuenosaires, telex: 0122196, "CATEL BA"

Brazil

Ericsson do Brasil Comércio e Indústria S.A. *Sao Paulo*, C.P. 5677, tel: 287 2011, tgm: ericsson, telex: 021817, "ERICSSON SPO"

Fios e Cabos Plasticos do Brasil S.A. (FICAP), *Rio de Janeiro*, caixa postal: 1828, tel: 290185, tgm: ficap, telex: 731563, "PLASTIVINE RIO"

Canada

L M Ericsson Limited *Montreal 381, Quebec*, 2300 Laurentian Boulevard St. Laurent, tel: (514) 331-3310, tgm: caneric, telex: 05-267-682, (TWX) 610-421-3311, "CANERIC MTL"

Ericsson Centrum (Canada) Ltd. *Montreal 381, Quebec*, 2300 Laurentian Boulevard, St. Laurent

Central America

Telefonaktiebolaget L M Ericsson, Oficina Tecnica de Centroamérica y Panama, *San Salvador*, Apartado 188, tel: 21 76 40, tgm: ericsson

Chile

Cía Ericsson de Chile S.A. *Santiago*, Casilla 10143, tel: (04) 82555, tgm: ericsson, telex SGO 389, "ERICHILE SGO389"

Colombia

Ericsson de Colombia S.A. *Bogotá*, Apartado Aéreo 4052, tel: (92) 411100, tgm: ericsson, telex: 044507, "ERICSSON BOG"

Fabricas Colombianas de Materiales Eléctricos Fácomec S.A. *Cali*, Apartado Aéreo 4534, tel: 42 10 61, tgm: facomec, telex: 55673, "FACOMEC CLO"

Costa Rica

Telefonaktiebolaget L M Ericsson, Technical office *San José*, Apartado L. M. E., tel: 21 14 66, tgm: ericsson

Ecuador

Teléfonos Ericsson C.A. *Quito*, Casilla 2138, tel: 21 61 00, tgm: ericsson

Guayaquil, Casilla 376, tel: 52 69 00, tgm: ericsson

Cont. on next page

Associated and co-operating enterprises and technical offices (*Cont. from preceding page*)

Mexico

Teléfonos Ericsson S.A. *Mexico D.F.*, Apartado 9958, tel: (25) 46 46 40, tgm: coeric, telex: 01772485, "EROICSSON MEX"

Latinoamericana de Cables S.A. de C.V. *Mexico 12 D.F.*, Apartado 12737, tel: (2) 549 3650, tgm: latincasa

Teleindustria, S.A. de C.V. *Mexico 1, D.F.*, Apartado 1062, tel: (2) 546 4640, Factory: (2) 576 3166, tgm: ericsson, telex: 01772485, "ERICSSON MEX"

Telemontaje, S.A. de C.V. *Mexico 1, D.F.*, Apartado Postal 1062, tel: (2) 576 4044, tgm: ericssonmexicodf, telex: 01772485, "ERICSSON MEX"

Peru

Cía Ericsson S.A. *Lima*, Apartado 2982, tel: 23 49 41, tgm: ericsson, telex: 3540202, "ERICSSON 3540202"

Soc. Telefonica del Perú, S.A. *Arequipa*, Apartado 112-1012, tel: 6060 tgm: telefonica

El Salvador

Telefonaktiebolaget L M Ericsson Technical office *San Salvador*, Apartado 188, tel: 21-79-40, tgm: ericsson

Uruguay

Cía Ericsson S.A. *Montevideo*, Casilla de Correo 575, tel: 92611, tgm: ericsson

USA

The Ericsson Corporation *New York, N.Y. 10017*, 100 Park Avenue, tel: (212) 6854030, tgm: erictel, telex: 620484, "ERICTEC 620484"

Ericsson Centrum Inc. *New York, N.Y. 10016*, 16, East 40th Street, tel: (212) 679 10000, tgm: erictel, telex: 620149

Venezuela

Cía Anónima Ericsson *Caracas*, Apartado 3548, tel: (02) 34 46 61, tgm: ericsson, telex: 22734, "22734 ERICVEN"

Alambres y Cables Venezolanos C.A. (ALCAVE) *Caracas*, Apartado del Este 11257, tel: (02) 33 97 91, tgm: alcave, telex: 845, "ALCAVE VE"

· AUSTRALIA & OCEANIA ·

Australia

L M Ericsson Pty. Ltd. *Broadmeadows, Victoria 3047*, P.O.B. 41, tel: (03) 309 22 44, tgm: ericmel, telex: 30555, "ERICMEL AA 30555"

Rushcutters Bay N.S.W. 2011, 134 Barcom Avenue, tel: (02) 31 09 41, tgm: ericsyd, telex: AA 21358 "ERICSYD"

Port Moresby, Territory of Papua and New Guinea, P.O.B. 1367, Boroko, tel: 56 965, tgm: ericpor

Teleric Pty. Ltd *Broadmeadows, Victoria 3047*, P.O.B. 41, tel: (03) 309 2244, tgm: teleric, telex: 30555, "ERICMEL AA 30555"

Rushcutters Bay N.S.W. 2011, 134 Bacrom Avenue, tel: (02) 31 09 41, tgm: teleric, telex: AA 21358, "ERICSYD"

Conqueror Cables Pty. Limited, *Dee Why, N.S.W. 2099*, P.O.B. 69, tel: (02) 98 03 64, tgm: concab sydney

A.E.E. Capacitors Pty. Ltd. *Preston, Victoria 3072, 202* Bell Street, P.O.B. 95, tel: (03) 480 12 11, tgm: engiquip melbourne

Representatives

· EUROPE ·

Austria

Telecom Handelsgesellschaft m.b.H., *1142 Wien*, Schanzstrasse 33, tel: 92 26 21, tgm: teleric, telex: 11638, "11638 TELECOM A"

Belgium

Allumage Lumière S.A. *Bruxelles 7*, 128-130 Chaussée de Mons, tel: 229870, tgm: allumalux, telex: 21582, "ALLUMALUX BRU"

Greece

Angelos Cotzias *Athens*, 18, Odas Omirou, tel: 626-031, tgm: cotziasan, telex: 252, "COTZIASAN ATHEN"

Iceland

Johan Rönning *Reykjavik*, P.O.B. 883, tel: 10 632, tgm: rönning

Spain

TRANSA Transacciones Canarias S.A., *Las Palmas de Gran Canarias*, Tomas Morales 38, tel: 21 85 08, tgm: transa, telex: 824, "MAVAC LPE"

Santa Cruz de Tenerife, Sabino Berthelot, 3. Tel: 24 5897, tgm: transa

Yugoslavia

Merkantile Inozemna Zastupstva *Zagreb* pošt pretinac 23, tel: 41 6655, tgm: merkantile, telex: 21139, "21139 YU MERTIL"

Beograd, Ul. 7. jula br. 18, tel: 62 1773, tgm: merkantile, telex: 11506, "YU MERKAN"

· ASIA ·

Abu Dhabi

Mohammed Bin Masaood & Sons, *Abu Dhabi, Trucial States*, P.O.B. 332, tel: 2367, tgm: almasaood

Burma

Myanma Export Import Corp., Agency Div. *Rangoon*, P.O.B. 404, tel: 146 18, tgm: myanimport

Cambodia

Comin Khmere S.A. *Phnom-Penh*, P.O.B. 625, tel: 23 334, tgm: engineer

Cyprus

Zeno D. Pierides *Larnaca*, P.O.B. 25, tel: 2033, tgm: pierides

S.A. Petrides & Sons Ltd. *Nicosia*, P.O.B. 1122, tel. 62 788, tgm: armature

Dubai

DOLPHIN Trading & Contracting Establishment, *Dubai, Trucial States*, P.O.B. 1566, tel: 22645, tgm: dolphin

Hong Kong and Macao

Swedish Trading Co. Ltd. *Hong Kong*, P.O.B. 108, tel: 23 10 91, tgm: swedetrade

Iran

Irano Swedish Company AB, *Teheran* Khiabane Sevom Esfand 29, tel: 310 66, tgm: iranoswede

Iraq

Usam Sharif Company W.L.L. *Baghdad*, P.O.B. 492, tel: 87031, tgm: alhamra

Jordan

The Arab Trading & Development Co. Ltd. *Amman*, P.O.B. 6141, tel: 25981, tgm: aradeve

Kuwait

Morad Yousuf Behbehani *Kuwait, State of Kuwait*, P.O.B. 146, tel: 32251, tgm: barakat, telex: 048, "BEHBEHANI KUWAIT"

Lebanon

Swedish Levant Trading (Elié B. Hélou) *Beyrouth*, P.O.B. 931, tel: 231624, tgm: skefko

Pakistan

H.M. Trading Company, *Karachi 2*, 218—219 Qamar House, 2nd Floor, Bonder Road, tel: (90) 22 2151

Philippines

U.S.I. Philippines Inc. *Manila*, P.O.B. 125, tel: 88 93 51, tgm: usiphil, telex: PN 3550, "USIPHIL PN 3550"

Saudi Arabia

Engineering Projects & Products Co. Ltd. (Eppco), *Riyadh*, P.O.B. 987, tel: Murraba 264, tgm: eppcol

Yeddah, P.O.B. 1502, tel: 4567, tgm: eppcol

Damman, P.O.B. 450, tel: 22 222, tgm: eppcol

Syria

Constantin Georgiades, *Damas*, P.O.B. 2398, tel: 266 73, tgm: georgiades

Taiwan

Trans-Eurasia Enterprise, Ltd. *Taipei*, P.O.B. 3880, tel: 517038, tgm: esbtrading

Republic of Vietnam

Vo Tuyen Dien-Thoai Vietnam, *Saigon*: P.O.B. 1049, tel: 22660, tgm: telerad

International Business Representative, *Saigon*, 26—28, Hai Ba Trung Street, tel: 22660, tgm: ibur

· AFRICA ·

Congo (Kinshasa)

I.P.T.C. (Congo) Ltd. *Kinshasa 1*, P.O.B. 8922, tel: 25 345, tgm: induexpan, telex: 327, "PTC KIN"

Ethiopia

Mosvold Company (Ethiopia) Ltd. *Addis Ababa*, P.O.B. 1371, tel: 101 00, tgm: mosvold, telex: 21090 "MOSFIRM ADDIS ABABA"

Ghana

R.T. Briscoe Ltd. *Accra*, P.O.B. 1635, tel: 669 03, tgm: Briscoe, telex: 295, "BRISCOE ACCRA"

Kenya

Transcandia Ltd. Telecommunications Division *Nairobi, Kenya*, P.O.B. 5933, tel: 27103, tgm: transcanda

Liberia

Post & Communications Telephone Exchange, *Monrovia*, Corner Ashmun & Lynch Streets, tel: 222 22, tgm: radiolibe

Libya

ADECO African Development & Engineering Co *Tripoli*, P.O.B. 3621 tel: 33906, tgm: adeco

Mozambique

J. Martins Marques & Ca. Lda. *Lourenço Marques*, P.O.B. 2409, tel: 5953, tgm: marquesco

Sudan

Contomichalos, Sons & Co. Ltd. Engineering & Agencies Dept., *Khartoum*, P.O.B. 866, tel: 77 695, tgm: suconta, telex: 251, "CONTOLOS"

South Africa, South-West Africa

Dryden Communications (Pty.) Ltd. *Johannesburg*, P.O.B. 2440, tel: 838-5454, tgm: qualsteels

Tanzania

Transcandia Ltd. Telecommunications Division, *Dar es Salaam*, P.O.B. 2, tel: 23 469, tgm: transcanda

Uganda

Transcandia Ltd. Telecommunications Division, *Kampala*, P.O.B. 5358, tel: 63 827, tgm: transcanda

· AMERICA ·

Bahama Islands

Anglo American Electrical Company Ltd. *Freeport, Grand Bahama*, P.O.B. 104

Costa Rica

Tropical Commission Co. Ltd. *San José*, Apartado 661, tel: 22 55 11, tgm: troco

Dominican Republic

Garcia & Gautier, C. por A. *Santo Domingo*, Apartado 771, tel: 3445, tgm: gartier

Guatemala

Nils Pira *Ciudad de Guatemala*, Apartado 36, tel: 62 257, tgm: nilspira

Guiana

General Supplies Agency *Georgetown*, P.O.B. 375, tgm: benwiks

Honduras

Quinchón Leon y Cia *Tegucigalpa*, Apartado 85, tel: 2-5171, tgm: quinchon

Jamaica and Brit. Honduras

Morris E. Parkin *Kingston*, P.O.B. 354, tel: 24077, tgm: morrispark

Netherlands Antilles

S.E.L. Maduro & Sons, Inc. *Willemstad, Curaçao* P.O.B. 304, tel: 11200, tgm: madurosons, telex: CU 92

Nicaragua

Sonitel Centroamerica S.A. *Managua*, Apartado 1271, tel: 4476, tgm: sonitel

Panama

Sonitel, S.A. *Panama*, R.P., Apartado 4349, tel: 25-3640, tgm: sonitel, telex: 134, "PA 134 SONITEL"

Paraguay

S.A. Comercial e Industrial H. Petersen *Asunción*, Casilla 592, tel: 9868, tgm: pargtrade

El Salvador

Dada-Dada & Co. *San Salvador* Apartado 274, tel: 21 79 40, tgm: dada

Trinidad, W.I.

Leon J. Aché Ltd. *Port-of-Spain*, 100 Frederic Street, tel: 32357, tgm: achegram

· AUSTRALIA & OCEANIA ·

New Zealand

ASEA Electric (NZ) Ltd. *Wellington C. 1.*, P.O.B. 3239, tel: 70-614 tgm: asea, telex: 3431, "ASEAWELL NZ 3431"

SATHERLUND & FROOK