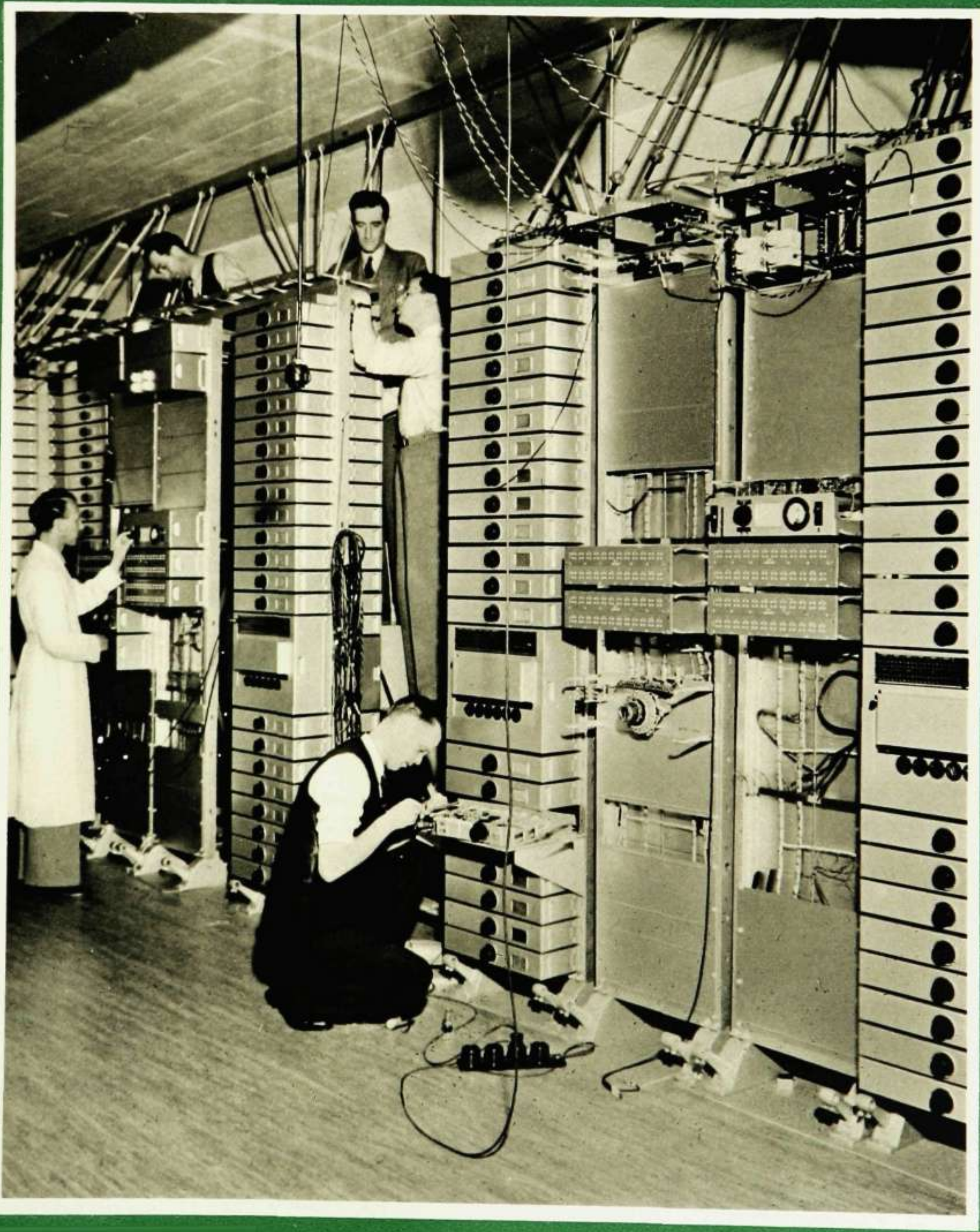
Ericsson Review



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Three-Channel Carrier Telephone System for Open-Wire Lines

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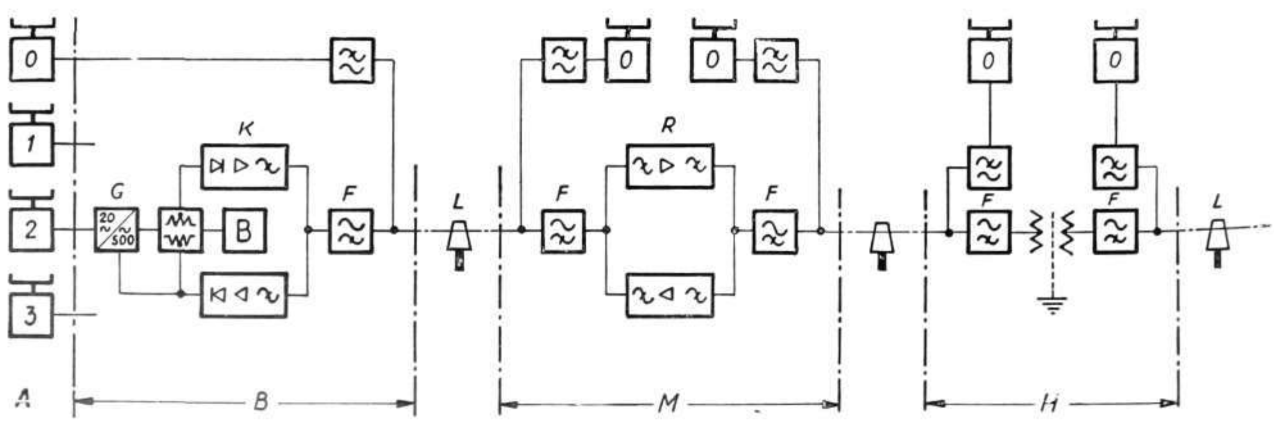
The three-channel system is the classic solution of the problem of high grade carrier telephone communication over long distances. The teletechnician possesses experience of nearly a quarter of a century's service of these systems, and it may with good reason be said that the systems of this type hitherto developed as a rule have well met the technical as well as the economical requirements that have been made upon them. Growing demands as well as steady improvements of both electron valves and other elements used in carrier technics, however, justified a thorough revision of the three-channel system. The new system built by L M Ericsson and completed in 1939 is of entirely new design. Installations with this new system have now been in satisfactory use during several years at different places. A description in detail of the system is given in the following article.

LM Ericsson's new three-channel telephone system for open-wire lines offers, as the name implies, in addition to the physical circuit three additional telephone channels. With its various possibilities of application it provides economically as well as technically good solutions of numerous traffic problems under very different conditions; it is suitable for circuits from about 100 km up to several thousands of km in length. For shorter distances up to 300—500 km terminal equipment only is required, but when longer distances are to be covered intermediate repeaters are inserted with appropriate spacing. Several systems can without inconvenience work on the same pole line. Especially suitable is this system as a skeleton for the telephone network in countries of large extent and comparatively sparse settlement, where for economical and other reasons the laying of underground cables to any great extent is out of the question and where the commercial life and the administrative machinery are concentrated to a few not very large centres.

This system is furthermore well suited for solving more exacting, special tasks, e. g. in railway telephone networks or along other long transport routes carrying heavy traffic etc. With its comparatively large repeater distances and its in general all-automatic level regulation a minimum of maintenance

Fig. 1 X 7366
Diagram of terminal, intermediate repeater and high-frequency shunt

A subscriber
B terminal
F line filters
G voice-frequency ringer
H high-frequency shunt
K channel and amplifier equipment
L open-wire line
M intermediate repeater
R amplifier equipment
0 physical circuit
1, 2, 3 carrier circuits



staff is required. It is designed to work on open-wire lines and is not suited to be used on long cable stretches, for which technically and economically more suitable systems have now been designed. On the other hand, occasional cables across water-ways or lead-in cables do not present any difficulties, although sometimes they require matching net-works or loading coils. Cables however cut down the geographical range considerably.

Fig. 1 shows in a greatly simplified diagram how the terminal and the intermediate repeaters are laid out and connected to the line and the subscribers. Each channel uses — reckoned from the fork side — a frequency band of 300—2700 c/s. Transmission and reception, which take place on different frequency bands, employ the whole of a high frequency band of from about 6 kc/s to about 30 kc/s. The communication circuits obtained are of high quality. The overall attenuation from fork to fork is ± 0 neper, maintained constant within ± 0.1 neper practically independent of the length of the circuit, providing automatic level regulation is used. Modulation and demodulation is performed with copper-oxide rectifiers. The carrier and one of the side bands are suppressed and the carrier oscillators are synchronized manually. A 500 c/s tone is used for signalling. The channels can also be worked in four-wire connection, the input level then being — 1.5 nepers and the output level + 0.5 nepers. The input impedance is, two-wire as well as four-wire, 600 ohms ± 4 %.

The phase velocity of the open-wire line is high, nearly 300000 km/s, and the propagation time for a pair of terminals from fork to fork on the voice-frequency side does not exceed 3 ms in the middle of the band. For a circuit of 300 km in length for example, a propagation time of about 4 ms can be reckoned with and for 1 500 km 8 to 10 ms. The difference in propagation time between the middle and the edges of the band does not exceed 2 ms and the system is therefore well suited for transmission of voice-frequency telegraphy. Up to 18 telegraph channels per telephone channel can be worked.

The recommendation laid down by C.C.I.F. that internal crosstalk within the system should be low has been fulfilled, as have the other requirements stipulated by C.C.I.F. for carrier systems of this type.

Lines and Line Attenuation

The usual open-wire lines of copper or bronze, twisted or transposed — in the latter case with not too large a distance between the transposition points — usually provide, even in their original condition and in any case after fairly simple preparations, satisfactory transmission properties within the whole of the required frequency band. Twisted steel-aluminium wires as well as steel-cored copper wires of good quality can also be used. Lines entirely of iron may be regarded as quite unsuitable.[1]

The line attenuation is appreciably higher for high frequency currents than for currents within the voice-frequency range. The attenuation depends not only on the specific resistance of the line material but also on the distance between the line conductors in the profile, the number and the quality of the insulators, the material of the insulator pins and cross-arms and on some other essential details of construction. The attenuation increases with the frequency from about 4 mN/km for 4.5 mm wires at 6 kc/s to about 15 mN/km for 2.5 mm wires at 30 kc/s. In wet weather, fog and rain, the attenuation increases, and this increase is particulary noticeable with types of lines where the crossarms and sometimes even the insulator pins are made of wood. Lines with crossarms and pins of iron and insulators of borosilicate (pyrex) glass are the least affected by dampness. The attenuation for a few types of lines

[1] An investigation of the usefulness of steel-cored copper wires was carried out by W Klein and is related in TFT 31/1942, p. 210.

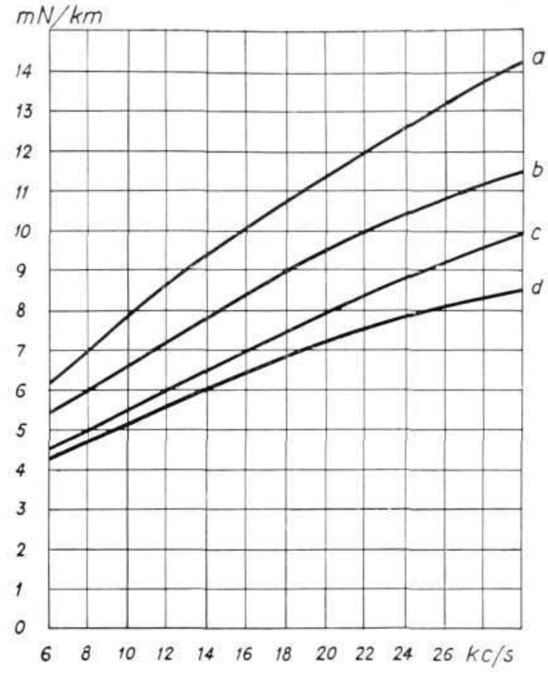


Fig. 2 X 6022

Attenuation curves for different types of lines

I line with crossarms of wood, insulators of alkali glass, wire 3.25 mm copper, 25 pairs of insulators per km, wire spacing 30 cm; plain transposed line
- a wet weather
- c dry weather

II line with crossarms and pins of iron, insulators of porcelain, wire 3 mm copper, 20 pairs of insulators per km, wire spacing $40 \cdot \sqrt{2} = 56.5$ cm; twisted line
- b wet weather
- d dry weather

in dry and wet weather can be read from the curves in Fig. 2. Wet snow and ice — frost — multiply the attenuation.

Data for calculating the attenuation of open-wire lines at high frequencies are given by the author in the Ericsson Review No. 1/1937, p. 27—31.

Range of Distance

Interference due to external sources are always induced in open-wire circuits. Their origin is very varied; the most powerful come, as a rule, from long-wave radio transmitters for intercontinental traffic. Occasionally high frequency interferences emanate from power lines, and finally atmospheric disturbances and other terrestrial currents are responsible. If the interference at the end of a telephone line is measured with a selective instrument which only registers voltages within a certain narrow frequency band with a width of e. g. 100 or 1000 c/s, it is found that the registered value varies between a few powers of ten, when the measuring band is continually moved from lower to higher frequencies. An example of this is shown in the curve, Fig. 3, which reproduces the measured interference at the end of a pair in a quad of about 250 km in length.

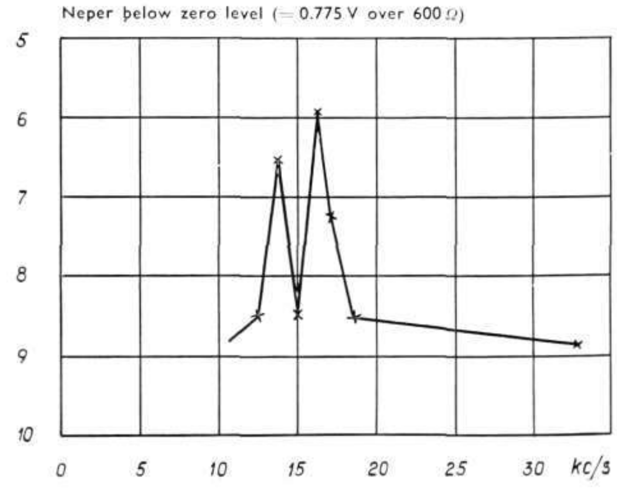


Fig. 3 X 6023

Diagram showing interference at end of a 250 km long double conductor line as a function of frequency

Highest measured values emanate from long wave telegraph transmitters

The interfering currents are demodulated together with the useful currents in the same frequency band and give rise to a background noise in the telephone receiver, the character of which varies with the type and origin of the disturbance. Weak interference of this nature as a rule give rise only to what may be called a »flaw in the beauty» of the circuit in which they appear. Should they, however, become stronger, they reduce the articulation appreciably. The strength of the interference determines, therefore, the lowest value to which the level ahead of the receiver can be allowed to fall without the quality of the circuit being impaired.

On the other hand, the highest level at which the transmitter can work is limited partly by the equipment which can reasonably be used for the generation and control of the transmitted power and partly by considering the crosstalk to other circuits in the vicinity. Experience has proved that on open-wire lines the transmitter should not work at a higher output level than about + 2 N at the beginning of the line, while the input level at the end of the line at 30 kc/s should not fall below — 3 N. In particularly favourable cases the input level may be as low as — 4 N. C.C.I.F. gives the last figure as a limit. In normal cases therefore, a three-channel system can cover a line attenuation of 5 nepers and, under conditions being favourable as regards interference, this attenuation can be increased to 6 nepers. With knowledge of the specific attenuation of the line, the greatest permissible distance between repeater stations in a three-channel system (= range of distance) can be computed. The highest attenuation which can arise under working conditions must be taken as a basis which means that, almost without exception, the value in wet weather must be reckoned with.

This leads to the following approximate figures for the range when copper lines with an overall attenuation of 5 nepers are used:

wire diameter	range
mm	km
2.5	350
3.0	400
4.5	550

In practice these figures are not attained, as cables in waterways, lead-in cables and other loads on the line cause losses which reduce the range considerably.[1]

Only in very exceptional cases, e. g. when the whole line runs through dry, saltless desert country and one can regard rain as a natural and unavoidable but seldom occurring cause of interruption, can a greater range be exploited on normal lines. On the other hand, cases exist where extra repeater equipment has been installed but only for operation in winter time to compensate for a more or less frequent formation of frost on the line.

Frequency Allocation

It has already been stated that the three-channel system occupies the frequency range between 6 and 30 kc/s and that different frequency bands are used for transmission in the different directions. There is a »lower group» for transmission from terminal A to terminal B and a »higher group» for transmission from B to A. In reality two different systems with different frequency allocation are used, ZAG 10 and ZAG 11, the frequencies of which are staggered in relation to each other, so that the frequency band of the one system lies for the most part in the gaps between the bands in the other. By this means the risk of crosstalk between two systems working in parallel on the same line is appreciably reduced. Fig. 4 a shows the position of the frequency bands in the two systems; arrows indicate the carrier frequencies.

[1] C.C.I.F. recommends 150, 300 and 500 km for 2, 3 and 4 mm wires respectively. This recommendation is, however, to a certain extent dependent on the prescribed interval between voice-frequency repeaters in two- and fourwire operation and should therefore be treated with a certain reserve.

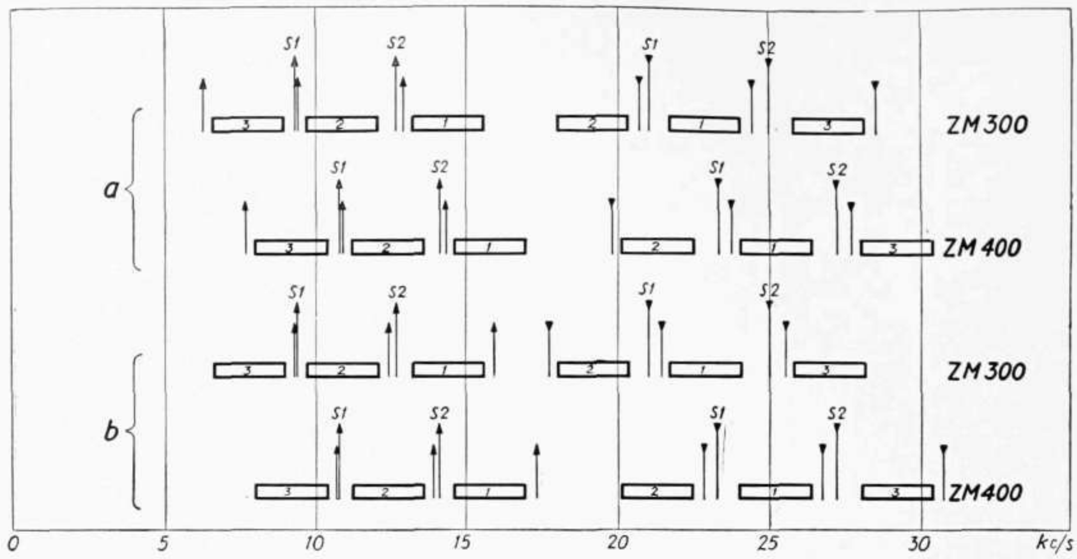


Fig. 4 X 7367

Frequency allocation of three-channel system

a with normal bands
b with inverted bands
Arrows denote carrier frequencies; S 1, S 2 alternative pilot frequencies; lower group transmits from north to south or from east to west (arrows pointing upward); upper group transmits from south to north or from west to east (arrows pointing downward)

If more than two three-channel systems are working in parallel on the same pole line, then obviously pairs of systems must, as a rule, be identical, and a certain risk for crosstalk between them exists. To reduce this risk, the frequency bands on one of the systems can be »inverted», i.e. the carrier frequencies can be shifted to the opposite edge of the bands, resulting in the high and low frequencies of the speech band changing places in the transmitted band. Any crosstalk then appearing will be unintelligible. The new carrier frequencies are included in Fig. 4 b, which otherwise is identical with Fig. 4 a.

It has already been mentioned that the carrier frequencies are suppressed and consequently are only present in the terminals and not on the line. On the other hand, each terminal transmits a pilot frequency, which affects the level regulating equipment on the receiving side. This pilot frequency is, within certain limits, displaceable within the group but is generally placed in the lower group in the gap between channel 1 and 2, and in the higher group in the gap between channel 1 and 3. The alternative pilot frequency allocations S1 and S2 are shown in Fig. 4.

A summary of all frequency bands, carrier and pilot frequencies is given in table I.

If several three-channel systems are to be worked in parallel, the frequency groups of the different systems must, on account of crosstalk, transmit in the

Table 1. Nominal figures of band limits, carrier and pilot frequencies in kc/s

system	group	channel	transmission band	carrier freq. normal	carrier freq. inverted	pilot freq. alternatively within band
ZM 300	lower	1	13.2—15.6	12.9	15.9	9.25—9.45
		2	9.7—12.1	9.4	12.4	12.35—12.95
		3	6.6—9.0	6.3	9.3	
	upper	1	21.7—24.1	24.4	21.4	20.65—21.45
		2	18.0—20.4	20.7	17.7	24.35—25.55
		3	25.8—28.2	28.5	25.5	
ZM 400	lower	1	14.6—17.0	14.3	17.3	10.65—10.95
		2	11.2—13.6	10.9	13.9	13.85—14.35
		3	8.0—10.4	7.7	10.7	
	upper	1	24.0—26.4	23.7	26.7	22.75—23.75
		2	20.1—22.5	19.8	22.8	26.65—27.75
		3	28.0—30.4	27.7	30.7	

same direction and not against each other. To avoid surprises in this respect in future extensions, it has been made a rule to have the groups working in fixed directions of the compass. Thus the lay-out is always, if possible, made in such a way that the lower group transmits from north to south or from east to west. Terminal A is therefore always put at the northern or eastern end of the line, and terminal B at the southern or western end.

Joint Working Circuits

The lowest transmitted frequency of the lower group is for system ZAG 10 about 6.6 kc/s, and for system ZAG 11 about 8 kc/s. The band below these frequencies down to zero frequency is not called into use for the three-channel system, but is utilized for various other purposes. First and foremost the 0.3—2.7 kc/s band is used almost without exception for carrying the normal physical circuit — generally with the use of two-wire repeaters. As ringing signal for this circuit 20 c/s is used directly, as long as the frequencies below 300 c/s are not used for sub-audio telegraphy, in which case 500 c/s is used for signalling. The range from about 3 kc/s to about 6 and 7.5 kc/s respectively may be used for carrier telegraph transmission of up to 4 and 8 channels respectively in either direction. Finally there are cases where, in system ZAG 11, the whole band between 0.03 and 7.5 kc/s is used either permanently or occasionally for transmission of radio programs. This may as an exception also be done with system ZAG 10, but in this case no frequencies higher than 5.5 kc/s can be transmitted. In these last two cases the physical circuit and the eventual carrier telegraph circuit must of course be disconnected.

The frequencies above the three-channel system range can of course in a similar way be utilized for simultaneous communication with other carrier circuits, but the necessary filters must be included in the additional equipment.

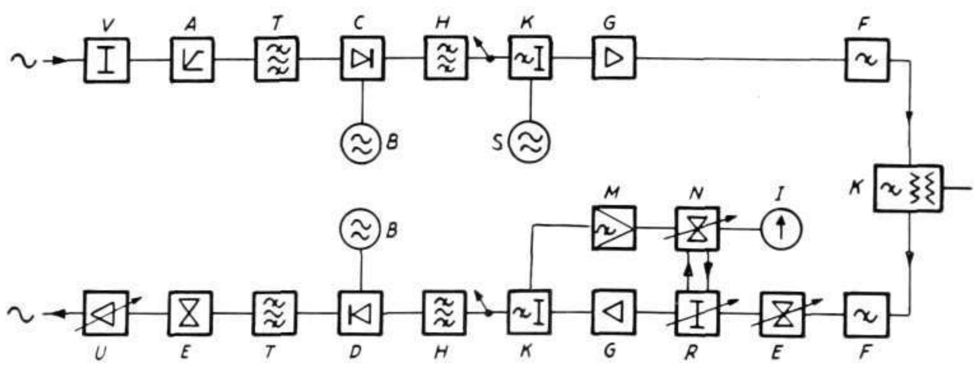
Channel and Amplifying Equipment

Fig. 5 shows the lay-out of the channel and the common amplifier equipment of a terminal. The transmitter lies in the upper part of the figure, the receiver in the lower part. Starting from the fork — not shown in the figure — the voice-frequency currents pass first through a volume limiter on the transmitter side, the function of which is to protect the transmitting amplifier from being overloaded by near-by loud talking subscribers. After the volume limiter follows a band filter, which cuts out frequencies under 200 c/s and over 2700 c/s. The remaining band is passed on to the modulator, which uses copper oxide rectifiers in conventional ring connection and is supplied with carrier current from an oscillator. After the modulator follows a band filter, which passes the high frequency band with the band limits shown in Fig. 4.

At this point the transmitting band filters of the three channels are connected in parallel through a compensation filter and the currents leaving here now occupy the frequency range of the whole lower or upper transmitting group. They pass through the common transmitting amplifier, the directional filter and the line filter and reach the line.

Fig. 5 X 7368
Diagram of channel and amplifier equipment of terminal

A volume limiter
B carrier oscillator
C modulator
D demodulator
E line equalizer
F directional filter
G group amplifier
H high-frequency band filter
I level indicator
K compensating filter
M pilot receiver
N level regulator
R regulating network
S pilot transmitter
T voice-frequency band filter
U voice-frequency amplifier
V pad



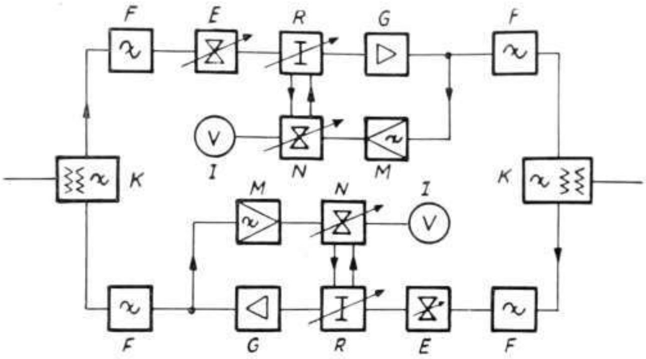


Fig. 6 X 6024

Diagram of amplifier equipment of intermediate repeater

- E line equalizer
- F directional filter
- G group amplifier
- I level indicator
- K compensating filter
- M pilot receiver
- N level regulator
- R regulating network

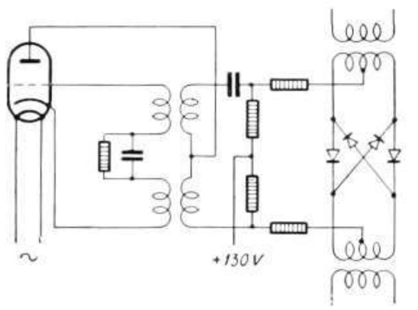


Fig. 7 X 4294

Frequency stable oscillator circuit

Modulator is connected in series with tuning circuit and output transformer is not used

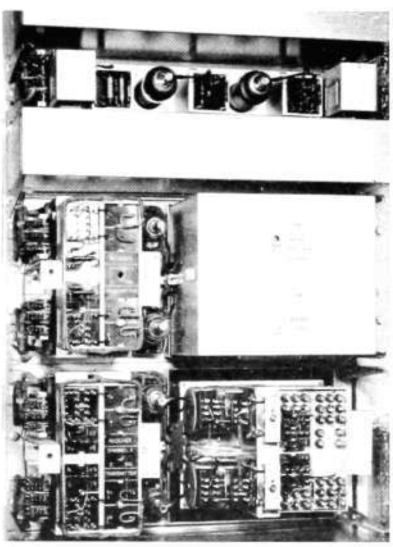


Fig. 8 X 4299

Two oscillator panels mounted in bay

On lower panel the cover is removed showing elements of tuning circuits; balancing device of modulator is placed between and to the left of valves; above oscillator panels, group amplifiers

In the opposite direction the high frequency currents arriving pass from the line through the line and directional filters to the receiving amplifier common for the three channels of the group. Before reaching the receiving amplifier the currents pass through two correcting networks; one fixed line equalizer, the function of which is to equalize the higher attenuation of the line at the higher frequencies, and one varying, which contains devices for taking care of the changes in the line attenuation caused by variations of temperature and weather. The receiving amplifier is connected through a compensating filter to the three receiving band filters, each of which connects to its demodulator with appropriate local carrier oscillator. The voice-frequency currents pass from the demodulator through a voice-frequency filter to be amplified in the channel amplifier before they reach the receiving side of the fork.

The amplifying equipment of the intermediate repeater is in the main the same as that of the terminal, but is of course arranged alike for both directions, Fig. 6. From the line filters the currents for both directions pass through the directional filters, the line equalizers and the regulating networks to the input side of the group amplifiers. The output sides are directly connected to the directional filters.

Channel Oscillators

Modulator and demodulator differ only in function and frequency. They are both mounted along with their oscillators on a common panel. The panels of A and B ends are identical, and the unit which works on A end as a modulator functions on B end as a demodulator and vice versa.

The oscillating circuit of the oscillators is connected in such a way, Fig. 7, that the feed-back voltage is practically free from phase shift, which results in the best possible stability. The load — the modulator — is connected in series with the elements of the tuning circuit without the use of an output transformer, which likewise contributes to stability. The tuning circuit itself is temperature compensated, and, to ensure that the compensation functions even during rapid temperature changes in the surroundings, the entire circuit is placed in a heat insulated box, by which means the effect of the different thermic inertias of the elements is eliminated. The same box is used for the oscillators of both the transmitter and of the receiver in the same channel.

One and the same unit can be altered as desired to transmit or receive the upper or lower side band through a simple shift of the carrier frequency from one side of the band to the other.

It is characteristic of the ring modulator that it suppresses the carrier. The condition for this is, however, that all four elements of the modulator are exactly alike. It is not always possible in practice to make them as identical as is required for the carrier to be sufficiently suppressed, but, on the other hand, it is possible by balancing to reduce the greater part of the »carrier leak», using a potentiometer and a small differential condenser, which are connected to the output side of the modulator. Fig. 8 shows two oscillator panels, each of which contains a transmitter and a receiver oscillator.

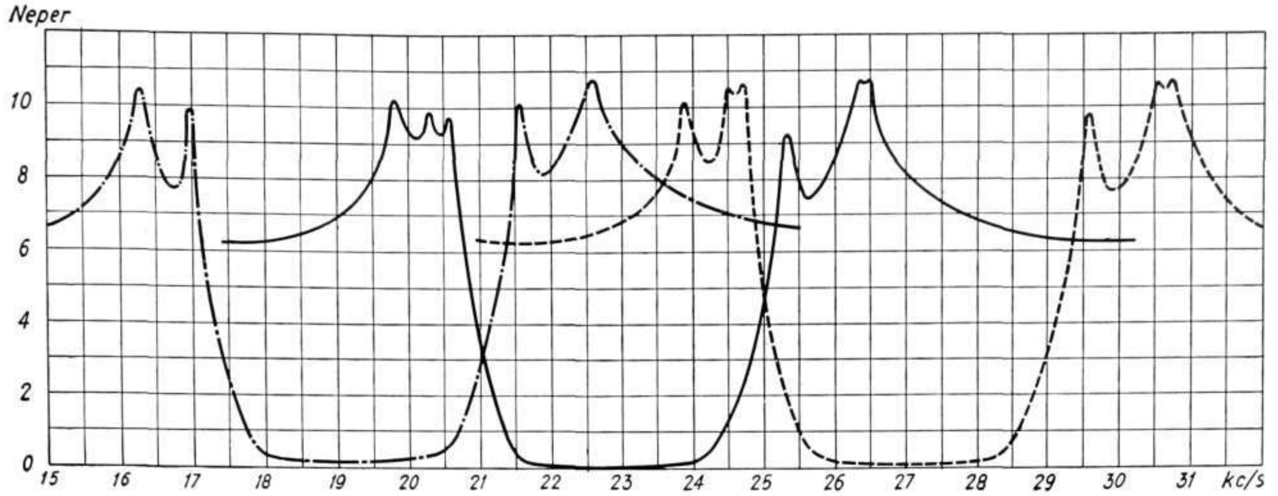


Fig. 9 X 7369
Attenuation curves of band filters in upper group of system ZM 300

Bandfilters

The crosstalk allowed between the speech channels determines the attenuation of the band filters. The attenuation requirements are especially high on that side of the band where the suppressed side band is located. As, however, the carrier frequency can be shifted from one side of the band to the other and as the suppressed side band then follows the carrier, the filters must be designed in such a way that they can without change meet the attenuation requirements regardless of the side the carrier frequency is placed at. The frequency characteristics of the filters are therefore nearly symmetrical around the passed band.

Fig. 9 shows filter characteristics of three of the six bands in system ZAG 10. The band filters used in system ZAG 11 are of the same design but with other cut-off frequencies.

The Group Amplifier

When several speech channels are to be amplified in a common amplifier, this must be free from non-linear distortion, as otherwise crosstalk will occur between the channels. The group amplifier of the three-channel system is of the negative feedback type. This ensures the desired low non-linear distortion, and at the same time a very good gain frequency characteristic and a very good stability in amplification.[1]

[1] The theory of negative feedback amplifiers is given briefly in Ericsson Review No. 2/1939, p. 46—48.

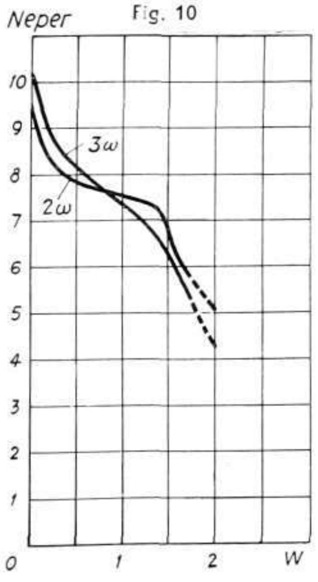
Fig. 10 X 4295
Harmonics of group amplifier for gain of 6 nepers

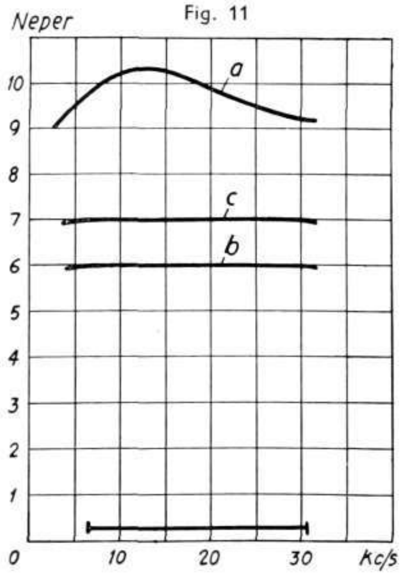
Second and third harmonic level as a function of output power

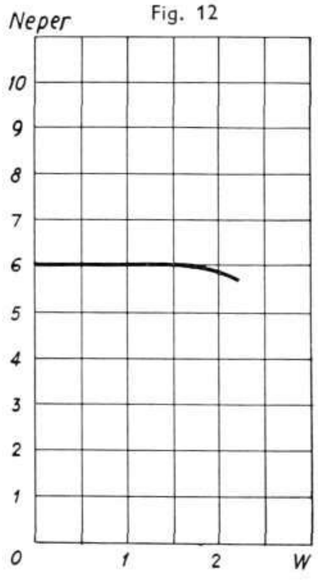
Fig. 11 X 4296
Gain of group amplifier as a function of frequency

a without negative feedback
b normal gain of 6 nepers
c with raised gain

Fig. 12 X 4297
Gain of group amplifier as a function of output power







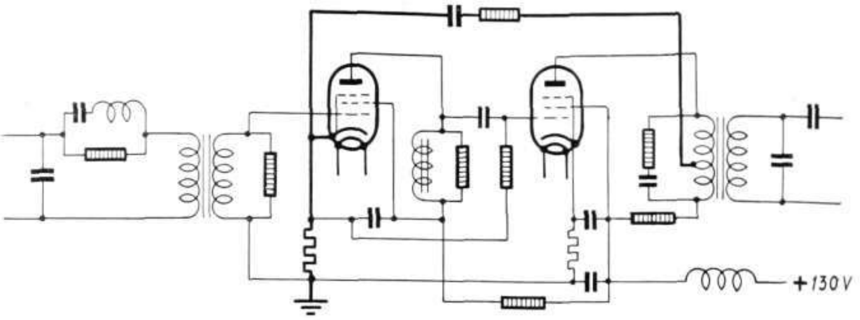


Fig. 13 X 6025
Diagram of group amplifier
Feedback circuit in heavy lines

Fig. 10 shows the level of the 2nd and 3rd harmonics in proportion to the level of the fundamental frequency as a function of the power output level. The gain as a function of the frequency is shown in Fig. 11 without and with negative feedback, in the latter case connected to give a gain of 6 and 7 nepers respectively. Finally Fig. 12 shows the gain as a function of the power output level. The amplifier employs two valves; from the diagram in Fig. 13 it may be seen that the negative feedback connection does not include the transformers. Against this, the output and input impedances are corrected with a few complementary elements. The whole amplifier is mounted on an 88 mm panel, Fig. 14. One spare amplifier, to be used for either direction, is mounted on each channel bay.

Equalizing the Line Attenuation

If the total attenuation is calculated for a stretch of line, the attenuation of which at 30 kc/s in wet weather is 5 nepers — that is to say the greatest attenuation the three-channel system normally can cover — the curves in Fig. 15 are obtained. These show that the difference in attenuation for the extreme frequencies in a band group is not inconsiderable, and also that the change in attenuation from dry to wet weather can rise to a considerable value even on a single repeater section.

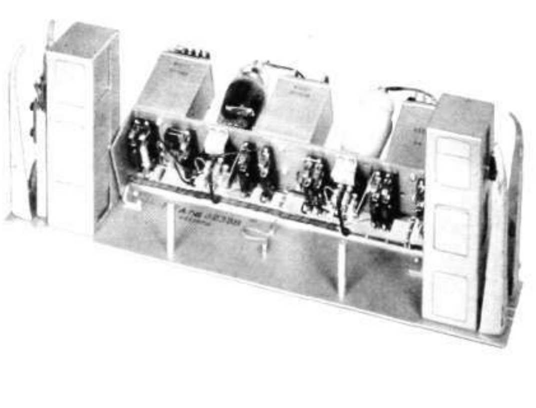
In order to prevent changes in the over-all attenuation of the speech channels the level ahead of the demodulator must be kept constant, and variable attenuation networks are therefore inserted in the common receiving branch to compensate for irregularities and changes in the line attenuation.

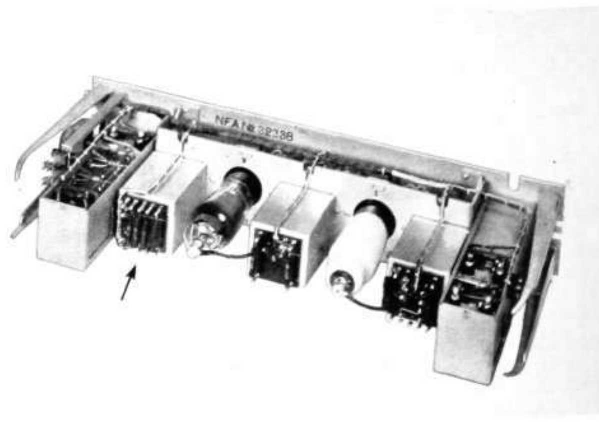
The variation of the line attenuation with the frequency is equalized mainly in the line equalizer network. This contains three units connected in series, which can be set to give an attenuation slope in steps of about 0.25 neper up to maximum 2 nepers in difference between the edges of the received band. This line equalizer is set once for all according to the length and the properties of the line.

The line attenuation changes from hour to hour owing to variations in temperature and weather conditions. These changes are equalized by the regulating network which therefore must be continually varied.

The regulating network consists in principle of a variable, phase-free attenuator, which is inserted on the receiving side and regulates all three

Fig. 14 X 7371
Group amplifier
To the left, panel opened for test; to the right panel in operating position; by cutting strap as arrow points gain is raised from 6 to 7 nepers





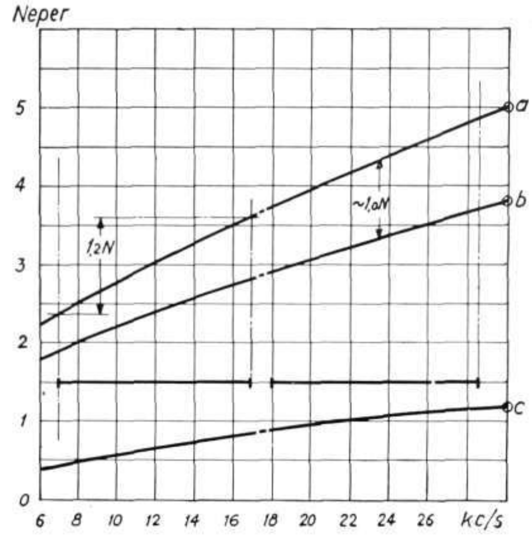


Fig. 15 X 6026
Attenuation curves for a line, which at 30 kc/s in wet weather has a total attenuation of 5 nepers

a wet weather
b dry weather
c = a — b = attenuation change; approximate position of »lower» and »upper» transmission groups are indicated

channels at the same time. Such an attenuator does attenuate all frequencies equally. If however curve c in Fig. 15 is studied closely it will be found that the changes in attenuation are larger at the higher frequencies. In the regulating the network, arrangements are made to take care of this by adding after the network an auxiliary voltage which varies its phase angle with the frequency. The resultant of the auxiliary and the main voltages varies with the frequency and the line attenuation in such a way that the changes of the line attenuation are compensated and the level is kept constant.

The function of this arrangement is seen more clearly from the diagram in Fig. 16. The currents arriving from the line over »I» first pass through the line equalizer and a fixed supplementary pad, and then at the regulating network delivers the voltage $\overline{U}_I$. By a differential transformer the currents are directed into two different branches, of which one is the phase-free network β and the other is the phase-shifting network α. Across the load resistance R the voltages $\overline{U}_\beta$ and $\overline{U}_\alpha$ are present. They compound as shown in the vector diagram Fig. 17 to a resultant $\overline{U}_R$ which can be larger or smaller than the main voltage $\overline{U}_\beta$ depending on the value the phase angle α has at the frequency in question.

When the frequency now rises from the lowest to the highest figure it can have within the band, vector $\overline{U}_\alpha$ will shift from position 1 to position 2 and the resultant voltage $\overline{U}_R$ hence decreases with the frequency from value $\overline{U}_{R1}$, to value $\overline{U}_{R2}$. The attenuation Θ through the regulating networks is derived from the following

$$\Theta = {}^{e}\log \frac{|U_I|}{|U_R|}$$

and increases therefore with increasing frequency.

The larger the vector $\overline{U}_\alpha$ is, the more the attenuation will increase for the same change in frequency, which is evident from comparison between a and b in Fig. 17.

In reality the voltage $|\overline{U}_R|$ is, through the varying attenuation β, kept constant at a certain frequency free of choice within the transmitted band, usually for the pilot frequency. This causes the voltage vector $\overline{U}_\beta$ to remain nearly constant when the line attenuation and hence the voltage $\overline{U}_I$ varies.

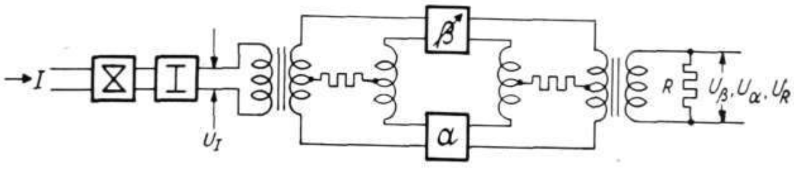


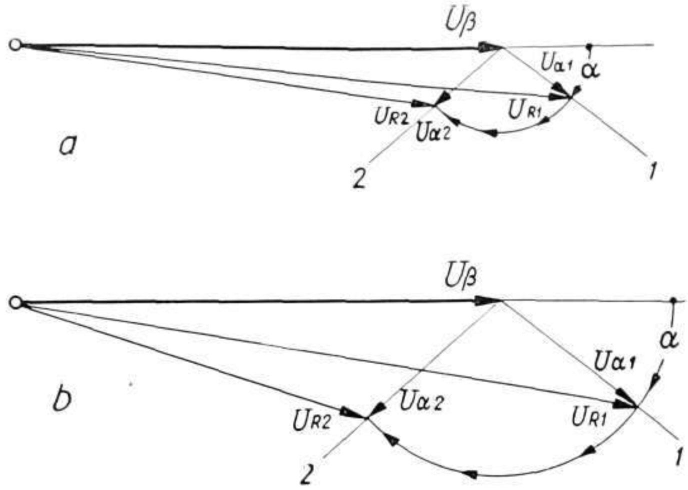
Fig. 16 X 6021
Diagram showing function of regulating network

α phase shifting network
β variable attenuator
I input side
R load resistance
U_I incoming voltage
U_α, U_β part voltages
U_R outgoing resultant voltage

Fig. 17 X 6027

Vector diagram of function of regulating network

- α angle of phase shifting network
- U_α, U_β part voltages
- U_R resultant voltage
- 1 position of U_α at lowest frequency of transmitted band
- 2 position of U_α at highest frequency of transmitted band
- a in wet weather; U_α is small, difference $|U_{R1}| - |U_{R2}|$ becomes small
- b in dry weather; U_α is large, difference $|U_{R1}| - |U_{R2}|$ becomes large



The currents passing through the phase-shifting network α are, however, not affected by the changes in network β. Hence the voltage $\overline{U}_\alpha$ rises and falls in time with $\overline{U}_r$. When $\overline{U}_\alpha$ therefore is low on account of high line attenuation in wet weather the attenuation Θ becomes almost independent of the frequency, Fig. 18 a. In dry weather, however, when the line attenuation is low, $\overline{U}_\alpha$ is high, resulting in a higher increase of Θ with increasing frecuency, Fig. 18 b.

Fig. 18 X 6028

Attenuation of regulating network for upper group

- a set for low attenuation (wet weather)
- b set for high attenuation (dry weather)

Fig. 19 X 6029

Correction of line attenuation by regulating network and line equalizer in wet and dry weater

- BN loss in filters etc.
- KN line equalizer
- LN line attenuation
- RN attenuation of regulating network

Lower figures show values of different attenuations, upper figures show totals of them

The attenuation of the regulating network is thus adjusted exactly to the variations of the line attenuation by working one single network. Wire dimensions, wire spacing and type and number of insulators determine, as seen before, the line attenuation to a high degree. With a simple setting of an additional attenuator connected in series with α the regulating network can once for all be adjusted to equalize the slope of any line existing in practice. How the line attenuation, the line equalizer and the regulating network work is shown in Fig. 19, where the condition for dry as well as wet weather attenuation is shown. KN is the line equalizer, which is all the time unchanged.

Fig. 18

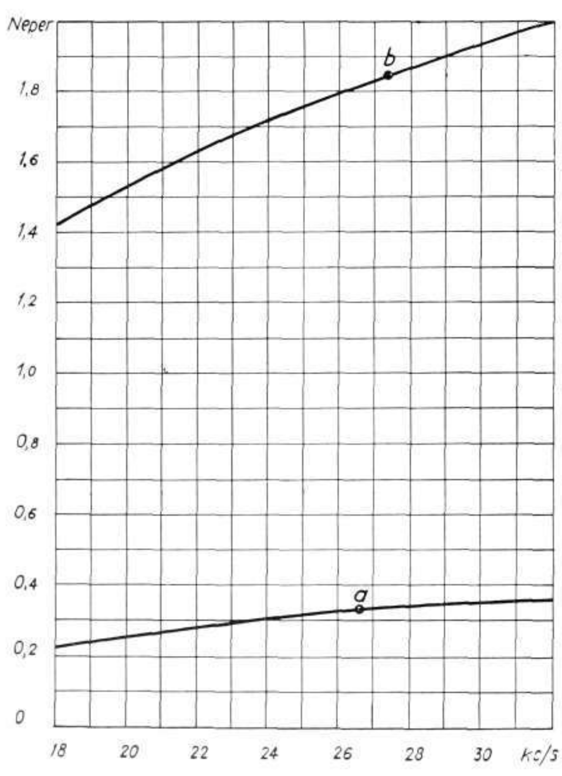
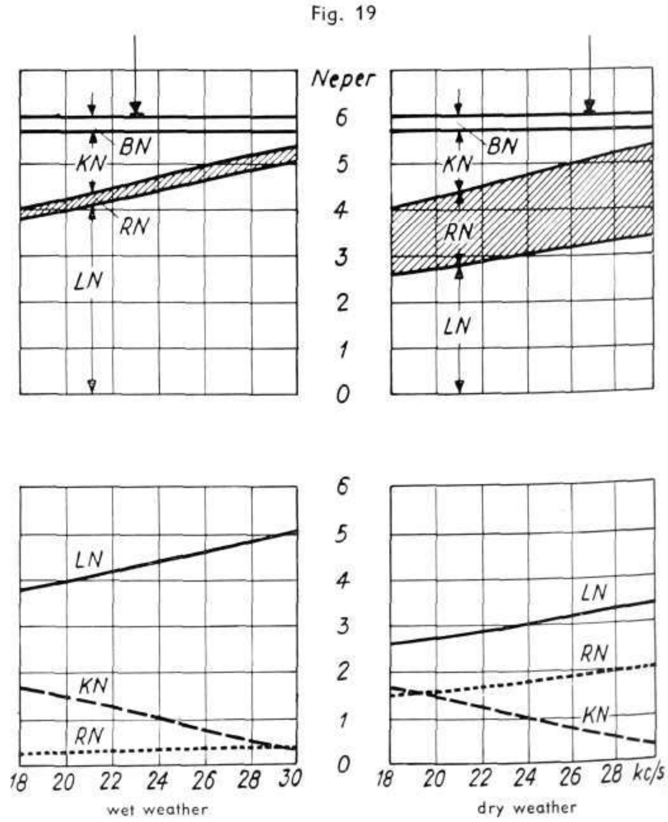


Fig. 19



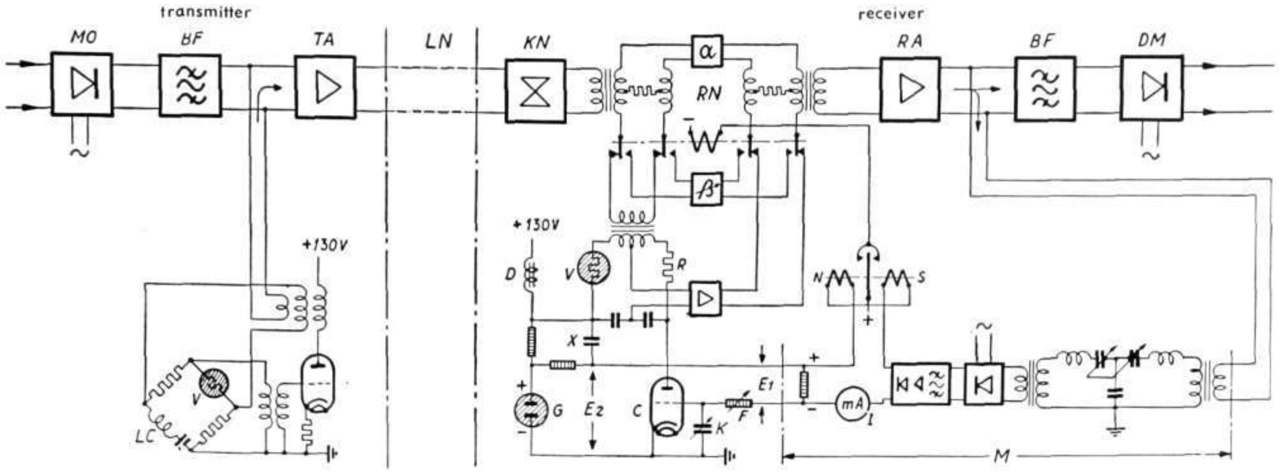


Fig. 20
Diagram of regulating circuit

X 7370

- BF band filter
- C control valve
- D choke coil
- DM channel demodulator
- E_1 pilot potential
- E_2 comparing potential
- F delay resistance
- G glow lamp
- I indicating instrument
- K delay condenser
- KN line equalizer
- LC tuning circuit
- LN line
- M pilot receiver
- MO channel modulator
- R fixed resistance
- RA receiving group amplifier
- RN regulating network
- TA transmitting group amplifier
- V current-controlled resistance
- X compensating condenser

LN is the line attenuation and *RN* the regulator attenuation. The upper part of the figure shows the combination of these three attenuations. When the line attenuation *LN* decreases from wet to dry weather the attenuation decrease is replaced by an increase of the regulator attenuation *RN* and this increases more at the higher than at the lower frequencies corresponding to the reduction of the line attenuation.

The regulating network is mounted on an 88 mm panel as seen on the lower part of Fig. 32.

Automatic Regulation

The purpose of the regulation is, as already stated, to keep the total attenuation constant between transmitter and receiver. As an indicator of this attenuation a pilot is used, which is added on the transmitting side ahead of the transmitting amplifier. After having passed the line the pilot proceeds through the line equalizer, the regulating network and the receiving amplifier on the receiving side. After the receiving amplifier the pilot is picked up by a selective circuit and its level is measured. The value of the pilot level is a measure of the total attenuation and the immediate function of the regulation is to keep this level constant. This can be done manually by adjusting the regulating network by hand after reading the pilot level on an instrument. It can also be done automatically, and in principle an automatic attenuation regulator can either be made with moving parts, such as relays, motor-driven rotary switches or variable condensers, or also with an all-electric operation. Both methods have obvious advantages and disadvantages and both are used in teletechnics.

In radio technics all-electric regulation systems are used almost exclusively, while carrier telephony rather prefers to use mechanical systems. LM Ericsson has, however, for nearly fifteen years employed all-electric systems to advantage, and such a system was chosen for the new three-channel system. The principal advantages of the all-electric system are as follows:

It works inaudibly
It works quickly
It works reliably and requires no maintenance
It can be designed for narrow adjustment limits without its operation being jeopardised — e. g. by dust or vibrations.

The disadvantages of the system are mainly two:
It is rather complicated
It does not retain the last adjusted value if the pilot fails. This is a serious disadvantage only if the pilot transmitter is unreliable, which is seldom the case.

Fig. 20 shows a diagram of the whole regulating system. It has already been stated that the three channels are regulated with one common device. Consequently only one pilot is needed for each transmitting direction.

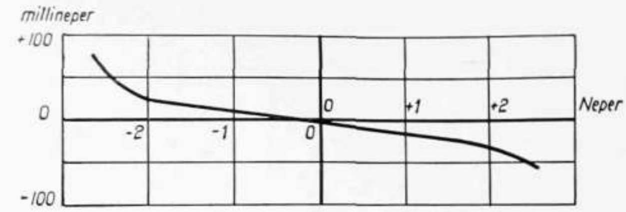


Fig. 21 X 6030
Curve of change in output level of automatic regulator as a function of change in line attenuation

On the transmitting side the regulating equipment consists only of the pilot transmitter. Its output level must of course be kept constant. The frequency must also for various reasons be kept constant. To meet these requirements in a simple way, an interesting bridge circuit has been used, which was originally introduced by Meacham. The tuned circuit LC and a current controlled resistance V form two opposite arms in a bridge, in one diagonal of which the feed-back voltage is taken out. The voltage and frequency over the other diagonal, which is connected to the anode of the oscillator valve, remains approximately constant, within certain limits, independent of fluctuations in the battery supply voltages and of the valve, as long as the amplification in the latter is maintained above a certain value.

On the receiving side the regulating equipment consists of pilot receiver, level regulator and control and indicator equipment. All this equipment is connected to the regulating network which also takes part in the automatic regulation. When regulating manually the desired attenuation value is set on attenuator β, which is adjusted in steps by a rotary switch.

When the automatic regulator is put into operation the manual attenuator is disconnected by a relay and is replaced by an attenuating circuit made up of a differential bridge with a fixed resistance R in one arm and a current controlled resistance V in the other. The entire bridge is connected into the anode circuit of a valve C in such a way that it is controlled by the D.C. anode current. At rest, i. e., when there is no current through the control valve, the bridge is in balance and the attenuation is very high. Through progressive increase of the anode current the attenuation of the bridge is conveniently reduced by 4 to 5 nepers.

The pilot receiver M, which must have a high input impedance and a great selectivity, is designed according to the superheterodyne principle. Its intermediate oscillator is stabilized in the same way as the pilot transmitter. The receiver which is negative feedback coupled and very stable, gives on the output side a comparatively high D.C. potential E_1, proportional to the

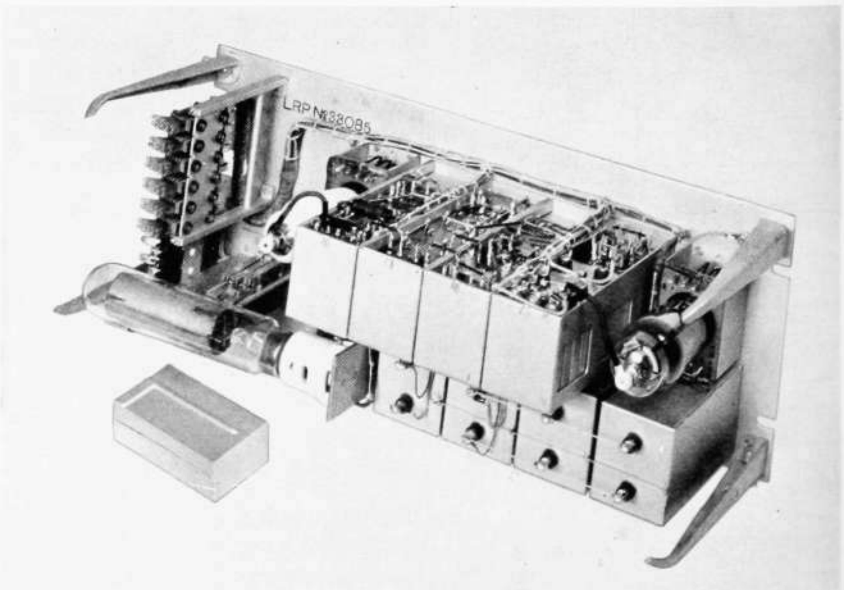


Fig. 22 X 6041
Level regulating panel

To the right, differential bridge with control valve; to the left, glow lamp for comparative voltage, shift relay and auxiliary amplifier valve; lower right, note condensers in delaying circuit

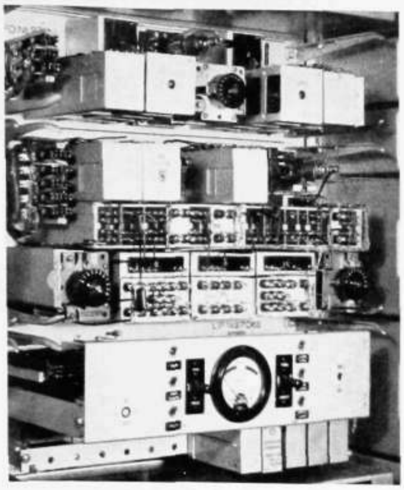


Fig. 23 X 4304
Regulating equipment

Mounted in channel bay, from the top: pilot transmitter, pilot receiver, control panel with indicating instrument and alarm relays

received pilot voltage. This D.C. potential is compared with an equally high, constant and opposing D.C. potential E_2 from a glow lamp G. The potential difference, which is a sensitive measure of the variation of the received pilot level, is applied to the grid of the control valve C of the regulating bridge in such a way, that an increasing pilot level increases the attenuation of the bridge, which consequently tends to restore the pilot level to its original value. On an instrument I, connected in the output circuit of the pilot receiver, the function of the regulator can be observed.

The sensitivity of the regulating system is such, that for an increase in the line attenuation of 1 neper the remaining level change is less than 0,02 neper, see Fig. 21. Such great sensitivity causes oscillations in the regulating system if a certain inertia is not introduced. Such an inertia is also desirable for other reasons, and a retarding chain, consisting of resistances F and condensers K is therefore connected in the grid circuit of the control valve, Fig. 20. By adjustments of these elements different regulating times can be obtained. To decrease further the risk of oscillation phenomena and thereby increase the speed of reaction, the regulator has a compensating device. During the course of a quick regulation a potential is obtained over the choke coil D in the anode circuit of the control valve. This potential is led back to the grid in opposite phase a condenser X and contributes to repress oscillations. Fig. 22 shows a photo of the level regulating panel and Fig. 23 the pilot transmitter, the pilot receiver and the control and indicator panel mounted on their places on the bay.

The curves in Fig. 24 show the course of the regulation during a sudden change in level. The quickest regulation is not aperiodic, but is quite satisfactorily damped.

When a line has several repeater stations connected one after the other, there is a certain risk of the regulators »hunting» each other. This manifests itself as follows: the highest change in level arising during the regulating period after each regulator in the chain is greater than the level after the regulator immediately preceding it, which means that during the regulating period a very great change in level can appear after the last regulator. Such a phenomenon can be appropriately prevented by making each regulator work more slowly than the preceding one. Despite this the regulation can, as seen from the receiving end of a circuit containing a chain of repeaters, be made to work quickly by letting the last regulator react the quickest of all. Fig. 25 shows the process with three series connected regulators arranged in this way.

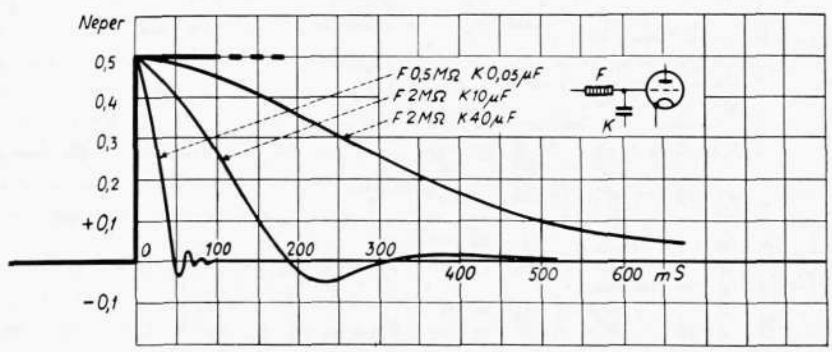


Fig. 24 X 6031
Course of regulation in a level regulator, whose input voltage is suddenly raised 0.5 neper

Curves show output voltage as a function of time in milliseconds for one regulator set for three different regulation speeds

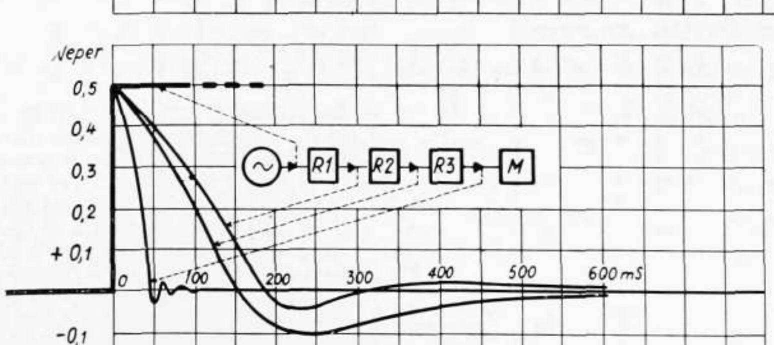


Fig. 25 X 6032
Course of regulation with three regulators R1, R2, R3 connected in series, when level ahead of the first is raised 0.5 neper

Note that over-swing of regulator R2 is not registered at M on account of the quick regulator R3

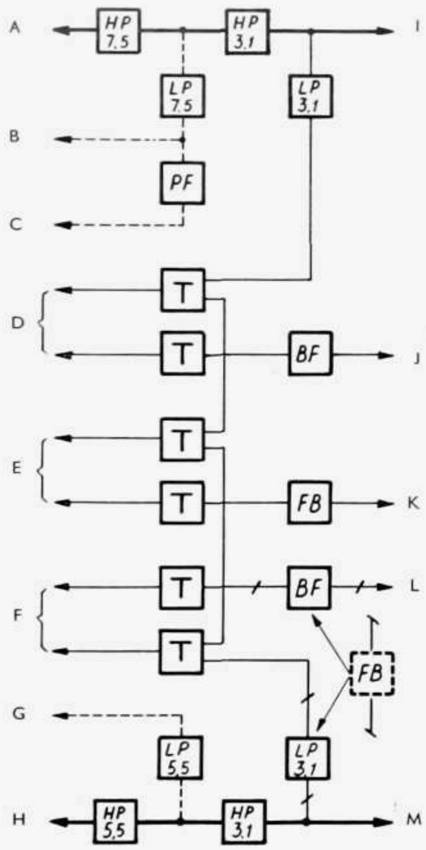


Fig. 26 X 4298

Diagram of line equipment

A equipment of three-channel system ZM 400
B equipment of carrier telegraph
C program equipment
D pair 1, to two-wire repeater or exchange
E phantom ½, to two-wire repeater or exchange
F pair 2, to two-wire repeater or exchange
G equipment for carrier telegraph
H equipment of three-channel system ZM 300
I line 1
J line balance 1
K phantom balance ½
L line balance 2
M line 2
LP 3.1 normal low-pass filter
HP 3.1 normal high-pass filter
BF balance filter for LP 3.1 when two-wire repeater is used
FB phantom-balance impedance compensation and filter substitute, to be connected in line and balance when LP 3.1 is omitted in one of side circuits and phantom circuit is to be arranged
LP 5.5, HP 5.5 low-pass and high-pass filters to be used when carrier telegraph is used together with system ZM 300
LP 7.5, HP 7.5 low-pass and high-pass filters to be used when carrier telegraph is used together with system ZM 400
PF auxiliary filter, to be used when system ZM 400 is used together with program-repeaters
T line transformer

If the regulated level deviates from the desired value by more than ± 0.2 neper — usually caused by line faults — and this condition lasts longer than one minute, the regulator gives alarm by a relay, Fig. 20. At the same time the regulating bridge is disconnected and replaced by the manual attenuator. If the latter from the beginning is adjusted to an average value suitable for the line, the fault in level will probably not be great enough to prevent calls in process from being continued when the line is restored again. In this way one of the regulator's greatest disadvantages is evaded, as the missing pilot no longer causes a break in the circuit.

Four-wire Termination

The fork circuit with its ring signal receiver and ring signal oscillator etc. together form a separate part in the three-channel system. The differential transformer has a nominal impedance of 600 ohms in all directions, and by using 8-pole design principles it has been possible to give it a constant and phasefree input characteristic from the balancing network and the switchboard sides.

The ring signal oscillator, which supplies a 500 cycle signal current, employs two valves. The first is bridge-stabilized in the same way as the pilot transmitter, and therefore gives an input voltage stable in frequency and amplitude to the second valve, which is strongly negative feedback coupled in such a way that the output level is kept constant independent of the load. The generator gives 50 mW with a harmonic content less than 1 %. The ring signal receiver, usually called »voice-frequency ringer», is of standard design för 500 c/s. It has previously been described in the Ericsson Review No. 2/1939. The ringer works best when the signal received consists of an uninterrupted 500-cycle tone. However, some administrations work with a 20-cycle interrupted tone. The ringer can, through a simple change, also work with such an interrupted tone. In consequence of this the ring signal oscillator can be equipped with an auxiliary unit for 20-cycle interruption of the 500-cycle tone.

Line Filters

The side of the three-channel system facing the open-wire line has an impedance of 600 ohms balanced to earth, and there is no practical obstacle to connecting the transformer of the directional filter directly to the line. However, as stated in the introduction, the frequency range below 6 and 8 kc/s respectively is utilized for other circuits on the same line. The different frequency bands are therefore separated by a separation filter — as a rule low-pass and high-pass filters. The design and type of these filters vary with the equipment and the lines which are to be connected through them, but they are always present in some form or other. If the lines are connected in pairs to a phantom circuit, allowance must be made for this in the design of the line filters.[1]

One system of filters must therefore be used for each line or pair of lines in a quad connected to the carrier system. Each terminal has thus one set of line filters, and each intermediate repeater two sets. The separation filters for sub-audio telegraphy — like any equipment which uses either of the wires of the pair for telegraph circuits independent of each other with the earths as

[1] The possibility of using phantom circuits is intimately connected with the transposing arrangement used on the line in question. If the number of pairs exceeds a certain limit it finally becomes impossible, with a given distance between the transposition points, for each pair and each phantom circuit to find a type for transposition which up to 30 kc/s fulfills the ordinary requirements for freedom from crosstalk and resonance. One then has to choose between reducing the distance between the transposition points, which would mean that the whole profile would have to be redesigned, abandoning the phantom circuit and instead useing more pairs for working carrier systems on. As a rule the latter solution proves to be the most economical. In the Ericssons Technics No. 6/1936 M Vos and C G Aurell give under the title: »Methods for increasing crosstalk attenuation between overhead lines» a comprehensive discussion of crosstalk problems.

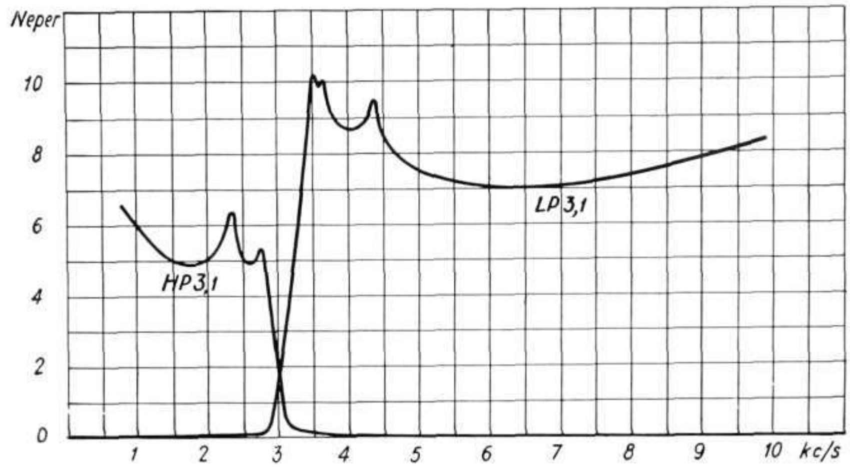


Fig. 27 X 6033
Attenuation curves for low-pass and high-pass filter LP 3.1 and HP 3.1

return (composite set) — are connected next to the line »outside» of the three-channel system and do not belong to its equipment. The arrangement of the remaining line filters in a three-channel system connected to a quad is shown in Fig. 26, which assumes that a system ZAG 11 is connected to one line-pair and a system ZAG 10 to the other pair, and that these pairs together form a phantom circuit.

The most used equipment is the low-pass filter *LP 3.1* and the high-pass-filter *HP 3.1*, which both are assembled to one unit. They separate a voice-frequency circuit below 2700 c/s. If this circuit is to be equipped with two-wire repeaters the balance filter *BF* must be added to the line balance and the filter substitute *FB* must be added to the phantom balance. When the lines also are used for carrier telegraph, filters *LP 5.5—HP 5.5* and *LP 7.5—HP 7.5* respectively, which separate a voice-frequency band below 5.5 and 7.5 kc/s respectively must be added. Finally, if one or two program circuits are arranged, filters *LP 3.1* and *HP 3.1* with the two-wire repeaters and the carrier telegraph equipment must be disconnected and a complementary program filter *PF* is connected to pair 1.

If the terminal is equipped with only one system, e. g. one system ZM 400, working on line 1, the filter set *LP 3.1* and *HP 3.1* and the balance filter *BF* in line 2 are excluded. In order to maintain the phantom circuit a filter substitute *FB* must replace *LP 3.1*, which in the phantom circuit has the same effect as the filter itself. If a two-wire repeater is used the same kind of filter-substitute must be added, replacing the balance filter.

The attenuation curves of the filters are shown in Fig. 27, 28 and 29.

Testing and Monitoring Equipment

A modern three-channel carrier system requires very little maintenance and little equipment is therefore necessary for supervision. It is limited here to an

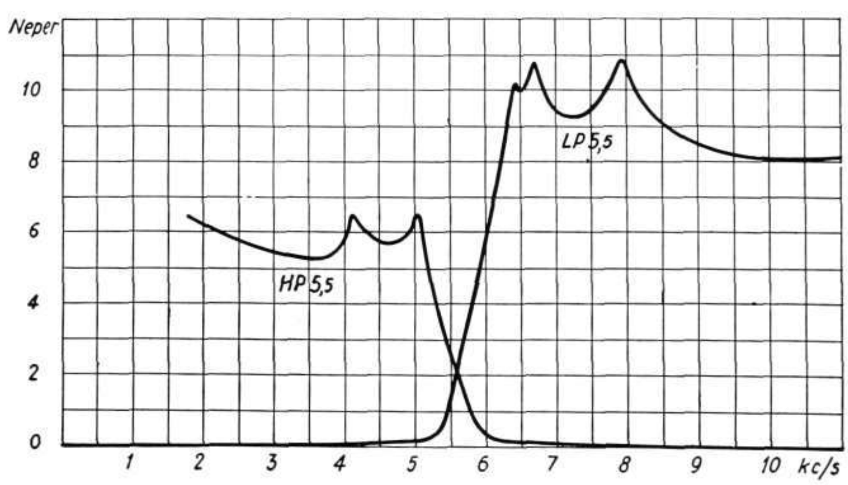
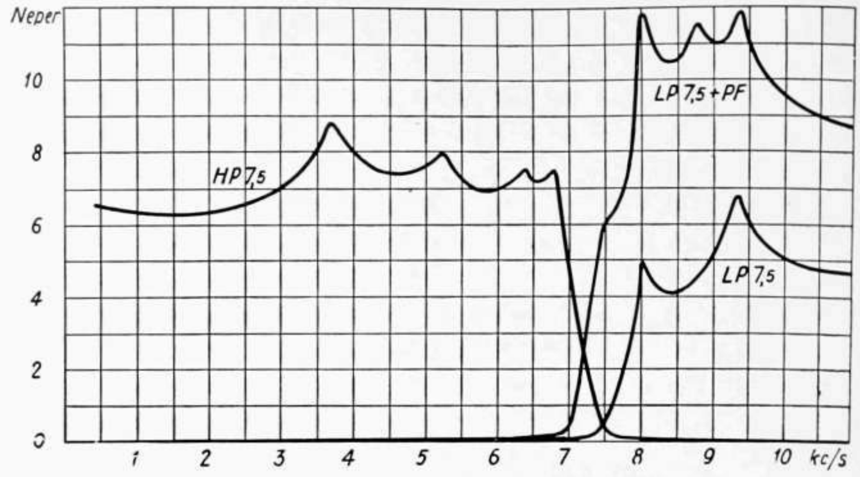


Fig. 28 X 6034
Attenuation curves for low-pass and high-pass filters LP 5.5 and HP 5.5

Fig. 29 X 6035

Attenuation curves for low-pass and high-pass filters LP 7.5 and HP 7.5 and total attenuation of LP 7.5 + PF



operator's set with devices for signalling, speaking and noise free monitoring, a test oscillator for the supply of 800 c/s test current and a level meter. Besides, there is a device for the synchronization of the channel oscillators. The current distribution equipment is in addition provided with milliampere meters, voltmeters and alarm devices.

The operator's set is used mostly on the two-wire side of the fork but can also be switched for use on the four-wire side, which is of importance if the circuit is to be arranged for four-wire connection. The operator's telephone set then employs two differential transformers which together form an 8-pole, Fig. 30. Two of the pole-pairs *A* and *B* are each connected in shunt to the passing circuits, and the other two pole-pairs to the telephone receiver and to the transmitter. In this way the currents from the transmitter are directed only to the pair which transmits in direction *A—B*, while the receiver receives currents only from the other pair. The person making the call is thus in connection with exchange *B* — he can ring it (with 500 c/s), speak and hear. When a ring signal is sent out the 500 c/s oscillator takes the place of the transmitter. If the leads *K—K* are shifted on one side of the microphone transformer, the direction is reversed, so that the caller will now only come into connection with *A*. If he wants to speak with both *A* and *B* at the same time, he breaks one of the microphone transformer leads *K—K*, which causes the 8-pole to be unbalanced and the directional effect to cease. The balance in the fork *T* is maintained all the time, so that no currents pass from one branch to the other of the four-wire circuit this preventing echo and singing. When using the monitoring equipment in two-wire connection the differential transformers are disconnected.

The test oscillator is designed in exactly the same way as the ring signal oscillator which has just been described. It has, unloaded, a terminal voltage of 1.55 volts and an internal resistance of 600 ohms and thus supplies 1 mW to a line with a 600 ohms real impedance.

Fig. 30 X 6036

Diagram of monitoring panel in four-wire arrangement

Microphone and ringsignal oscillator are connected alternatively

- A connection with side A
- B connection with side B
- A—B repeater in direction A→B
- B—A repeater in direction B→A
- M transmitter
- O receiver
- K switching point
- T differential transformers

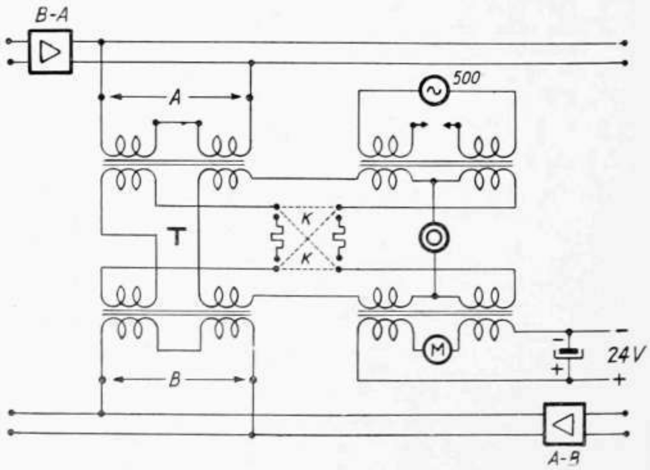
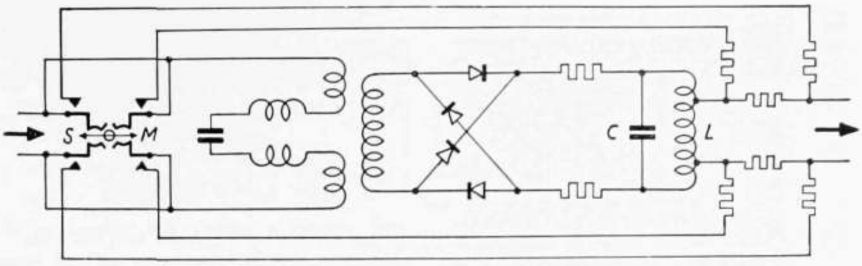


Fig. 31 X 6037

Diagram of synchronizing apparatus

Tuned circuit L-C is tuned for 1600 c/s; when transmitting, with key in position S, 800 c/s enters apparatus and equal voltages of 800 c/s and 1600 c/s leave; when receiving, with key in position M, 800 ± △ c/s and 1600 ± △ c/s enter, while 1600 ± △ and 1600 ± 2 △ leave; △ is error of synchronism in c/s



The level measuring set, which measures voltages and levels between — 3.2 and + 2.6 nepers with frequencies between 200 and 100000 c/s, has previously been described in the Ericsson Review No. 2/1939.

The synchronization of the channel oscillators is based on a new principle. Let it be supposed that a transmitter with the carrier frequency b is simultaneously modulated with the frequencies t and $2t$. If the modulator transmits, for example, the higher side band the frequencies $b + t$ and $b + 2t$ are present on the line. Let it further be supposed that the receiver oscillator, which also ought to have the frequency b, has increased so that in reality it has the frequency $(b + \triangle)$. The demodulated frequencies will then be:

$$f_1 = b + t - (b + \triangle) = t - \triangle$$
$$f_2 = b + 2t - (b + \triangle) = 2t - \triangle$$

If a non-linear resistance, e. g., a copper oxide rectifier, is inserted on the receiver side, second harmonics of both frequencies, namely $2f_1$ and $2f_2$, are produced there. Only $2f_1$ and the f_2 present of interest. If this mixture of frequencies is listened to with a telephone receiver which itself is non-linear, a beat tone s between the two last mentioned frequencies will be heard.

$$s = f_2 - 2f_1 = (2t - \triangle) - (2t - 2\triangle) = \triangle$$

The difference between the two carrier frequencies is thus heard.

The frequency t on the transmitting side is taken from the test oscillator. In a simple circuit, Fig. 31, $2t = 1600$ c/s is produced, which is then mixed with $t = 800$ c/s and supplied to the channel which is to be synchronized. The same device serves on the receiver side for the doubling of $f_1 = t - \triangle$ and for the suppression of the undesired tones. The beat thereby becomes the clearest possible and the synchronization will be very easy to execute even for a person with an untrained ear. As the level measuring set contains a rectifier next to the instrument it can also be used for indicating the beat as long

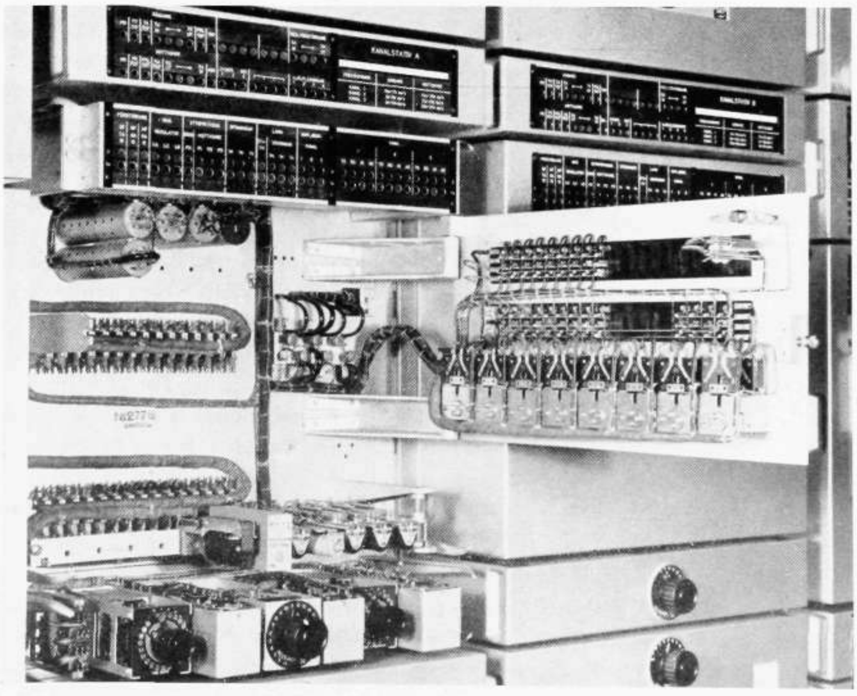


Fig. 32 X 6042

Jack field and current distribution panel, latter with opened front

On front plate, switches; on back plate lower part, relays; *below, current distribution panel,* regulating panel with potentiometers for line slope, receiver level and auxiliary line attenuator as this is not higher than 10 c/s. The level measuring set then takes the place of the telephone receiver and the beat is indicated by the pointer deflections. With suitable setting the deflections can be made to cover the greater part of the scale.

Current Distribution

The required power for operating the system is taken in on the main fuse panel on one of the bays and is from there distributed to the current distribution panels, of which there is one for each bay. On these panels the fuses, power switches, reduction resistances, meter shunts, alarm relays, alarm lamps and in one of the bays an alarm bell are placed. These panels are arranged with double plates, of which the front plate can be swung out to make all parts easily accessible, Fig. 32. The relays are mounted on bars, which also can be swung out.

Bay Assembly

The terminal channel and amplifying equipment, including the automatic regulator, together with the current distribution panel, fill the front and rear of an entire bay 485 mm wide and 2590 mm high, Fig. 33. A second bay takes the line filters, forks and ringers as well as the current distribution panel for two three-channel systems, one ZAG 10 and one ZAG 11. All equipment for monitoring and testing is placed on this bay, Fig. 34, as well as a jack field, in which all circuits, both the carrier and the physical concerning the system, are accessible. All the auxiliary circuits necessary for supervision or belonging to the test equipment are connected to the jack field. The bay is furthermore equipped with spare panels for ringer, ring signal oscillator and line filters, and these are also connected to the jack field. At the top of the bay there is the main fuse panel from which the incoming power is distributed. The space on the line filter bay is relatively large, but this is necessary, as local conditions often require extra line filters to be added.

A terminal consisting of two three-channel systems with their line filters and ringers thus takes three bays, Fig. 35. The bays are electrically joined with easily fixed plug-in type interconnection cables. The intermediate repeater takes one bay, and the necessary line filters require, as on the terminal, one bay for two repeaters. The test equipment is here limited to an operator's set and a level measuring set. Fig. 36 shows the complete equipment with two repeater bays. On each of them may be seen the switching keys and indicator instruments of the regulators. At the top of the middle bay a fuse panel is placed as on the terminal. The line transformers do not form part of the three-channel system equipment but, as Fig. 26 shows, they are, as regards their connection, close to the line filters. For this reason a place has been provided for them on the rear of the filter bay both in the repeater and in the terminal. The wiring is arranged in such a way, however, that they can also be placed outside of the bay in the event of transformer racks being available.

In stations along the line where the circuits need to be available for low frequency operation, the high frequency band is by-passed in a high frequency shunt which contains two standard low-pass—high-pass filter sets. To prevent crosstalk between the phantom circuits on each side of the shunt, the high-pass filters are joined through a transformer with a static-earthed screen between the windings, Fig. 1. The two filter sets and a jack panel, which also contains the above mentioned transformer, are mounted on an iron frame 485 × 878 mm which is intended for wall mounting. Thus for one quad two such filter units are needed. A third iron frame of the same size is provided for taking the balance filters which are needed if two-wire repeaters are to be connected into the physical circuits. In the same balance unit there is space for all necessary line transformers and filter substitutes and balance filters which may be required for the equipment of the whole quad. A complete high-frequency shunt for a quad thus consists of three units together requiring 1455 × 878 mm. The shunt can also be mounted on a standard frame.

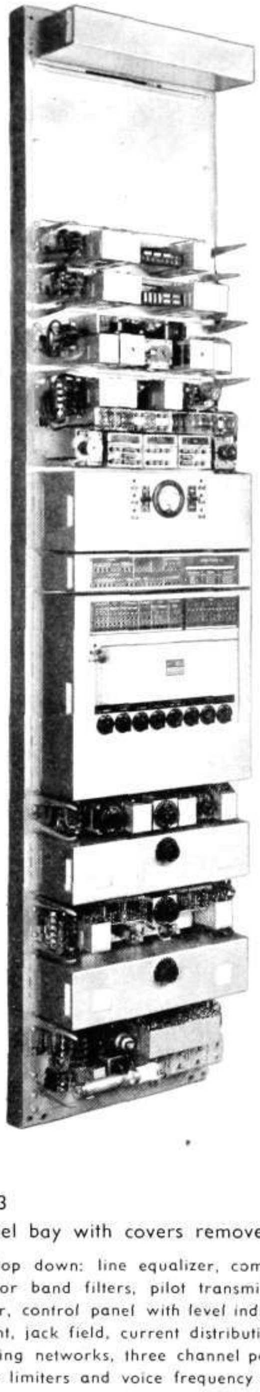


Fig. 33 X 4300

Channel bay with covers removed

From top down: line equalizer, compensating filter for band filters, pilot transmitter, pilot receiver, control panel with level indicating instrument, jack field, current distribution panel, regulating networks, three channel panels with volume limiters and voice frequency amplifiers and at bottom level regulating panel

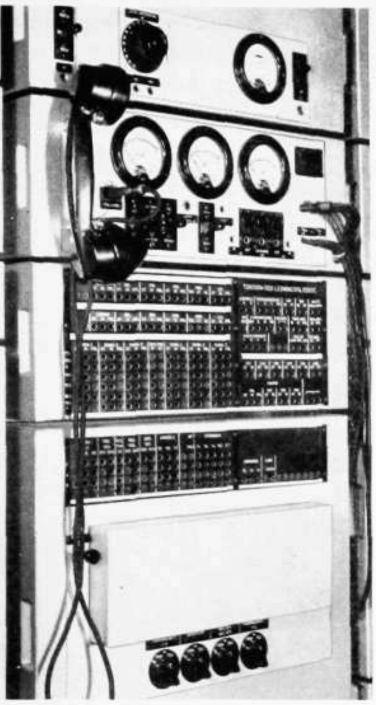


Fig. 34 X 4301
Control and test equipment of terminal

From top down: level measuring set, meter and monitoring panel, jack field and current distribution panel

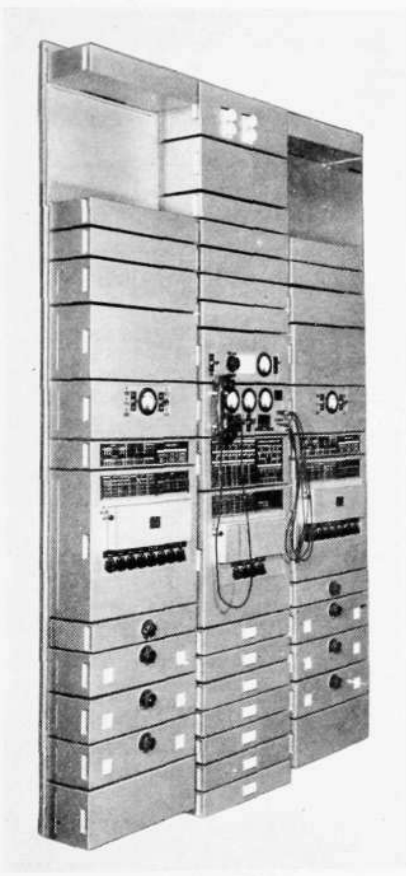


Fig. 35 X 4302
Complete terminal for two three channel systems

In centre: line filter and ringer bay; on sides: channel bays

Current Consumption

Four sources of power are needed for the system:

anode current	130 volts	± 5 %
filament (heater) current	24 »	± 5 %
relay current	24 »	± 15 %
ringing current	80 »	20 ~

The filament circuits can be connected for either 21 or 24 volts supply and the power can either be D.C. or A.C. In the latter case 21 volts is suitable. The average value of the filament voltage should, in consideration for the life of the valves, not deviate by more than ± 3 % from the nominal value, whether this is 21 or 24 volts.

The current consumption for normal operation and the maximum current consumption with all test equipment and spare equipment switched on and all alarm circuits in function are seen in table II.

Table II. Current consumption of three-channel system

equipment	anode current at 130 V		filament current at 24 V		relay current at 24 V	
	normal	maximum	normal	maximum	normal	maximum
	A		A		A	
terminal, 1 system	0.25	0.35	4.2	5.5	0.31	0.90
terminal, 2 systems	0.47	0.65	7.9	9.8	0.60	1.60
repeater, 1 system	0.25	0.31	3.3	4.3	0.21	0.72
repeaters, 2 systems	0.50	0.62	6.6	8.2	0.42	1.40

The source of power for relay current and filament current can be the same, e. g. one battery can supply both of them, but separate feeders should be used in such a case right from the battery terminals.

A pole changer is sufficient for the generation of the ringing current. It can be connected so that it is normally at rest and is started from the system only when ringing current is needed.

Types of Valves

Three different types of valves are used in the system, a small one, RTR 4141, and two larger ones RTR 4341 and RTR 4342. The most important data pertaining to them are as follows:

	RTR 4141	*RTR 4341*	*RTR 4342*
filament (heater) voltage	5.25 V	21 V	21 V
filament (heater) current	0.380 A	0.285 A	0.315
anode voltage	130 V	130 V	130 V
anode current	6 mA	10 mA	40 mA
grid bias	— 5 V	— 1.5 V	— 8.5 V
mutual conductance	1.2 mA/V	8 mA/V	9 mA/V
internal resistance	200000 ohms	250000 ohms	15000 ohms

Four valves RTR 4141 work in series on 21 volts.

A glow lamp of about 80 volts glow voltage is used in the automatic level regulator.

Measurements

A typical curve of overall quality of a channel from fork to fork is reproduced in Fig. 37, while Fig. 38 shows the limits within which twenty arbitrarily selected curves all lie. The variations of the propagation time within the transferred band is seen from Fig. 39, which has been plotted from impedance measurements from the two-wire side of a fork, to which the transmitted band has been returned. During these measurements, when both terminals must be close to each other, the modulator oscillator was kept in true synchronism with the demodulator oscillator by special arrangements.

The near-end and far-end crosstalk figures are given in table III.

Table III. Measured near-end and far-end crosstalk attenuations of the terminal

Attenuation values in neper between points with equal nominal level
S transmitting channel M receiving channel

Average value measured at terminal						Lowest value measured at terminal					
A channel			B channel			A channel			B channel		
1	2	3	1	2	3	1	2	3	1	2	3
S	9	10	M	8.5	8.8	S	9	9	M	8.2	8.4
>10	S	>10	8.3	M	8.6	10	S	>10	8.2	M	8.2
>10	>10	S	8.6	8.9	M	>10	10	S	8.6	8.8	M
M	8.5	8.7	S	9.5	10	M	8.2	8.5	S	8.5	9.5
8.5	M	9.1	>10	S	>10	8.2	M	8.8	>10	S	>10
8.3	8.5	M	>10	10	S	8.2	8.2	M	>10	9.5	S

It is to be noted, that the measured crosstalk to the greatest part is unintelligible and according to C.C.I.F. rightly ought to be considered and measured as noise. When there are only three channels the rythm of speech will come through although unintelligible, and at high crosstalk attenuations, when in any case only the rythm of speech is heard and the words are not expected to be understood, the noise effect is the same as if the noise had been of intelligible nature. It can therefore be justified in this case to measure the interference as crosstalk and not as noise.

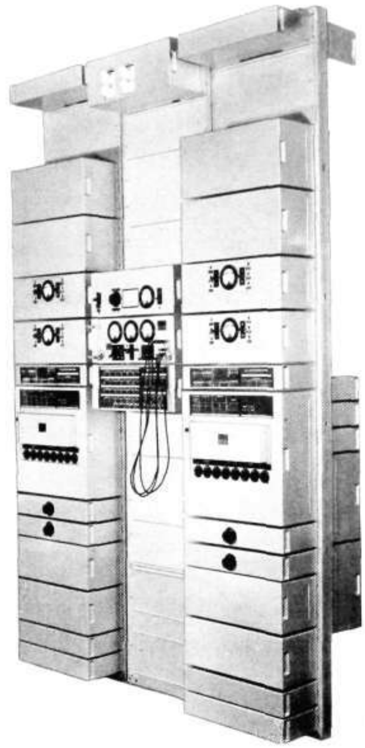


Fig. 36 X 4303

Intermediate repeater for two systems

In centre: line filter bay with control and test equipment; at sides: repeater bays each with two level indicating instruments

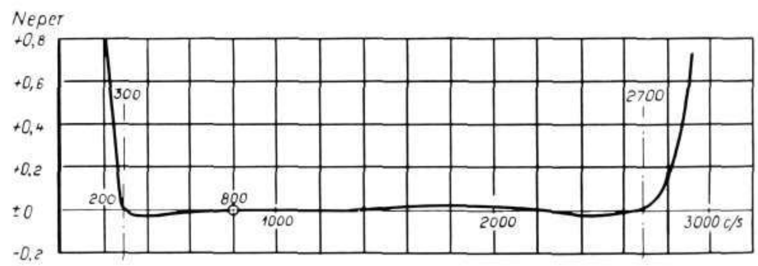


Fig. 37 X 6038

Over-all attenuation curve from fork to fork

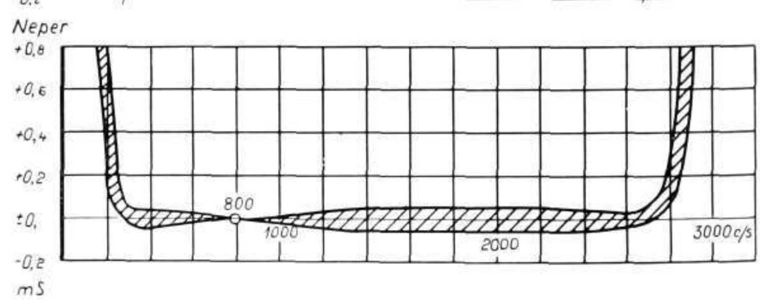


Fig. 38 X 6039

Limits within which all of a great number of arbitrarily selected over-all attenuation curves fall

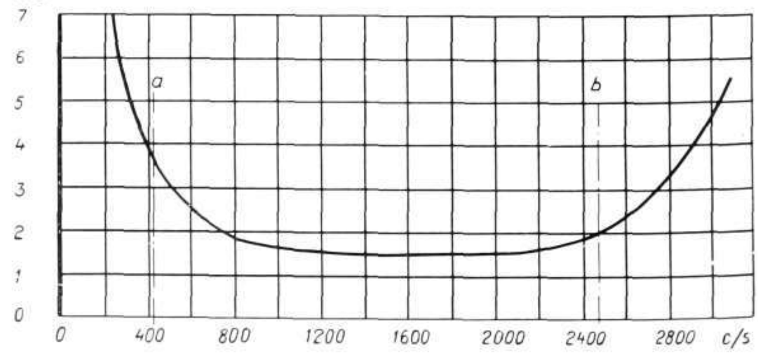


Fig. 39 X 6040

Propagation time from fork to fork

Lines a and b show the position of highest and lowest frequency of an 18-channel voice frequency telegraph system

Rural Line Repeater with Negative Feed-back

J LJUNGBERG, TELEFONAKTIEBOLAGET LM ERICSSON, STOCKHOLM

U.D.C. 621.395.64

For lines, which are long but not long enough or with so many circuits that a normal repeater station, is warranted a small repeater equipment is often useful to compensate part of the line attenuation. This equipment consists of 2-wire repeaters, which may be connected to the electric mains and which are easy to install and to maintain.

The rural line repeater ZMK 5001, described below, is designed to meet the above demand and is an improvement on LM Ericsson's rural line repeater of older construction. The line repeater has smaller dimensions in its present construction.

The principal diagram for the rural line repeater is shown in Fig. 1. The circuit from the subscriber A is connected to L_A and the circuit from the subscriber B to L_B. The balancing networks corresponding to the circuits mentioned are connected to B_A and B_B respectively. The speech currents from the subscriber A enters the differential transformer, which consists of the transformers *1* and *2*, and is passed on through the grid winding on tranformer *2* to the repeater valve *3*, which amplifies the current in direction A to B. The grid winding is equipped with 4 tappings, by means of which the gain may be varied. Behind the amplifier valve there is a filter which limits the amplified frequency range to 2500 c/s. This filter consists of the coil *4* and the three condensers *5*. After having passed the filter the currents flow through the anode winding on the transformer *6* to the other differential transformer of the repeater and is put out on the circuit L_B to the subscriber B. The speech currents in the opposite directions pass the transformer *7*, the amplifier valve *8* to the transformer *1* in a similar way.

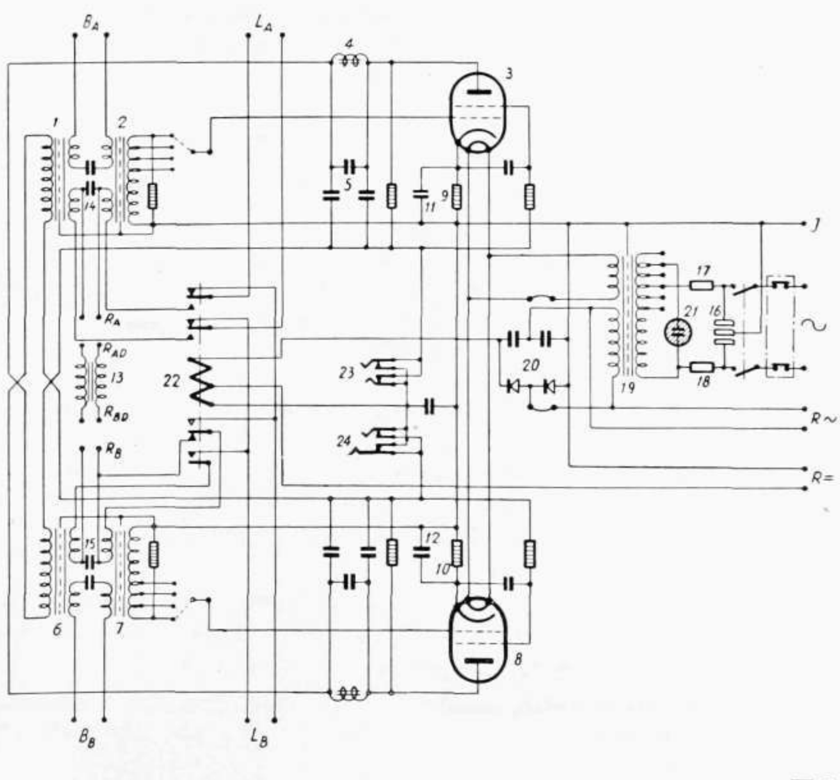


Fig. 1
Diagram of rural line repeater

1, 2 differential transformer
3 repeater valve
4 filter coil
5 filter condensers
6, 7 differential transformer
8 amplifier valve
9, 10 resistance
11, 12 condensers
13 filter coil
14, 15 filter condensers
16 lightning protector
17, 18 fuses
19 mains transformer
20 rectifier
21 glow lamp
22 relay
23, 24 jacks

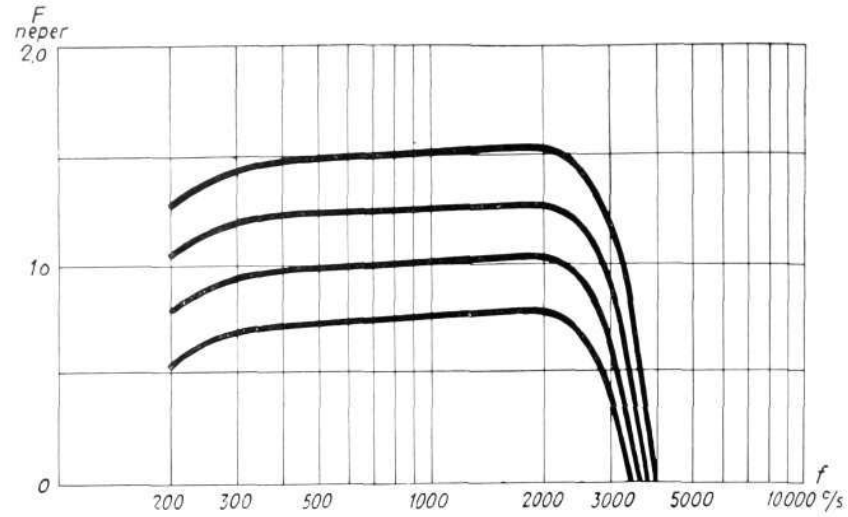


Fig. 2 X 5888
The gain F as a function of requency f

The feedback is obtained by the resistances *9* and *10* not being parallel with a condenser of sufficient size to make a short-circuit for A.C. By means of the feedback the gain is kept more constant with varying mains voltage and the disturbances from the anode and filament voltages are better suppressed. Further the repeater will be more independent of the ageing of the repeater valves. The condensers *11* and *12* serve as equalizers, by means of which a small rise in the frequency is obtained in the gain curve.

The gain curve of the repeater is shown in Fig. 2. The maximum gain at 800 c/s is 1.5 neper. By means of the tappings on the transformers *2* and *7* the gain may be reduced in 3 steps of 0.25 neper each. The gain corresponding to the different steps is shown on Fig. 2.

Ringing current is used of 15—50 c/s A.C. and the repeater is equipped with a corresponding shunt, which may, however, be disconnected if a normal ringing repeater is desired. The coil *13*, connected with its terminals R_{AD} to R_A and R_{BD} to R_B, forms together with the condensers *14* and *15* a low-pass filter. The attenuation for the ringing current with the ringing shunt in function is shown on Fig. 3. If the line is so long that the ringing current has to be reduced at the repeater point, a ringing repeater of normal design has to be connected between R_A and R_B.

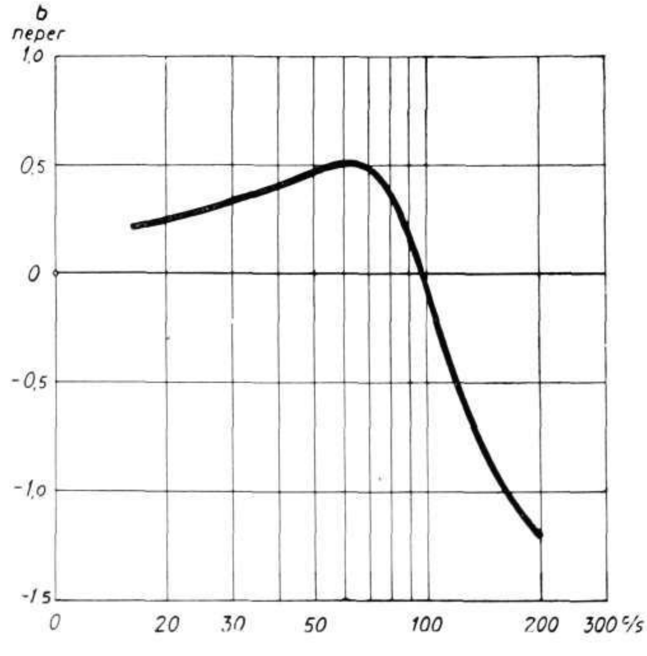


Fig. 3 X 5869
The attenuation *b* for the ringing current as a function of frequency f

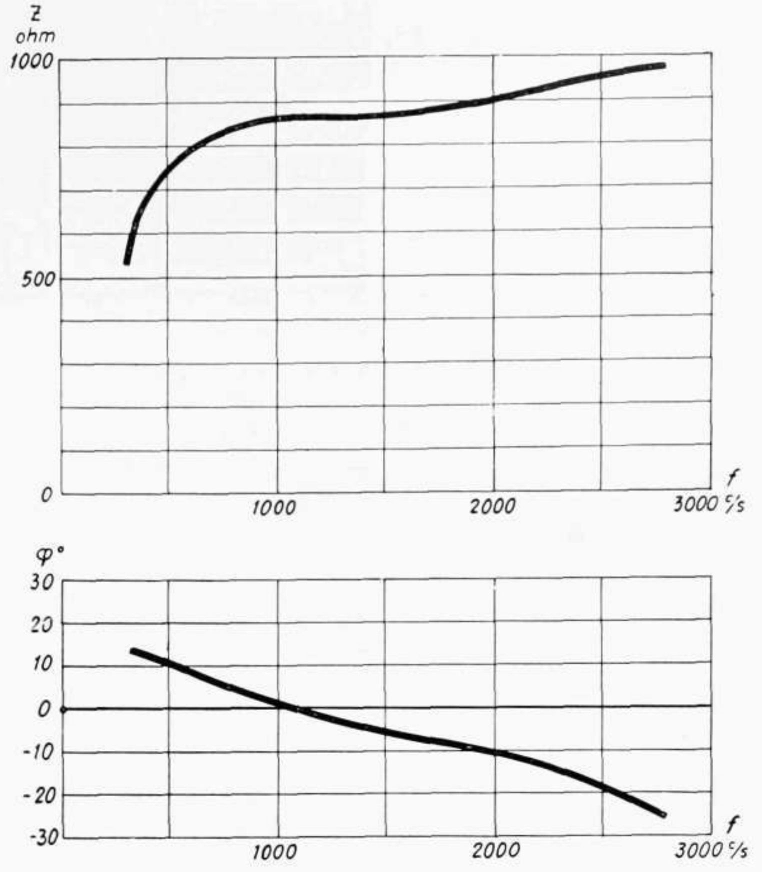


Fig. 4 X 5890
The impedance Z and its phase angle φ as a function of frequency

The input impedance for the repeater is shown on Fig. 4.

The repeater may be connected to electric mains with A.C. voltages 110, 127, 140, 150, 220 or 245 V and with a frequency between 25 and 60 c/s. Voltage adjustment is done by means of a switch on the mains transformer *19*, Fig. 1. On the mains side the repeater is provided with a lightning protector *16* and with the fuses *17* and *18*. Close to the mains contact there is, besides the normal disconnecting switch, also an interruptor which automatically disconnects the mains voltage when the cover is removed from the repeater. By this arrangement every part of the repeater is voltage-free as soon as the cover is removed. Across the mains transformer there is a glow lamp *21*, which indicates when mains voltage is on.

The mains transformer *19*, Fig. 1, delivers both 6.3 V A.C. to the filaments of the valves and 100 V which gives an anode voltage of approximately 160 V by means of a metal-rectifier *20* used as voltage-doubler. I a ringing repeater is used together with the repeater, A.C. voltage may be obtained for the outgoing signal from the terminals $R\sim$ while D.C. for the relays from $R=$, and the right valve, 24 V, is obtained by a tapping on relay *22*.

After the rectifier *20* the anode current passes through relay *22*, which partly acts as filter coil for the anode current and partly as reconnecting relay. If *e. g.* the A.C. voltage from the electric mains fails, relay *22* falls and connects the subscriber *A* directly with the subscriber *B* so that the connection may be ensured though without amplification until the mains voltage comes back.

The valves used are indirectly heated, screened pentodes of the types RTR 4141, KTZ 63 or 6J7G. The filament voltage is 5.25 V for RTR 4141 and 6.3 V for KTZ 63 and 6J7G. The filament current is 0.37 A and 0.3 A respectively. The total power consumption from the electric mains is approximately 10 W.

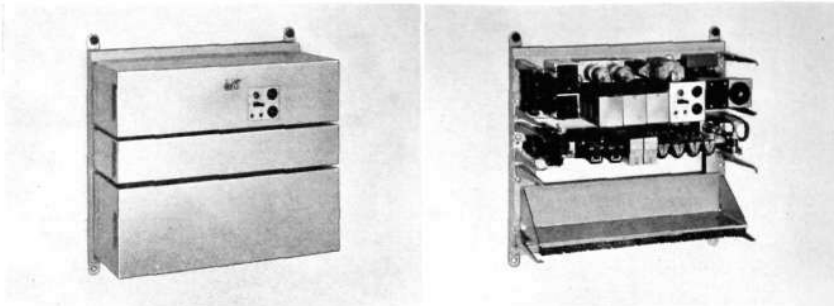


Fig. 5 X 5889

Repeater equipment ZDA 1003 comprising

rural line repeater ZMK 1003 mounted together with a ringing repeater and a transformer shelf; to the left with, to the right without, covers

The repeater is mounted on a 3 mm iron panel with the dimensions 482.6×132 mm. A removable cover with a depth of 180 mm is placed over all those parts, which need not be accessible during a normal function. The mechanical design is seen from Fig. 5, showing the repeater (the upper panel on the figure) partly with and partly without covers. In an aperture in the cover are to be found the switch, the glow lamp, the fuses and the jacks *23* and *24*, Fig. 1, intended for the measurement of the anode current.

Fig. 5 shows the repeater mounted on an iron frame together with a ringing repeater ZMN 1001 and a shelf for nine line transformers and balancing networks. The repeater can be delivered either without this iron frame or with an iron frame for other combination possibilities according to the table below, Fig. 6. When the repeater is delivered mounted on a frame together with a transformer shelf and a ringing repeater, the required connections between these are executed so that one only has to connect the mains voltage, the lines *A* and *B*, and to place the necessary transformers and balancing networks on the transformer shelf.

type	height of frame mm	number		
		rural line repeater ZMK 5001	ringing repeater ZMN 1001	transformer shelves
ZDA 1001	165	1	—	—
ZDA 1002	345	1	—	1
ZDA 1003	435	1	1	1
ZDA 1004	300	2	—	—
ZDA 1005	655	2	—	2
ZDA 1006	835	2	1	2
ZDA 1007	835	2	2	2
ZDA 1008	435	3	—	—
ZDA 1009	520	3	—	2
ZDA 1010	1055	3	1	2
ZDA 1011	1055	3	2	2
ZDA 1012	1055	3	3	2

Fig. 6

Combination possibilities for rural line repeater ZMK 5001 together with ringing repeater and transformer shelves

New Ringing Repeater

J LJUNGBERG, TELEFONAKTIEBOLAGET L M ERICSSON, STOCHOLM

U.D.C. 621.395.64

With the ringing repeater types earlier used for two- and four-wire circuits with 15—50 c/s signalling current, the outgoing signal from the ringing repeaters is shorter than the incoming and furthermore the signal is delayed a comparatively long time owing to the inertia of attraction which is necessary in repeaters of older design. This has caused the inconvenience that, as regards long lines needing several ringing repeaters one after the other, the length of the ringing signal is reduced in each *ringing repeater. Thus the original signal must have a length exceeding the total of* these reductions.

Below a ringing repeater is described, where the output signal has the same length as the incoming one and where the operation time has been reduced to less than a third of that for ringing repeaters of older type.

The diagram of the new ringing repeater is shown in Fig. 1. The ringing repeater is connected both to a D.C. voltage applied in order to feed the relays and to an A.C. voltage for the outgoing ringing signal. For the signalling from subscriber *A* to subscriber *B* the relays *1*, *3* and *5* are used while the relays *2*, *4* and *6* are for signalling in opposite direction.

The ringing repeater works as follows:

If a signal enters R_A the relay *1* is actuated and transmits over its contacts *1* and *2* minus voltage to relay *3*. This relay is actuated and separates F_B and L_B by means of the contacts *1*, *2*, *4* and *5* and transmits a new ringing current to L_B over the contacts *1*, *3*, *4* and *6*. Over the contacts *7* and *8* on the same relay minus voltage is passed to relay *5*, which is actuated and by means of the contacts *1* and *2* disconnects relay *2* which acts as receiving relay for the opposite signalling direction. The break-off of the relay *2* is done in order to prevent the reflected part of the signal, returning from L_B when relay *3* is disconnected, from entering relay *2*, which otherwise would transmit a false signal in opposite direction. Relay 5 is slow-acting on break so

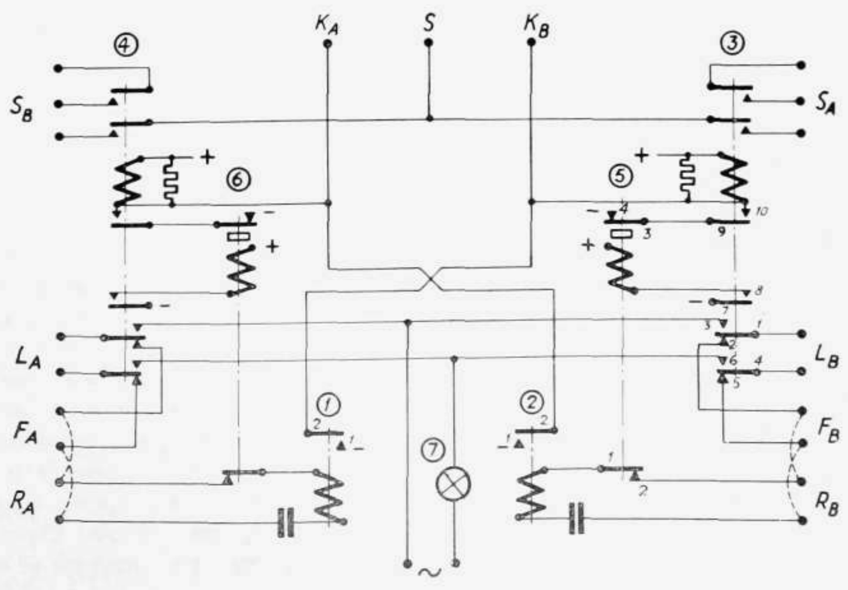


Fig. 1 X 5873

Diagram of new ringing repeater

F_A, F_B	to repeater
K_A, K_B	for station signalling
L_A, L_B	to line
R_A, R_B	to ring signal relay
S, S_A, S_B	for clearing
1, B, 5	relay for signal from A-subscriber to B-subscriber
2, 4, 6	relay for signal from B-subscriber to A-subscriber
	lamp for limiting outgoing signal currents

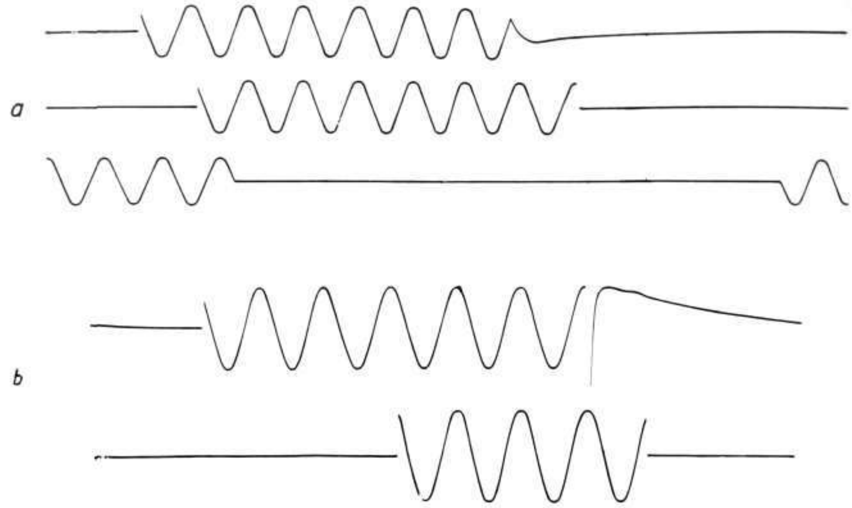


Fig. 2
Oscillogram

X 5874

a for the new ringing repeater
b for an older ringing repeater

that the signalling direction L_B to L_A is blocked long enough to enable the reflected wave to be extinguished before relay 5 breaks off and once more connects the receiving relay 2.

If relay 1 gets a very short signal so that its contacts are connected for an instant only, relay 3 would connect and disconnect without relay 5 being actuated. In such a case relay 3 would transmit a short signal over L_B causing a reflected wave, which would then freely pass on to the receiving relay 2, which is sending out a signal on L_A over relay 4. In that way the signal would oscillate through the ringing repeater. This is prevented by the contacts 9 and 10 on relay 3 and by the contacts 3 and 4 on relay 5. Over these contacts relay 5 is forced to act as soon as relay 3 has closed its contacts 9 and 10, relay 3 being incapable of disconnecting until relay 5 has been actuated and has broken its contacts 3 and 4. For signalling in the opposite direction the relays 2, 4 and 6 are used in the way described above for the relays 1, 3 and 5.

The terminals S, S_A and S_B serve to forward the clearing signal etc. to the operator when the repeater is used combined with a cord-circuit repeater. The terminals K_A and K_B may be used for controlling the ringing repeater *e. g.* from the supervisory device of the repeater station. The lamp 7 serves only to limit the outgoing ringing current on short lines or if a short-circuit occurs on the line.

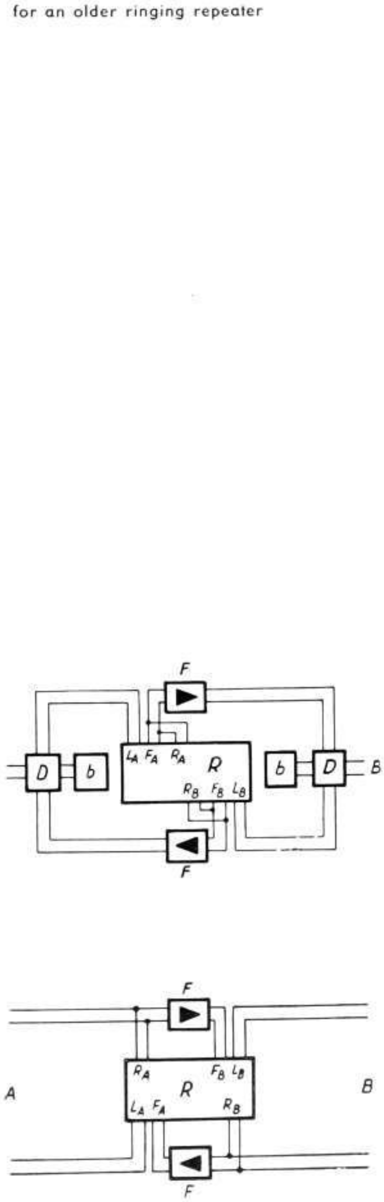


Fig. 3

X 4181

Connection of the ringing repeater together with two-wire repeater and a four-wire repeater

A, B line to A- and B-subscriber
R ringing repeater
F repeater
D differential transformer
b balance

Fig. 2 shows oscillograms for a new and an old ringing repeater. The upper curve of the first oscillogram shows the time during which an A.C. voltage with a frequency of 25 c/s has been connected to R_A, Fig. 1, the central curve shows the time during which the signal has been transmitted on to L_B and finally the third curve shows the time during which the receiving relay 2 has been disconnected by means of the contacts 1 and 2 on relay 5. The time from the signal entering R_A and until the new ringing current reaches L_B is approximately 40 ms and the time from the voltage disappearing on R_A until the outgoing signal stops is 43 ms. The receiving relay 2 is disconnected about 150 ms after the outgoing signal stops. The upper curve of the other oscillogram shows the incoming voltage on a pair of terminals corresponding to R_A, Fig. 1, and the lower curve the outgoing voltage from the ringing repeater on a pair of terminals corresponding to L_B for a ringing repeater of an older design. This ringing repeater does not disconnect the receiving relay for the opposite signalling direction. The protection against the reflected ringing voltage is obtained by the considerable time required to start a signal from the ringing repeater. The time from the signal entering the ringing repeater and until the new signal starts is 140 ms, and the time between the end of the incoming signal has stopped and the outgoing signal stopping is 45 ms.

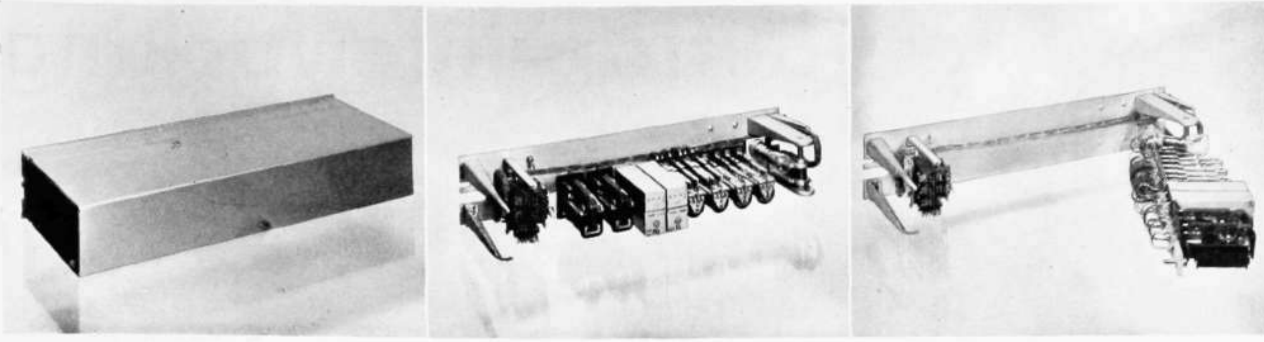


Fig. 4 X 7284
Ringing repeater
to the left with cover, in centre without cover, to the right with the bar swung out

A comparison between the two oscillograms shows that the new ringing repeater delays the signal only 40 ms and transmits a new signal of practically the same length as the incoming one (in the oscillogram corresponding to an extension of the signal by 3 ms) and blocks the reversed signalling direction for false signals during a period of 150 ms. As to the ringing repeater of older design the corresponding periods are: a signal delay of 140 ms, a shortening of the signal by 95 ms and a protection time for false signals in the opposite direction of 140 ms.

If several ringing repeaters are connected one after the other in a circuit it is at once seen that, with the ringing repeater of the older type, one has to give a very long signal in order to compensate for the reduction of the signal in each ringing repeater. Thus it is practically impossible, when calling to determine the length of the signal at the far end of the line. With the new ringing repeater, however, the length of the transmitted signal needs not to be greater than the length of signal to be received at the far end of the line. The signalling may, therefore, also be of code type. Furthermore, a considerable decrease in time for the transmission of the signal is obtained.

On the upper part of Fig. 3 is shown how the ringing repeater is to be connected to a two-wire repeater and on the lower part how to connect it to a four-wire repeater. The connection is done in the same way as for ringing repeaters of older types, thus enabling replacement without difficulty of older ringing repeaters.

The mechanical design of the ringing repeater is seen on Fig. 4. The repeater is mounted on an iron panel with the dimensions $482.6 \times 88 \times 3$ mm, provided with a removable cover of a depth of 180 mm. On the panel, counting from the left, the soldering tag, the receiving relays with their series condensers, the relays for the outgoing signal, the slow-acting break relays and the lamp for the limiting of the outgoing ringing current. All the relays are mounted on a movable bar in order to facilitate the inspection of the soldering etc. on the wiring side of the relays.

The ringing repeater is designed for 24 V D.C. and for transmission of signals with a signal frequency between 15 and 50 c/s.

New Press-Button Interlocking Control Machine

H INSULANDER, L M ERICSSONS SIGNALAKTIEBOLAG, STOCKHOLM

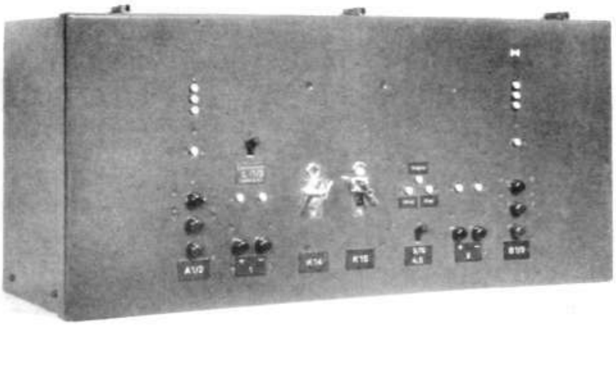
U.D.C. 656.257

In conjunction with the ordering by the Swedish State Railways of twenty-five press-button interlocking control machines, Signalbolaget put in hand a re-designing of the press-button interlocking control machines as formerly manufactured. The construction of press-button interlocking control machine thus arrived at, which displays a number of essential improvements in respect of facility for alterations and enlargements, is described in the following article.

The press-button interlocking control machines supplied by LM Ericsson's Signalaktiebolag in the course of years have without exception been made in single examples. There had been no manufacture of several apparatus at a time. The apparatus therefore have been individual to a rather high degree. A typical apparatus from this period of manufacture is shown by Fig. 1. Briefly, the apparatus consists of a sheet-metal box on the front of which a number of operating and indicating devices are fitted in prescribed order.

It often happens, however, that a station is enlarged or altered. In that event the interlocking plant must also be altered and adapted to the new lay-out of the station. The old mechanical interlocking machines were fairly easy to alter by putting in fresh cranks and levers in reserve positions or by replacing cranks and levers by fresh ones having different functions. The procedure was similar with the older electrical interlocking machines, where new switches could be fitted in reserve positions or put in place of old ones. This build-up of the apparatus by means of a number of more or less standardized components — cranks, levers or switches — fitted into a frame, not only facilitated alteration and extension, but simplified manufacture to a high degree, while it also made it possible to keep stocks of parts for manufacture.

The situation was quite different with the press-button interlocking machine. Of course, certain stocks of parts for the operating devices could be held, but any alteration or extension of an apparatus was a rather troublesome procedure, as fresh holes had to be bored in the front plate and so on. Nor was any stock of semi-finished apparatus possible as the finished apparatus was



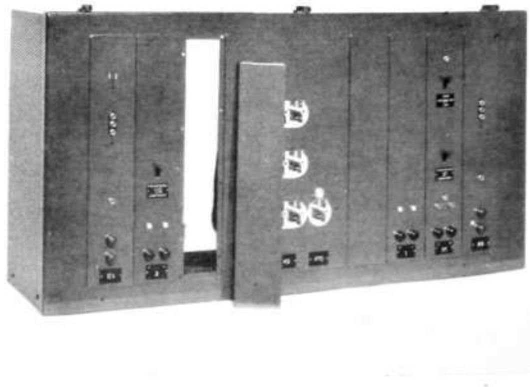


Fig. 1 & 2 X 7274
Press-button interlocking machines
left, as formerly constructed, right, in the new design

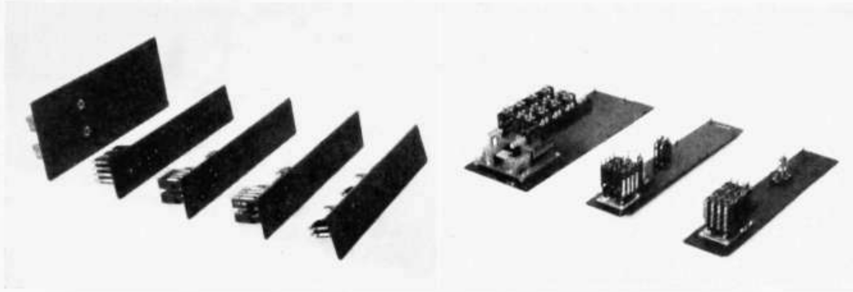


Fig. 3 & 4 X 7273
Insets
left, front views; right, back views; extreme left in both illustrations, insets of double width

as a rule dependent on the lay-out of the station. Moreover the apparatus were usually ordered one at a time and the turnover was not of such a size as to make re-designing a paying proposition.

The position was quite changed, however, when the Swedish State Railways, after thorough consideration of the advantages and disadvantages of the press-button interlocking machines, ordered 25 press-button switchgear plants all together in the autumn of 1941. This made it possible to undertake a thorough redesigning of the apparatus in order to eliminate as far as possible all troubles that had arisen.

One of the new apparatus, intended for Nälden station, is shown in Fig. 2.

A number of openings — in this case ten — have been provided in the front plate. Each of these openings, which have a height of 425 mm and a width of 80 mm, is covered by a plate, known as an inset. These insets are so constructed that any inset can be fitted in any opening whatever. There is one exception to this rule, in that a number of insets which are fitted with certain mechanical devices have been made with a width that is two or three times the normal width.

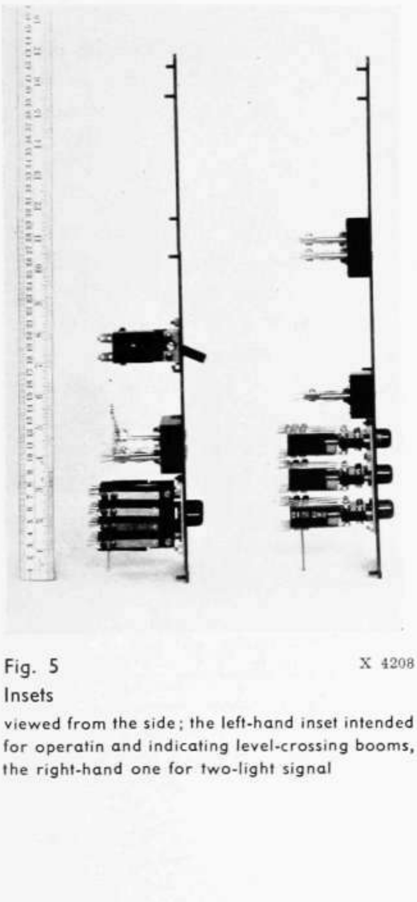


Fig. 5 X 4208
Insets
viewed from the side; the left-hand inset intended for operatin and indicating level-crossing booms, the right-hand one for two-light signal

Fig. 3, 4 and 5 show a number of different insets. On Fig. 3 and 4 can be seen right to the left an inset of double width. Such an inset carries two control locks equipped with contact devices. These locks are mechanically dependent on each other through a rod which moves forwards or backwards when the bolt of the far lock moves up or down. In this position, the reverse of that shown on the illustration, the rod blocks the bolt of the nearest lock. Fig. 4 and 5 show how the insets are attached to the interlocking machine cabinet.

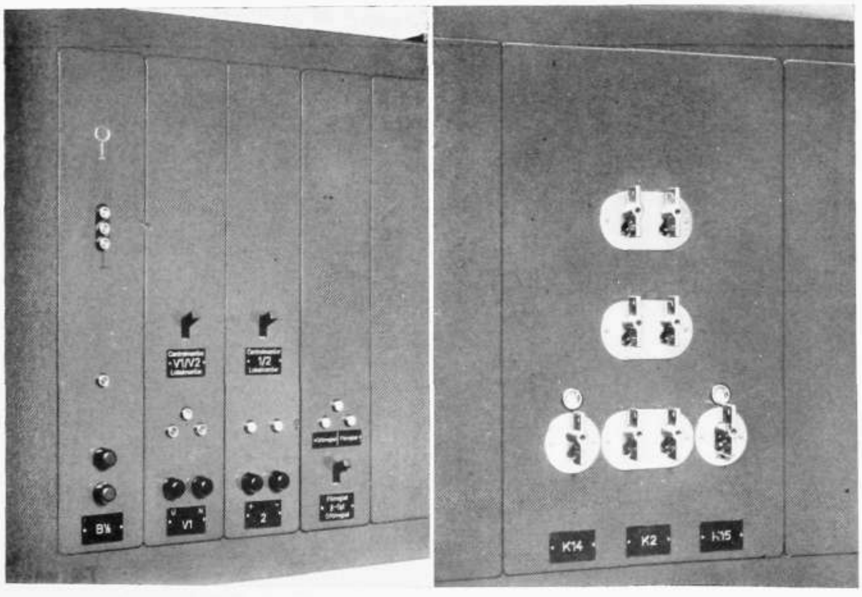


Fig. 6 & 7 X 5907
Insets fitted

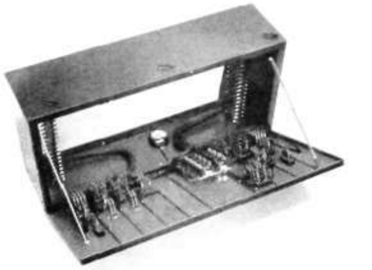


Fig. 7 X 5908
Press-button interlocking machine with front let down

On the edge of the plate may be seen the welded fixing screws. The two right-hand insets on Fig. 4 are reproduced in Fig. 5 as viewed from the side. The lefthand inset on this fig. is intended for operating a pair of drop barriers. It carries a double press-button for operating a lamp strip with three lamps for indication and a switch for permitting local operating of the gates. The right-hand inset is intended for operating a two-light signal. It carries three single press-buttons for operating, a lamp strip with one lamp which shows whether the train route concerned is locked or not and a lamp strip with two lamps for repeating the signal lights.

The three insets described above may be regarded as representative of current types. The devices on an inset are restricted to single and double press-buttons, lamp strips with one to five lamps, one or two way switches and control locks with or without contacts.

Fig. 6 shows part of one of the interlocking machines intended for the State Railways. As may be seen the insets have been freed from all visible screws. All operating and indicating devices are attached to the insets by means of screws welded on them.

Of the five insets shown on Fig. 6, that furthest to the left serves for the operation of a three-light entrance signal, the next for operating a pair of drop barriers, then one for switching a set of points and the last for locking a number of points and block sections. Far to the right may be seen a reserve position covered by a dummy plate. On Fig. 7 is shown an inset with width corresponding to three openings and carrying a control lock *K2* for locking points and block sections together with two other control locks *Kl4* and *Kl5* with contact devices, the former for unattended operation and the latter a train route lock. Mechanical dependence is arranged between the different locks.

Fig. 8 shows another of the apparatus included in the delivery to the State Railways, with front let down. As may be seen the connections are conveniently arranged with leads to the terminal blocks located at the ends, to which on mounting the circuits from relays etc. are connected. The interlocking machine of the type described are made in two sizes, a small one, Fig. 2 and 8, with space for ten and a larger for sixteen insets. Fig. 9 illustrates a large interlocking machine intended for Håkantorp station.

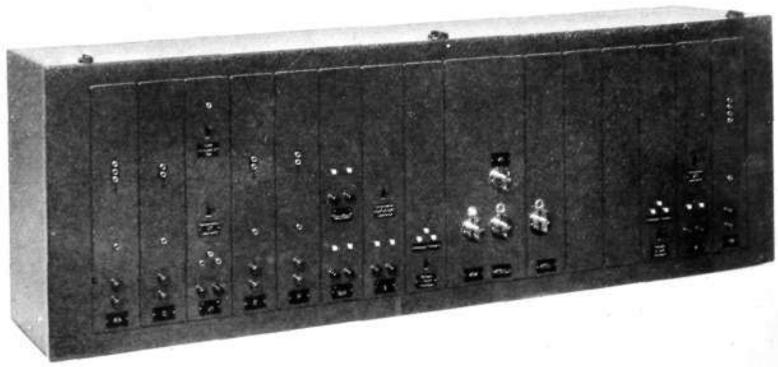


Fig. 8 X 5909
Press-button interlocking machine of large type with space for sixteen insets

Street Traffic Signal Plant with Impulse Coils

NELS FORCHHAMMER, L M ERICSSON A/S, KØBENHAVN

U.D.C. 656.05

For many years Dansk Signal Industri A/S, Copenhagen, in collaboration with L M Ericsson's Signalaktiebolag, Stockholm, has been working on street traffic signal plants. In 1933, the company executed the plant at Frederiksberg, which aimed at the best possible adaptation to the traffic by making the different signals dependent on each other by synchronizing. It was arranged for the traffic on the main streets to proceed according to a »driving plan», enabling drivers who maintained a fixed constant speed to meet green lights at a number of successive crossings, see Ericsson Review No 3, 1936.

In recent years a different principle has been introduced, whereby the signals are wholly or partially operated by the vehicles themselves. The system has obtained considerable application in the big cities of America and Britain, and it has been found that the main streets of these cities with their enormous traffic are better utilized when the timing of the signals is automatically adapted to the needs of the traffic.

As regards Copenhagen, there are no traffic problems approaching in magnitude a city like London, but there are other questions that make the matter of such signals important, including the question of safety at times when traffic is small.

The first signal constructed by Dansk Signal Industri for vehicle operation is specially designed for such conditions, as it is a type particularly suited for employment where a main street with heavy traffic is intersected by a street with traffic which, though small, is appreciable — at least at certain times of the day.

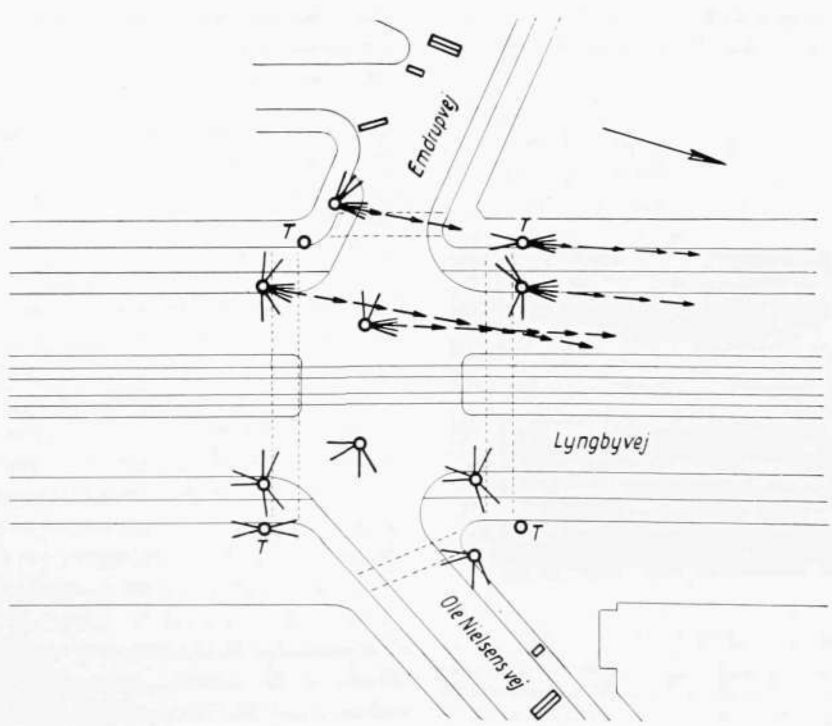


Fig. 1 X 5671

Lay-out plan for signal plant at Lyngbyvej

The impulse coils in the side-streets are single coil in the cycle tracks, in the roadway double coils dependent on direction; for north to south traffic arrows indicate how the different signal lights with their individual setting together give good sight over the whole width of the roadway

T press-button for pedestrians

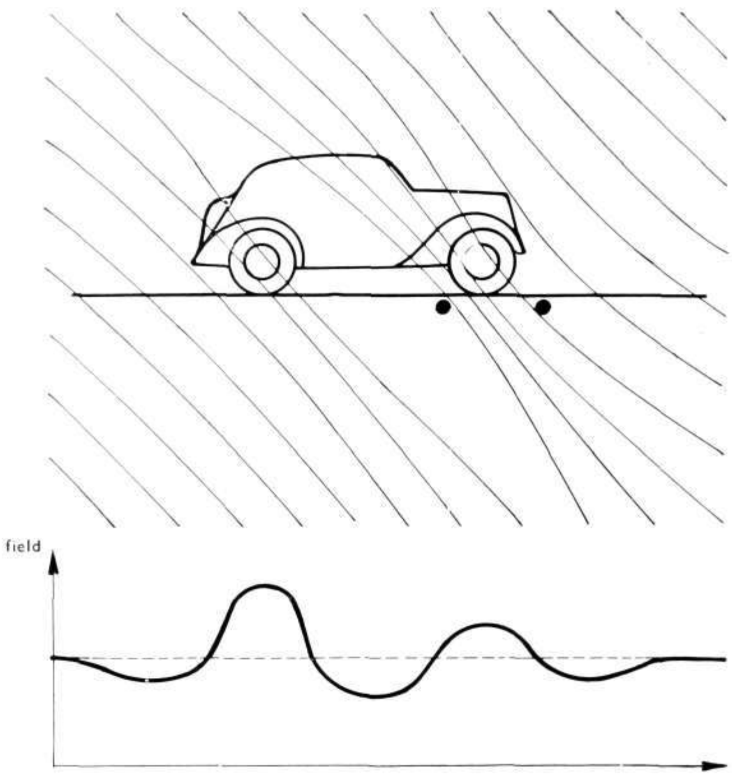


Fig. 2 X 5647 X 5648

Principle of the impulse coil's operation

above, distribution of the lines of force of the earth field in a motor vehicle's steel mass; below, variation of the field through the coil as the vehicle passes over

The Impulse Coil

The first signal plant of this type was delivered early in 1939 and installed at the crossing of Lyngbyvej (main street No. 3) and Ole Nielsens Vej (to the east) — Emdrupvej (to the west), Fig. 1. An essential feature in this plant is the special impulse device, the impulse coil. In place of a street contact, where a mechanical action by the vehicle is converted to electrical contacts, a purely electrical inductive action on a buried coil is employed. As a motor vehicle passes, its steel mass acts on the earth field through the coil, inducing a current in it, see Fig. 2, which actuates the connected impulse relay. By way of an accessory relay this operates the remainder of the signal mechanism. The sensitivity can be so regulated that either vehicles and cycles or vehicles only will actuate the relay.

The principle here applied was published by *A O Malvig* in 1930. In the years since then the system has been employed in a large number of traffic counting plants (including the experimental highway at Roskilde and the Little Belt, Storstrømmen, Guldborgsund and Oddesund bridges) and has proved itself in practice.

One advantage of the impulse coil is that no moveable parts lie in the roadway; the coil is embedded in concrete, after which it is covered by the surface material of the road, see Fig. 3. Thus there is no possibility of rain penetrating it or snow or ice affecting it. As the whole of the energy serving the relay is produced inductively, there is normally no tension in the coil; the tension on passage of a vehicle takes some few millivolts, so that no insulation troubles arise with the parts embedded in the road. No part of the contact devices comes above the road surface; even though with mechanical contacts this may be only a matter of millimetres yet it is an advantage to avoid it. There is no wear on the parts in the roadway; the coils lie 4—6 cm below the surface of the road, which can be relaid without disturbing them. The fitting is simple and subsequent adjustment is not required should the roadway settle or be displaced; for mechanical contacts, on the other hand, a firm foundation must be provided and the part above must be accurately adjusted to the contact.

Fig. 3 X 3979

Laying of impulse coil

one coil is lying in the excavation, 4—6 cm below road level; the other is already embedded in concrete

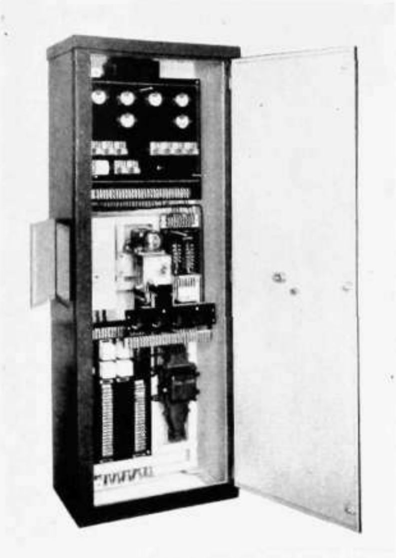


Fig. 4 X 3980

Instrument cabinet for roadway control

top, relay equipment; middle, motor-driven control apparatus with four buttons for regulating signal timing; bottom, fuses and terminal strips for connection of cables

The impulse coils of the two side-streets to Lyngbyvej are single coils in the cycle tracks, as traffic here from its nature is one-way. In the roadway double coils are used, these having direction effect, so that only vehicles moving in the direction of the crossing are recorded.

Instrument Cabinet

The chief feature of the system is the sensitive relay which receives the induced impulse from the coil. It is constructed with a moving coil system and a special contact device. All the other auxiliary and time relays in the apparatus operate with weak current, 12 V, supplied by a built-in rectifier. All these components therefore are assembled along with the impulse relays on a common panel at the top of the cabinet, Fig. 4. When the cover of the panel is removed the whole relay equipment can be lowered outwards for inspection of the connections at the back or it can be taken out altogether if the clamps at the bottom are loosened.

The contacts for the lamp circuits are served by a motor-driven control apparatus fitted in the middle of the cabinet. The motor runs at the same tension as the lamps; it receives control impulses from the roadway controls, but is otherwise independent of them, so that the signal plant, in case of failure or when the roadway controls are being inspected, can operate undisturbed with the apparatus set for fixed times. The plant can also be operated manually by inserting a handle.

The time-setting of the control apparatus is done by resistances; by means of four buttons at the front separate times can be set for »Green light main street», »Yellow 1», »Green light side-street» and »Yellow 2». Setting can be done during operation.

Exactly the same control apparatus can be employed without roadway operation for general operation with fixed signal times, Fig. 5. The apparatus can, moreover, be arranged for any signal colours whatever, *e. g.*, red—yellow—green—yellow or red—red + yellow—green—green + yellow and so on.

At the bottom of the cabinet there are the terminals for connecting power current, *i. e.*, for lamps, control apparatus and the rectifiers which deliver D.C. for the auxiliary and time relays.

The cabinet itself is locked with the key used by the public lighting supply employees, as it is only to be opened for inspection and repair. The various controls to be operated by patrolling constables are assembled in a box built in the cabinet at one side and which the police can open. In this are a main switch for 220 V, a switch for automatic or manual control, a switch for roadway or general operation, a handle to be inserted for manual operation and directions for use.

The plant is generally lit up during the whole twentyfour hours, as it is just the night traffic on the main street with high speeds that is dangerous at the crossing. At present it works with the following timings: the signal normally shows green light for Lyngbyvej; there are no impulse coils installed in this roadway as it is reckoned there will always be traffic on it. A vehicle coming on one of the side streets changes the signal to the side streets in 5 s from yellow to green, which signal remains for 20 s; the time must be so long, as otherwise it would be difficult for cyclists to get across.

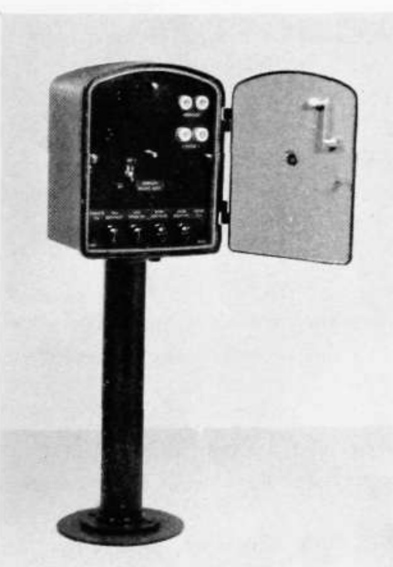


Fig. 5 X 3981

Control apparatus for fixed signal timing

fitted in cast iron cabinet for use without roadway operation

When the signal returns to green for the main street, there starts a block period during which it cannot change. This period is at present different for motor vehicle traffic than for cyclists and pedestrians; the periods are 40 s

Fig. 6 X 5637

Different forms of mounting signals

In the foreground, fixed signals mounted singly or in groups on lamp-posts or on separate poles, right, pole with press-button for pedestrians; above the roadway suspended multi-sided signal units

and 70 s respectively. To ensure against vehicles being caught (e. g. delivery trucks making a stop between the coil and the stop line) and to give pedestrians »stranded» on the refuges in the middle of the main street a chance to proceed, the signal is further provided with a reserve time fixed at 120 s, so that even *when there is no traffic in the side-streets green light is given for them every* 2.5 min. The different times can be regulated separately; thus if inconvenience is caused by the special time to waiting cyclists this can be made shorter, or possibly set for the same period as the waiting time for cars.

The Signals

In putting up the signals the greatest possible attention has been devoted to ensure clear and unmistakeable signal indications for the different streams of traffic, a difficult matter especially in the wide main street (36 m from curb to curb). All signals are arranged individually at the angle giving the best *visibility for the traffic stream concerned.* The signal units may be mounted in different manners and in various combinations, see Fig. 6 and 7. The opening of the signal is 200 mm and it is fitted with reflector and spreader; each signal has a 40 W lamp of standard street lighting type.

On some of the signal poles a press-button is mounted, by means of which a pedestrian can attract attention. Similar buttons are also mounted at a couple of places on separate stands. To supplement the signals there are suspended above the road crossing two double-sided sets of signals.

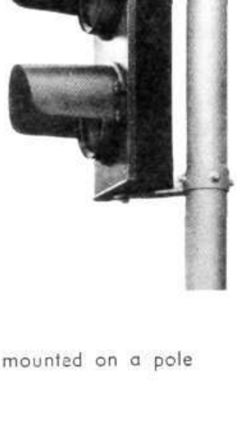


Fig. 7 X 3982

Signals mounted on a pole

Besides the main-street signal plant here described, Dansk Signalindustri A/S also make vehicle-operated signals of other types. The most universally employed type is made with coils in all the meeting streets and can be used, for instance, for crossings with heavy traffic in both directions, especially if the traffic varies in the different directions according to the time of the day; the same system finds employment where signal plant is to be set up with the particular object of utilizing the »go» time to the last second, as in the case with traffic arteries which are decidedly overloaded for shorter or longer periods.

Interlocking Plant at the Bascule Bridge over the Falsterbo Canal

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U.D.C. 656.216.2+656.25

In conjunction with the construction of the Falsterbo Canal and the bridge over the canal for railway and highway traffic to Falsterbo there was arranged an interlocking plant. The plant was ordered by Mr. Rudolf Kolm, chief of the bridge building section of the Highways and Waterways Board, from Signalbolaget and was put into service in April 1941. The interlocking machine comprised in the plant is a relay interlocking machine (or press-button interlocking machine).

Owing to the difficult shipping conditions that arose through the blockade of shipping around Falsterbo Head, the Swedish Riksdag decided that a canal should be cut through the narrowest part of the Falsterbo isthmus to provide passage for shipping which would otherwise have to go round Falsterbo Head.

As this canal would cut across both highway and railway to Falsterbo a bridge had to be provided. The nature of the ground was such that a high-span bridge could not be arranged to advantage and it was necessary to have a bascule bridge. A readymade bridge was purchased, the wellknown Knippels Bridge of Copenhagen which had been replaced by a wider bridge necessitated by the needs of the traffic. As the bridge bought is not wide enough to allow the railway track to run alongside the highway it has been necessary to lay the track in the roadway. Railway and road traffic, therefore, must proceed alternately across the bridge. Obviously the railway and road traffic must be stopped to give passage to ships necessitating the raising of the bascules, Fig. 1.

Drop barriers and illuminated signals have been provided for barring the road traffic, see Fig. 2. The barriers are operated by electric winches, fixed directly on the frames. The illuminated signals *L* show white flashing light when the bridge is free for road traffic, otherwise red flashing light. In addition lowlying signals *G* have been placed close to the foot-walks immediately in front of the bascule, these showing red light when the bridge is raised.

To make the vehicles keep to the left half of the road in the bridge area, traffic dividers have been set up in the middle of roadway immediately outside the barriers.

For stopping the railway traffic illuminated home signals *A* and *B* have been arranged, these showing fixed red light when the bridge is given up to road traffic or the bridge bascules are locked in raised position, and fixed green light when the route is clear for railway traffic. Owing to the track making

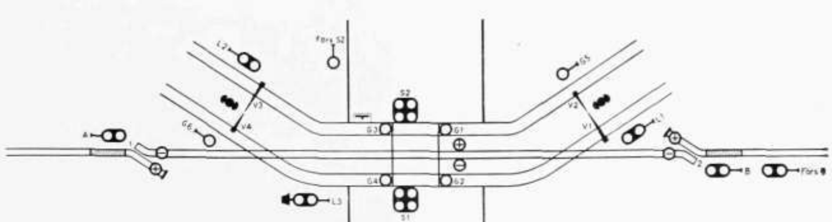


Fig. 1
Lay-out of the plant

X 5891

Fig. 2 X 5803
Lifting gates, illuminated signals and traffic dividers
at the entrance to the bridge

a curve in front of signal *B*, so that signal is only seen at a comparatively short distance, the distant signal *B* has been arranged. Inside the signals *A* and *B* electrically operated safety points have been laid, which take up protective positions when the bascule is up. Outside the safety points, insulated track sections are arranged, used for track locking and for point locking. The track locking is cleared only when the train has passed the last insulated section in the direction of its passage. When the bridge is to be opened, in order that the bascule be locked, the safety points must take up protective positions, the home signals *A* and *B* show fixed red light, the barriers be down and the signals *L* show red flashing light.

Water traffic is regulated by two illuminated signals S_1 and S_2 (signal S_2 has a distant signal at the south canal entrance), constructed as position light signals with four points of light. These signals are set up at either side of the pillar that carries the bascule. By means of these signals »stop», »tie up at quay» and »free passage under the bridge» can be signalled. The signal indications consist of two uncoloured lights, together forming the signal aspect. »Stop» is two lights side by side in horizontal line. For signal indication »tie up at quay» one light lies 45° to the right above the other. In the signal indication »free passage» the lights lie one above the other. All these indica-

Fig. 3 X 5814
Control tower of the bascule bridge

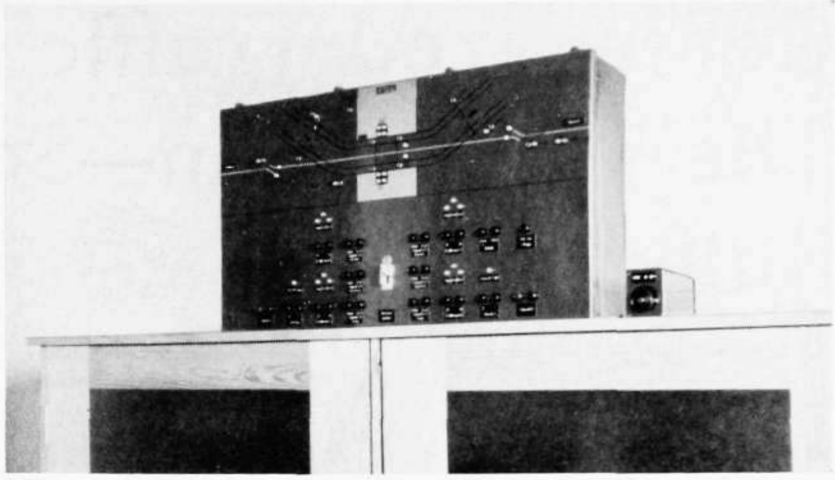


Fig. 4 X 5804
Interlocking machine
with press-buttons and illuminated diagram

tions are either flashing or fixed. The flashing signal indication is preliminary to the fixed indication which is the execute signal.

The signal indication »free passage» can, when the bridge bascule is raised, only be given by one signal at a time. »Stop» and »tie up» can be given no matter what indication the opposite signal may give or what position the bascule may be in.

For the operation of the above-described devices an interlocking machine is fitted in the bridge control tower, provided with press buttons, see Fig. 4. The buttons actuate relays, which in turn operate points, signals, lifting gates and locking motors. Relays are likewise used for indication and interlocking. On the upper part of interlocking machine there is arranged an illuminated track diagram, showing in miniature the canal, the highway and the railway line, as well as points, barriers and signals. All the signal indications together with the positions of points, locks and barriers are indicated by lamps.

For the interlocking plant three-phase alternating current is taken from the power network which feeds the bridge machinery and this current is transformed or rectified for the different apparatus. A three-phase generator driven by an internal combustion engine is installed as reserve power feed. If the power feed fails, the bascule bridge must be operated by a reserve internal combustion engine which is coupled to the bridge pinion gear by a claw clutch. This clutch is locked by a control lock in such a way that the key, normally under lock on the interlocking machine, sets all signals at »stop» when it is removed from the interlocking machine. In addition the clutch lever of the engine is locked in disconnected position by a magnetic lock, which cannot be unlocked until all electric interlockings have been set for the raising of the bascule.

Centralized Traffic Control on The Stockholm—Saltsjöbaden Railway

H MONTELL, TELEFONAKTIEBOLAGET L M ERICSSON, STOCKHOLM

U.D.C. 656.257 (487.1)

In recent years systems of the kind described below have found increased employment abroad, especially in USA. In Sweden a plant of this type was delivered in 1938 by L M Ericssons Signalaktiebolag to the Stockholm—Saltsjöbaden Railway. The plant which has now been in service for 6 years with good results was developed in consultation and under the supervison of Mr. T. Hård, departmental chief in the Royal Swedish Board of Railways. The account which follows was published in Nordisk Järnbanetidskrift, with whose kind permission it is reproduced.

Since the spring of 1938 there has been in service on the Stockholm—Saltsjöbaden Railway a plant for centralized traffic control on the CTL system. The railway, which connects Saltsjöbaden with Stockholm, has a length of 15.5 km and runs through several densely built up communities, also serving some large industrial centres.

Traffic on the railway is dense, with one train per hour in each direction. In addition there are supplementary trains at certain times of the day, in to Stockholm in the morning and back from Stockholm in the afternoon.

From the graphic timetable shown in Fig. 1 it may be seen that the trains start from the two terminal stations at practically the same time.

The line is single-track except for the sections Saltsjö-Duvnäs—Storängen and Järla—Nacka, which are double-track. Train crossings are for the most part confined to the section between Saltsjö—Duvnäs and Storängen. In certain cases, however, trains cross at Henriksdal station.

Fig. 1 X 5577
Graphic timetable
for the Stockholm—Saltsjöbaden railway

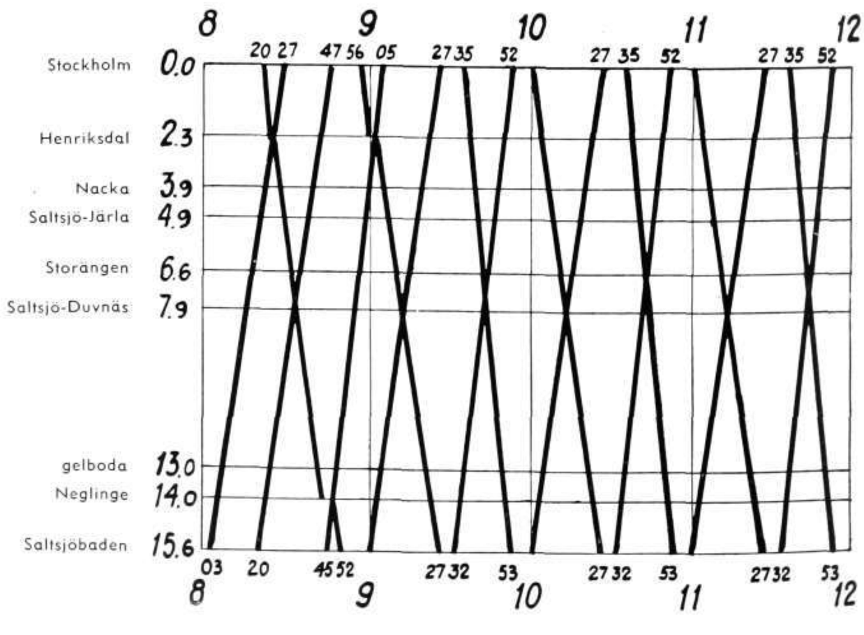


Fig. 2 X 4361
Illuminated signal

The line is elektrified for D.C. current, with 1300 V operating voltage. The stations had mechanical locking machines.

In the beginning of the 1930s the question became urgent of a thoroughgoing reconstruction and modernising of the interlocking plants at the different stations, with the object of rationalising operation. Various proposals were considered and finally the following decision was reached, which was regarded as the most suitable from all points of view.

The whole line should be furnished with automatic line blocking.

All barriers should be let down automatically by trains approching and be automatically lifted immediately the train had passed the level crossing. In one case existing automatic bell ringing should be retained.

The stations of Saltsjö-Duvnäs, Storängen, Järla, Nacka and Henriksdal should be distance controlled from a control centre located at the depot station Neglinge.

The work of reconstruction at the stations which were to be distance controlled was put in hand in 1937. The existing mechanical locking machines (crank apparatus) were replaced by completely electric locking plants.

Construction

The semaphores and in some cases the existing illuminated signals were replaced by up-to-date illuminated signals; the points on the main tracks were provided with electrical point machines; on the sections between the stations and on the main and meeting tracks at the stations track circuits were arranged. A number of level crossings were supplied with new barriers and all of them were equipped with electric operating devices. Those points and scotch blocks that were not furnished with electric operating devices were equipped either with locks, the keys for which are kept under lock and key at each station, or the points and scotch blocks were locked from existing crank apparatus which are kept locked.

The newly installed *illuminated signal lights* are of up-to-date construction with double lens system. The entrance signals have 2 green and 1 red light, the exit signals 1 green and 1 red light. The lamps of the entrance and exit signals for the main line tracks are mounted on poles or suspended in the power line suspension bridges, so that the signal lights are about at eye-level for the engine-drivers. Exit signals for side tracks, on the other hand, consist of low illuminated signals mounted direct on concrete foundations alongside the track, see Fig. 2. This placing of the illuminated signals at different heights in relation to the track is due to the desire to distinguish them in a marked way and thus prevent any confusion.

The *point machines* are of Signalbolaget's standard design, equipped with tongue control and built-in point lock, and driven by 220 V three-phase motors.

The *barrier machines* also are provided with 220 V three-phase motors.

The *track circuits* are made as A.C. track circuits and are fed by 50 c/s A.C. For track relays there are used two element two position vane relays. The track feed is done over transformers and the track current is regulated by shift resistance. The relay transformers are connected between the tracks and the relays.

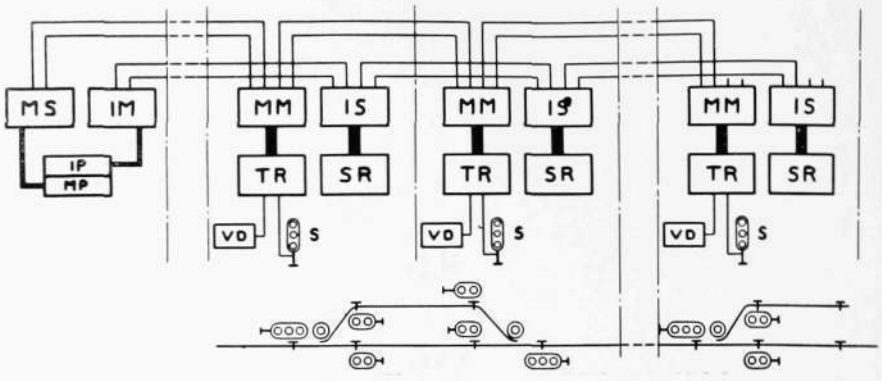
Distance Control System

The operating centre from which the distance controlled stations are controlled and supervised is located at Neglinge. The centre comprises a control apparatus and the control transmitters and indication receivers cooperating with it.

Fig. 3 X 5975

Diagram of the distance control system lay-out

IM indication
IP illuminated diagram
IS indication transmitter
MM contol receiver
MP control panel
S signals
SR track relays, point indication relays
TR train route relays
VD point machine



A telephone cable has been laid along the whole line. Two wire-pairs in this cable are employed for the distance control system, two pairs for telephone purposes and the remaining pairs for the automatic line blocking and other purposes.

The operating centre at Neglinge is connected, via the two wire-pairs employed for the distance control system, with CTL-sections, one at each of the stations Saltsjö-Duvnäs, Storängen, Järla and Nacka. Each such CTL-section comprises a control receiver and an indication transmitter. In addition two CTL-sections have been connected at Henriksdal station to the wire-pairs, as this station is too large to be conveniently served by a single section. Fig. 3 shows the lay-out in diagram of the distance control system.

By means of the operating apparatus the train dispatcher stationed at Neglinge sets and starts orders wanted (train routes and the like) to the different stations, where the orders are received in the control receiver. These in turn actuate special order relays which take care of the execution of the orders. Everything is done completely automatically, so there is no need for any staff at the stations to allow entrance and exit of trains or for regulating the run of the trains between the stations.

Through the indication transmitters communications are transmitted from the different stations to the control centre, when trains enter and later leave the different track circuits, of the positions of points, whether barriers are up or down etc.

In this way the running of the trains is arranged and the situation at the different stations are supervised from the train dispatcher position.

It has not been the intention with the distance control system to provide interlocking in the ordinary sense, i. e., the dependence between points and signals. This has been provided for by the local interlocking plants at the stations and by the automatic line blocking.

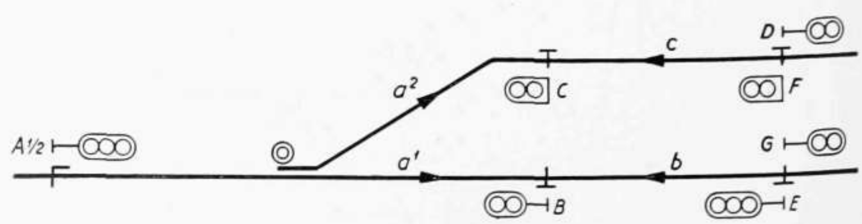
The characters of the distance controlled stations on the Stockholm—Saltsjöbaden line are such that it has been possible to make them practically alike as regards control.

Fig. 4 shows in principle how the stations are arranged. In view of the existing double track it has been possible to arrange automatic signals on the sections between Saltsjö-Duvnäs and Storängen and between Järla and Nacka. The automatic signals always show clear if line sections before them which they are to protect are free from traffic and any barriers along them are

Fig. 4 X 5976

Track lay-out in principle at station

A 1/2 entrance signals
a¹, a², b and c train routes
B exit signal for straight track
C exit signal for side track
D, E, F and G automatic signals



down, provided that conflicting train routes have not been set from the control centre at Neglinge. The first thing that happens when an order for a fresh train route from Neglinge comes into a station is that the previous order is cancelled. Then the points comprised in the train route are shifted automatically, if they are not already in correct position, after which the setting of the signal to clear is prepared. If there is no level crossing before the signal along its protection stretch and if the stretch is free the signal goes to clear at once. If there is a level crossing on the section clear signal is not given until the barriers are down. Conflicting train routes cannot obviously be ordered simultaneously.

Train route locking has been introduced and makes it impossible to alter a train route laid if a train is approaching. If there is a train on the block section and it is absolutely necessary to re-arrange the train route, this may be done by the sending out from Neglinge of a special order for terminating the train route locking that has been made. The distance operated signals at the station will then show danger. After the lapse of a certain time, regulated by a time relay, the train route locking is released automatically. The new train route can then be arranged. Signals applying to entrance from opposite directions to the same block section cancel each other out.

Control Centre

The control apparatus installed at Neglinge, shown on Fig. 5, comprises a control panel, provided with six fitted control fields and 2 reserve fields, viz: one control field for each CTL-section. The control fields, identical with each other, are fitted with a control knob with necessary order lamps, a starting button and a lamp to show faulty signalling. By means of the control knobs which have 7 setting positions the following order settings can be made:

1 train route a^1: entrance on straight track
2 » » a^2: » » side track
3 » » *b*: exit from straight track
4 » » *c*: » » side track
5 *L*: order permitting local operation of points
6 *A/B/C stop*: order cancelling train route locking introduced
7 *p*: test starting of indication transmitter. The start button is used to start order sending after the control knob has been set.

Above the control panel an illuminated diagram has been arranged. This is made of etched glass sheets on which is shown a miniature of the CTL-operated railway line. The track system with its track circuits is made up of illuminated ribbon.

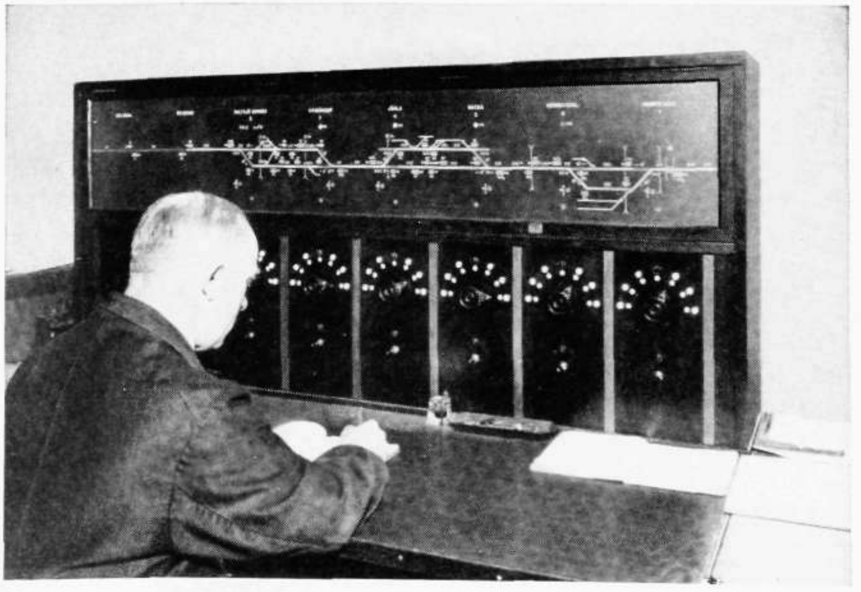


Fig. 5
Control apparatus

X 5977

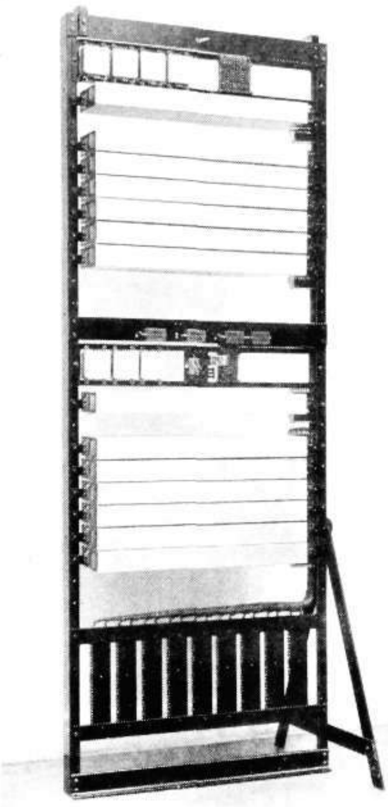


Fig. 6 X 4262
Relay and selector rack at Neglinge

In addition to the track circuits there are indicated the positions of the distance controlled points, the raised positions of the barriers, if the distance controlled signals A, B and C at the stations concerned show danger and if the master locks mentioned above as at each station and which lock the central lock or the crank apparatus respectively are really locked. Fig. 6 shows the rack with relay and selector equipment for the control transmitter and the indication receiver at Neglinge.

The control transmitter is equipped with relay devices for 6 CTL-sections, but the rack is cabled for 2 further sections, to allow of later enlargement to 8 CTL-sections, should that prove necessary. In the same way the indication receiver is constructed for receiving indications from 8 CTL-sections, though at present only fitted with relays for indication receiving from 6 CTL-sections. From each CTL-section indication can be given respecting the two positions of 10 devices.

The relays are mounted on bars. Each bar is provided with a fixed connecting plug, enabling the bar to be easily loosened and taken out of the rack for inspection or replacement. This is done without the necessity of loosening any connection. All connections of wires to the rack are made on a number of terminal blocks, mounted on the lower part of the rack.

Control Receivers and Indication Transmitters

As stated above, at each CTL-section there are control receivers and indication transmitters. These apparatus consist of a base-plate on which is fitted a relay grid. Relays and selectors are fitted on the relay grid, which can be swung out. The relay grid is connected to the base-plate by means of flexible connecting cords provided with plugs which are plugged into jacks on the base-plate. It is a simple matter to take the connecting cords out of the jacks after which the relay grid can be lifted and taken out for examination and if necessary for replacement by a reserve grid.

Fig. 7 shows a control receiver. The components comprised in the distance control system, such as relays and selectors, are parts wellknown in automatic telephony and to be found in the different automatic systems.

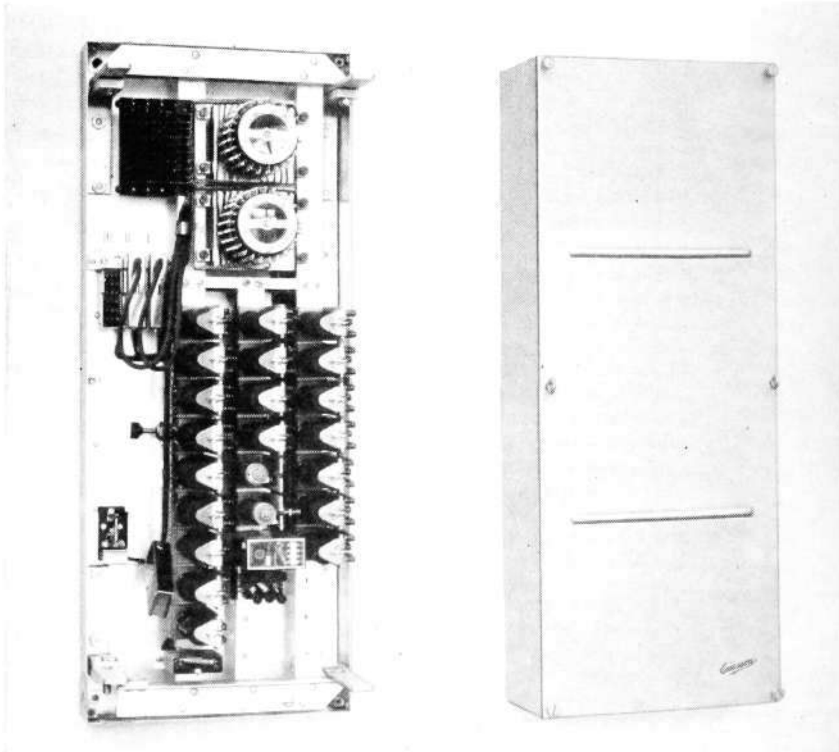


Fig. 7 X 5978
Control receiver
left, without cover: top, selectors, below, relay sets; rigth, with cover

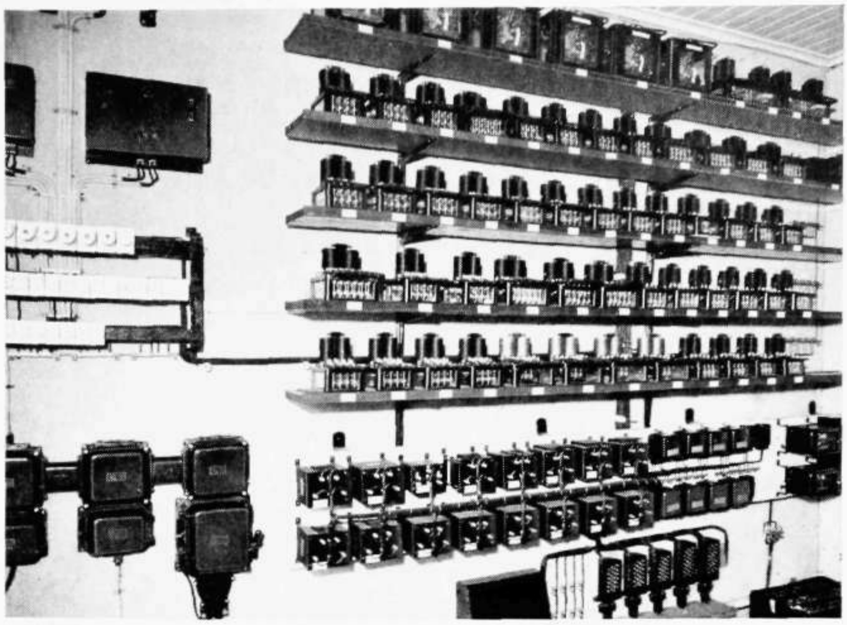


Fig. 8 X 5979
Inside view of relay room

At the different stations special relay rooms have been arranged in the station buildings. The relays required for the interlocking plants are arranged on shelves and transformers for illuminated signals and track circuits are put up either in the relay rooms or in small cabinets out at the different signals or insulated track joints. The CTL-apparatus are also mounted in the relay rooms. Fig. 8 shows an example of how the fittings are arranged at Saltsjö-Duvnäs station and Fig. 9 shows a relay cabinet.

Power Supply

For the line section Saltsjö-Duvnäs—Henriksdal the power supply for the interlocking plants is provided from a 3300 V three-phase network along the line. Power at Neglinge is obtained from a local 3×220 V network.

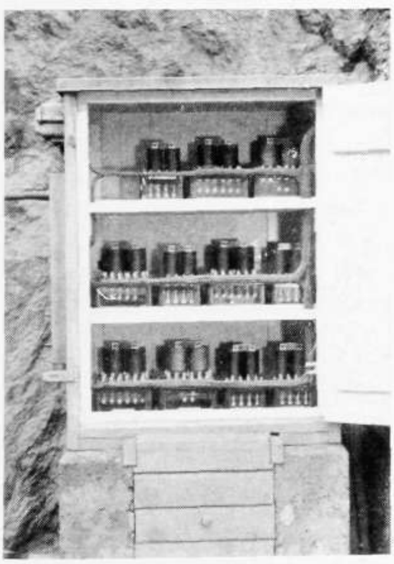


Fig. 9 X 4263
Relay cabinet

Outdoor transformers have been set up at the various stations and these transform the tension down to 3×220 V with secondary zero taken out. From this secondary network there is then tapped the power requirement at the stations for illuminated signals, point machines and barrier raising machines, relay equipments etc. For the CTL-devices there are used 24 V Nife batteries and for the relays of the interlocking plant 12 V Nife batteries. The batteries are kept constantly charged from metal rectifiers.

In projecting the work of reconstruction and the subsequent working out of details there was very close collaboration between the chief inspector of the line Mr. J. Andersson and Mr. T. Hård of the State Railways, acting a technical adviser and supervisor, on the one hand and Signalbolaget on the other.

The CTL-system as used for the distance control proper was worked out by Signalbolaget in conjunction with Mr. Hård. The system differs in essential parts from earlier similar American relay systems, among other things in the use of selectors as components as well as relays. The actual work of erection was carried out under the railway company's own management, with Mr. Hård as supervisor.

New Interlocking Plant at Stockholm East Station

S KULLENBERG, ELECTRO ENGINEER, TRAFFIC ADMINISTRATION STOCKHOLM—ROSLAGEN RAILWAYS, STOCKHOLM

U.D.C. 656.257 (487.1)

The Stockholm—Roslagens Railways have for some years had a number of relay interlocking control machines (with press-buttons) in operation. As the traffic at the biggest station of this railway system, Stockholm East, had grown to such an extent that a complete reorganization of the whole station has become necessary and with it a new signal interlocking plant had to be constructed, the administration decided to equip the station with a relay interlocking control machine of Signalbolaget's manufacture. That this choice was made is due largely to the good experience obtained from earlier plants.

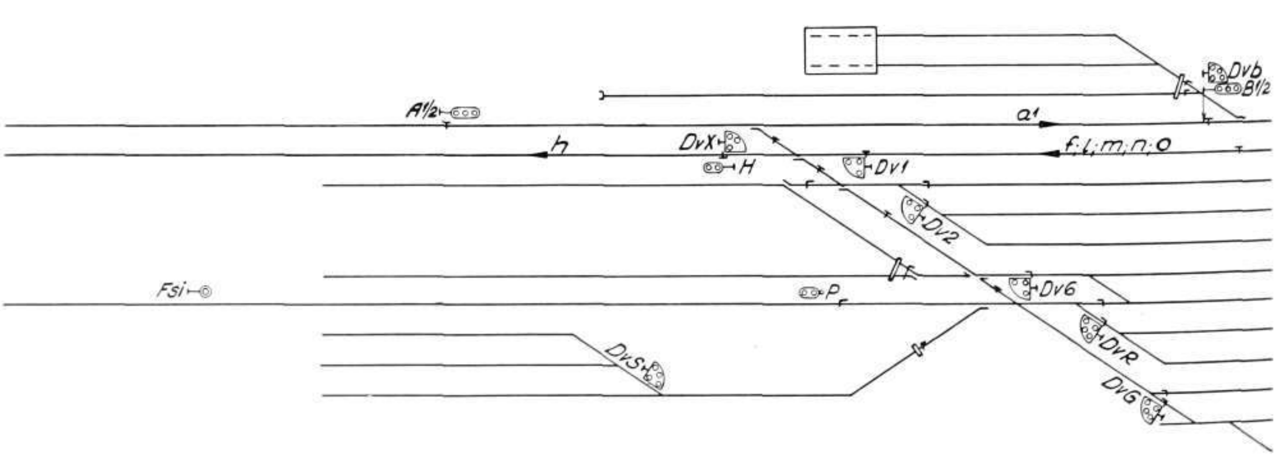
Stockholm East normally has to deal with about 180 trains per day of traffic, special trains and doubling excepted. Of these, 102 consist of local trains to and from Djursholm, 70 of passenger trains to and from Rimbo, Vallentuna and Österskär, the remainder being goods trains. All the Djursholm trains run on a special double track, see Fig. 1, which continues as a single track through Engelbrektsgatan for about 1 km into the city proper with terminus at Humlegården. The other passenger trains are distributed over tracks *II—V*, to be seeen on the figure below the Djursholm tracks. Goods trains are run as a rule to and from the goods yard over a side-track which cuts across the main tracks just inside the outermost signals.

X 7248
X 7247

Obviously the amount of traffic requires farreaching rationalization of the operation of the station while the demands of operating safety must not be neglected. The relay interlocking machine has been produced with the object of creating a type of interlocking machine which is so easily operated that the train dispatcher alone may be capable of handling both the interlocking machine and the train dispatching even for moderately large stations. The interlocking machine therefore must be so constructed that the train dispatcher from his office is not only in a position to keep an eye on it without trouble but, with the least possible exertion, can deal with its operation, Fig. 2. In addition he must have automatic control over all movements of trains and trucks and over the positions of signals on the station area.

Fig. 1
Track lay-out at Stockholm E

- home signal with three lights
- home signal with two lights
- distant signal
- dwarf signal
- *insulated rail joint*
- scotch block
- signal cabin



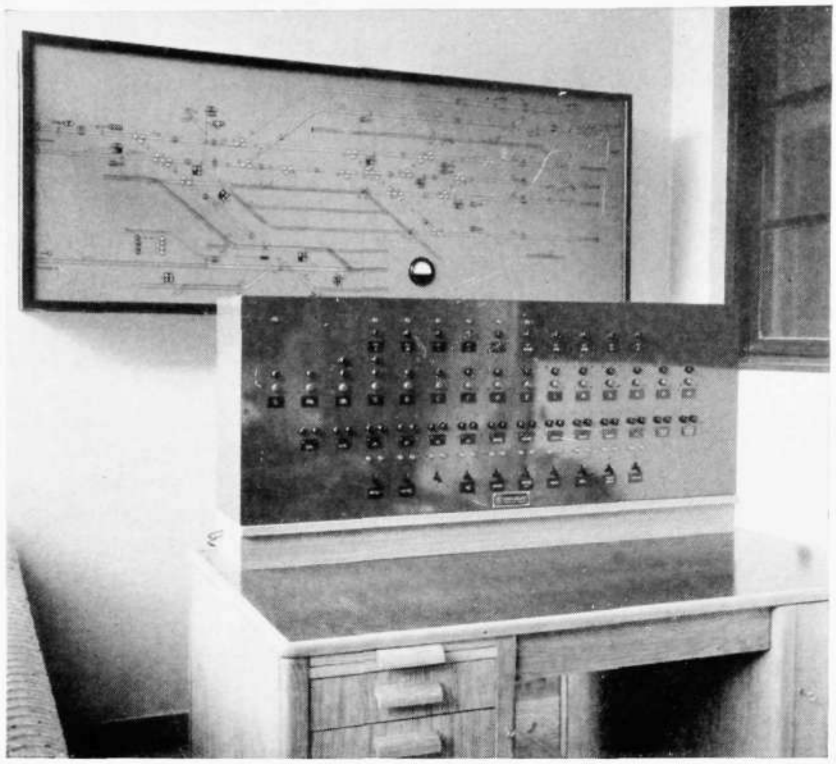


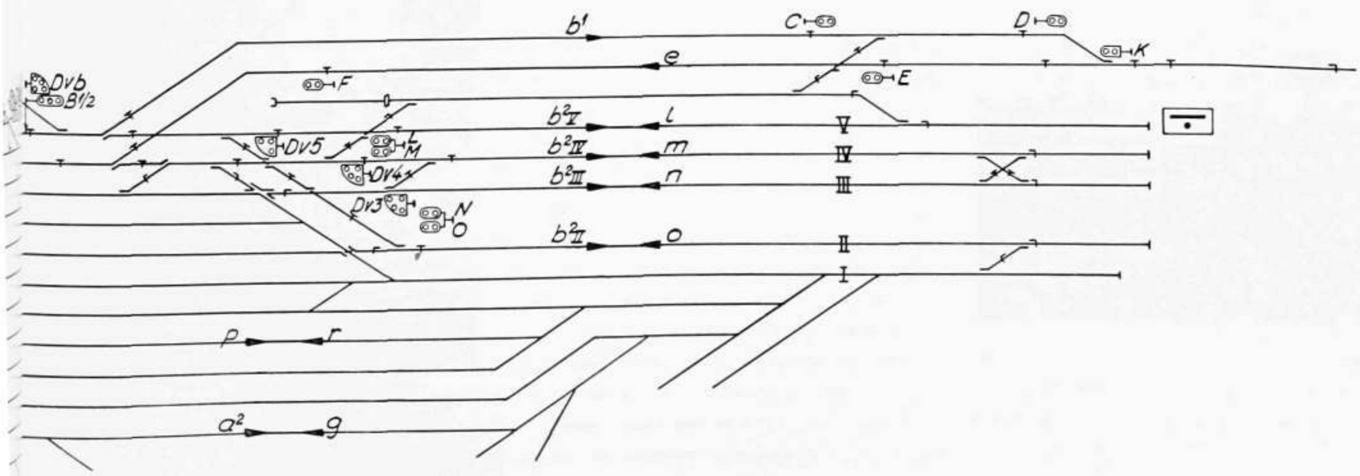
Fig. 2 X 5816

Interlocking machine and illuminated track diagram

located in the train dispatcher's office

The first of these conditions is fulfilled by the interlocking machine being constructed in very concentrated form with the simplest possible of operating devices, arranged in a manner that is surveyable and logical. Thus signals and points are operated by press-buttons and locking devices by small tumbler switches. The second condition is met by an illuminated track diagram. On this a number of goods tracks have been left out as these are not comprised in the locking, and truck movements can proceed to a limited extent on them without disturbing train movements.

Each illuminated signal that is governed by the train dispatcher's operations is repeated on the track diagram by a miniature pattern which reproduces its actual appearance. A small number of dwarf signals which are automatically dependent on nearby points etc. are not repeated in the signal patterns. In addition plus and minus position is indicated for all centrally operated points, whereby the train dispatcher can immediately check if certain routes are switched correctly. For those points which have both central and local operation the lamp which marks the point tongue or crossing point constitutes an indication of whether permission for local switching has been given or not. Normally the lamp shines but if permission for local switching has been given it is extinguished.



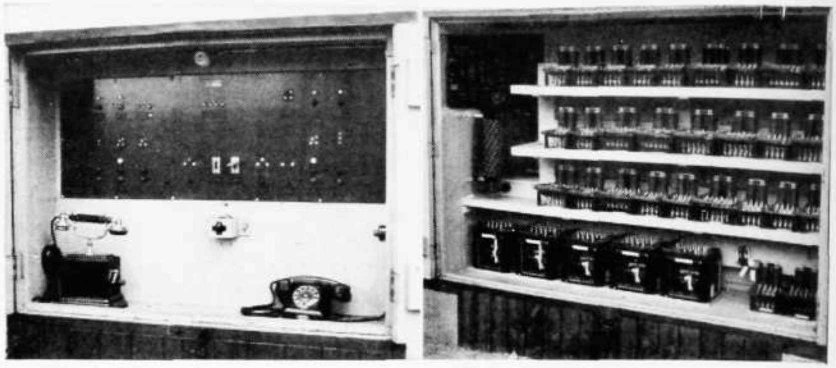


Fig. 3 & 4 X 7246
Local interlocking machine for the goods yard
left, control board; right, relay cabinet

All tracks which concern the train routes are divided up into a number of track circuits which are marked on the track diagram, each being there provided with a control lamp which shines with a pale blue light when the track circuit is free from rolling stock. The track circuit lamps have the purpose of informing the train dispatcher concerning train movements on the different tracks.

When the track circuit in which a centrally operated point is included is entered by a vehicle, the switching device of the point is blocked automatically by a contact on the track relay blocking the operating current circuits for the point's switching.

As at all terminal stations, the train routes at Stockholm E branch out fanwise from the main tracks, Fig. 1. Departure from this rule occurs, however, owing to the necessity of giving the Djursholm tracks an exceptional position due to the special traffic on them and because the goods yard has received a direct entrance and exit train route. The branching of this train route requires a first entrance signal $A1/2$ and the separating of the Djursholm trains from the other passenger trains another entrance signal $B1/2$. The Djursholm trains enter on signal *B1* and other passenger trains enter for one of four train routes on signal *B2*. The four corresponding exit signals *L*, *M*, *N* and *O* are combined with a number of dwarf signals as protection for the points when shunting. As the two Djursholm tracks are relatively long it has been possible with advantage to divide them by an intermediate signal on each track, enabling the succession of trains both in and out to be made closer. This arrangement is only a logical consequence of the automatic line blocking existing for 15 years, which allows of a train density of app. one train a minute.

Signal *A1* has been made semi-automatic, *i. e.*, in addition to being operated when necessary from the interlocking machine it changes automatically to danger when it is passed by trains but returns to clear when the train leaves the block circuit covered by the signal. In addition the signal shows green flashing light when signal *B* is at danger. It can thus for this train route be made to function in the same manner as an automatic block signal. The entrance signal *C* and the exit signal *E* northwards to and from the Djursholm train platforms function in similar manner.

For transshipping between the Roslagsbanan railway and the State Railways there is a track connection between Stockholm E and the State Railway station Stockholm N. This track crosses the Roslagsbanan railway goods train route after which it is divided in the goods yard into three tracks one of which is built as a three-rail track.

On the comparatively few occasions when train movements take place on these goods train routes the signals and locking are operated from a local interlocking machine, Fig. 3 and 4, set up in the immediate vicinity of the crossing between the State Railways and the Roslagsbanan railway tracks. The local interlocking machine is of the same type as the main interlocking machine but of simpler construction. Thus there is no illuminated track diagram but the control lamps and miniature signals to be found on it are instead

Fig. 5 X 4162
Exit northwards from Stockholm E
left, entrance signal H to first block section; middle, between tracks, rear view of dwarf signal; further to the right, entrance signal A ½

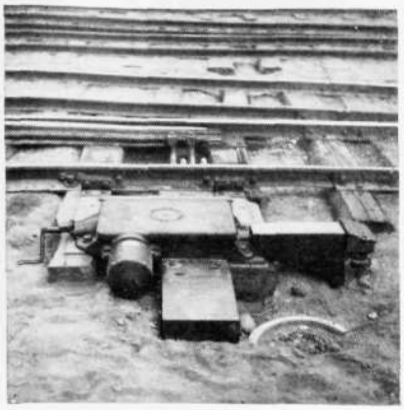


Fig. 6 X 4151
Electric point machine

grouped on the control board in a manner easily visible. The track circuits in this section can, like the home signals, therefore be controlled both from the local and the main interlocking machine. The local interlocking machine is concerned with only three points switched centrally that are also combined in the train routes for passenger trains. These points are always switched from the main interlocking machine, after which when the train route to or from the goods yard lies clear permission is given to the local switchgear to operate the signals concerned whereby the train route is locked. The train routes to and from the State Railways group of tracks do not touch the passenger train routes but all the same permission from the main interlocking machine is required for these train routes. Consequently the train dispatcher has control here also over train movements and signal positions.

The entrance signals from State Railways trains have been constructed as ordinary illuminated signals while the exit signals for both State Railway and Roslagsbanan railway goods tracks have been made for practical reasons as dwarf signals with four light apertures.

In order to be able without difficulty with single track operation to take in the trains, a special dwarf signal for the up-track, Fig. 5, has been arranged which can be set at caution and danger from the main interlocking machine. When the signal is set at caution all signals enemy to this are simultaneously blocked.

From Stockholm E there has for long been, as stated above, an automatic block system for the line northwards. The entrance to the first block section after Stockholm E is signal *H*, Fig. 5. This signal is controlled by the train dispatcher to the extent that he can set it at »danger», but not always to »clear». On the other hand he can set it so that it acts as automatic block signal. In this way therefore the automatic block signal system and the relay interlocking machine have been linked up.

Signalbolaget has supplied for this interlocking plant a new electric point machine, Fig. 6 and 7, which differs in essential parts from its predecessors. As the point machine can be laid between two sleepers the normal distance apart, thus requiring only two straight iron plates for fixing the machine to the point plate, the foundation bedding has been considerably simplified. The fully enclosed motor is fixed on the outside of the point machine. The power is transmitted to the drawbars by an angle gear. For moving the points in case of failure of current or other faults there is used a crank, Fig. 6, by means of which switching is completed with 11 turns only as against about 50 previously. Moreover, as may be seen by Fig. 7, the box holds the necessary contacts etc. for relay current circuits, supervisory current etc. The motor's power is 0.5 hp. The whole point machine weighs only 180 kg, *i. e.*, 40% less than the older type.

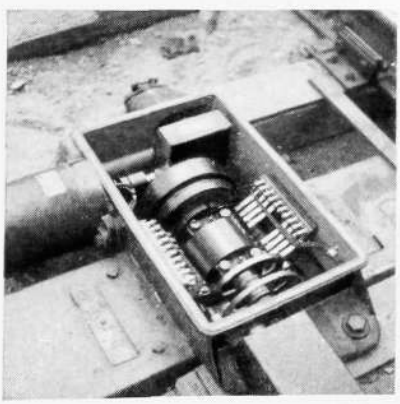


Fig. 7 X 4152
Electric point machine
with cover removed

To accomodate the interlocking control machine and the train dispatcher a small extension to the station building has been added, on the wall of which the illuminated track diagram has been set up. At a convenient distance from this a desk for the train dispatcher is placed with the control board mounted on the back edge, Fig. 2. The whole of the left wall consists of a window with a clear view over the platforms. On one wall there is a wholly enclosed electric plant, fed from the station main supply with 220 V A.C., 50 c/s. From this plant the current is distributed to group plants for the interlocking machine and station illumination. In this office there is a main switch by means of which all lights on the station can be extinguished. Further fuses for the interlocking machine are grouped in a relay room for all relay current circuits and in a cupboard of the desk for all motor current circuits. These last consist of automatic fuses by means of which if a fuse blows in a motor current circuit the train dispatcher can rapidly and easily re-connect the current without needing to call in signal repairers.

The relay compartment is in the cellar beneath the interlocking machine room. In this way it has been possible to draw the wires in a convenient and simple manner through the beams. In addition to five lighting and telephone cables there lead out from the interlocking machine 15 signal cables, with altogether about 400 wires. Of these, 10 are main cables which lead to as many distribution boxes and apparatus cabinets to which signals, track transformers, locking devices, point machines and so on are connected by local cables. In the relay compartment and the apparatus cabinets all multi-wire cables have been terminated in boxes, so that the wires should be most easily accessible for test and repair.

The work of fitting, which was done by the staff of the Roslagsbanan Railway with the assistance of a fitter from Signalbolaget, was begun in the summer of 1940 and has just been completed. The cost of the plant amounts to some 130000 kronor.

In addition to the advantages stated there is the further gain with the electric interlocking machine that the staff previously required is set free for other work, which means a decrease of operating costs by about 13000 kronor per year. Apart from the fact that the old interlocking machine would not have been capable of dealing with present traffic without thorough-going reconstruction the saving referred to constitutes satisfactory interest on the capital expended.

Laboratory Terminal Blocks

H BLOMBERG & J WIKSTRÖM, TELEFONAKTIEBOLAGET L M ERICSSON, STOCKHOLM

U.D.C. 621.317.2

In conjunction with the fitting up of laboratories and test-rooms in L M Ericsson's office and factory building at Midsommarkransen, Stockholm, the need arose for up-to-date connection panels for the connection and distribution of current required for laboratory and working benches. As suitable arrangements were not to be had on the market and as the numbers required were large, the problem was tackled of producing special designs for the purpose. The result has been a connection unit, the laboratory terminal block, by means of which connection panels of different types and for various requirements may be built up. These should certainly find great employment in laboratories, test-rooms etc. in factories, schools and higher educational establishments, and have consequently been made available for sale.

The types of electric connection panels for connection and distribution of current to benches in electrical laboratories, test-rooms and workshops hitherto employed can hardly be said to meet modern demands on such equipment. They have as a rule, consisted of panels of marble, insulation material or sheet-metal, drilled appropriately for the fixing of the necessary switches, fuses, terminal clamps etc. The switches have consisted of ordinary knife-edge switches, when great current intensity was concerned, or of box switches of the various types on the market. In the former case the parts under tension were not protected against touching. Such panels had to be designed for each occasion and there were no standard types available. In place of these panels, there had also been used the castiron enclosed installation material that is really intended for outdoor service or special premises, a number of these being set up alongside each other on walls or racks. In this way the equipment has been less appropriate from the point of view of work and besides it was expensive and clumsy.

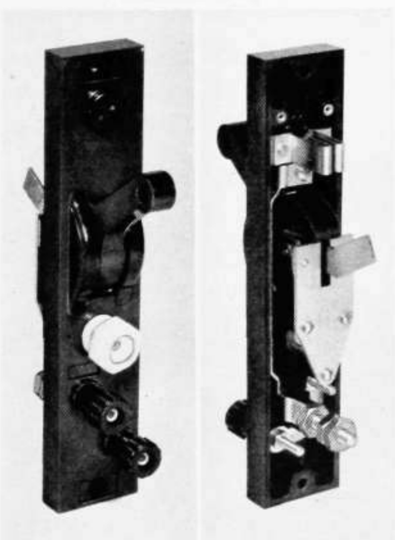


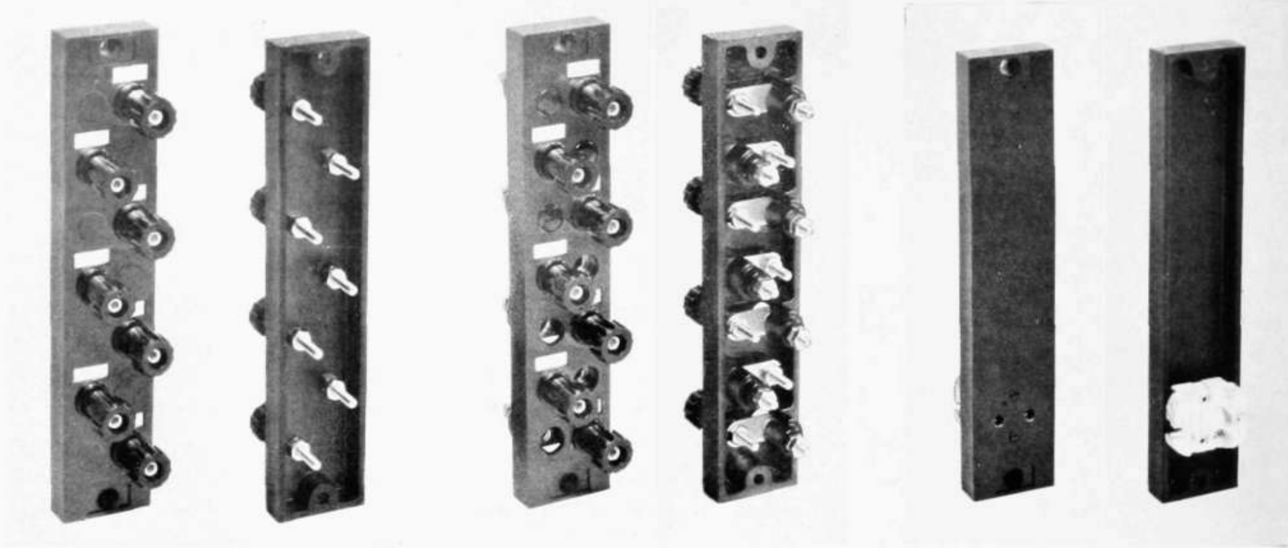
Fig. 1 X 4087
Laboratory terminal block BPL 1302 with knife-edge switch
front and back views

General Execution

By means of LM Ericsson's *laboratory terminal block* it is now possible to build up connection panels in any combinations according to the purposes to be provided for. It consists of a terminal block, to be had in a number of variants, comprising the basic element of which the connection panels are made up. In this way the panels are such that they can easily be altered or extended should need arise.

The block is made of bakelite with the live parts protected against touch, it is of small convenient size and easy to fix on the frame or other fitting constituting the support. At present it is available in the form of a block containing knife-edge switch, fuse and terminal clamps, a block containing terminal clamps and fuses, a block containing terminal clamps only and finally a block which is either unfitted and then is used to fill up free space in the connection panel or fitted with any desired device such as wall tapping, special connection jacks or the like.

All blocks consist of a moulded rectangular base of electro-brown bakelite, 50 mm wide and 250 mm long, on which the connection devices are arranged. At each end of the base there is a hole for fixing it on the frame on which the blocks are fitted close together. On the front of the blocks there are rec-



X 4089
X 4088
X 4090

Fig. 2
Laboratory blocks

left, BPL 1207 with terminal clamps and fuses; middle, BPL 1107 with terminal clamps only; right, BPL 1000 fill-up block fitted with a wall tapping

tangular recesses intended to hold label frames, in which are fitted a strip of thick paper protected by a cellon sheet. The paper is used for labelling the block. Corresponding label recesses are to be found beside all terminal clamps, Fig. 2.

Block with Knife-edge Switch and Terminal Clamps

The knife-edge switch terminal block BPL 1302, Fig. 1, has connection bolt, knife-edge switch, fuse and two terminal clamps. The connecting bolt for the incoming line is located at the bottom of the back of the block. It is connected with the fixed contact springs of the knife-edge switch by a connecting bar. The knife-edge switch, which is single-pole, is also located on the rear of the block, but the switch lever projects from the front through a slot in the block. This lever is of bakelite and the knife itself is cast into it. It actuates contact springs which are supported by a bar at the bottom, which also constitutes the bottom contact in the fuse arranged below the knife-edge switch. The switch is made without momentary break and with 250 V D.C. can break 25 A and, with 500 V A.C., it breaks 50 A non-inductive load. To maintain centring of the knife in off-position, for which the lever points upwards, the lever is centred in this position by drag-springs fitted at the back.

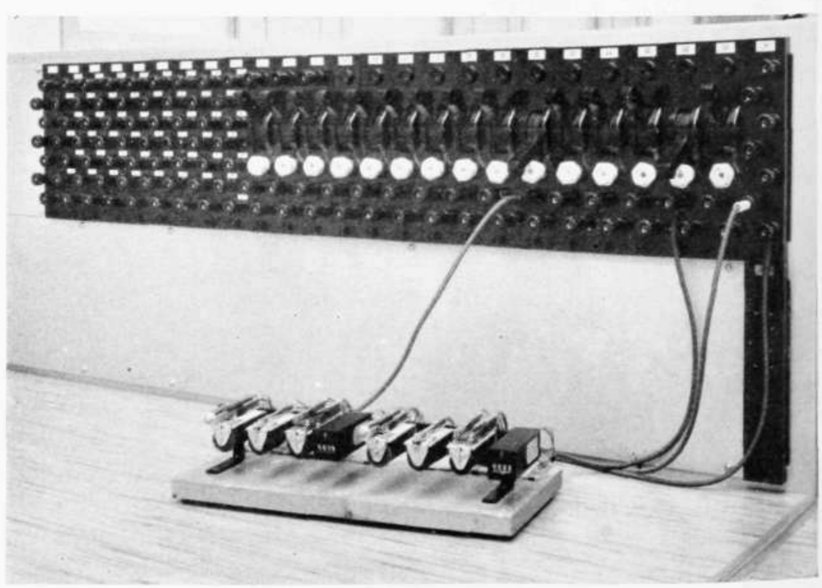


Fig. 3 X 5781
Connection panel for laboratory bench
with blocks fitted in one row

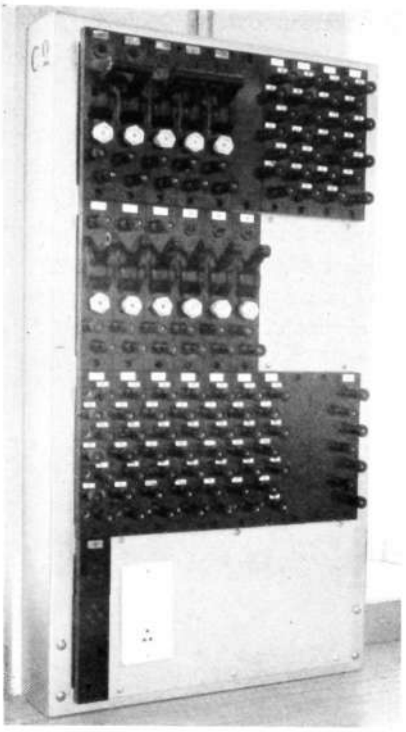


Fig. 4 X 4091
Connection panel
with blocks fitted in several rows

The fuse is of standardized construction with fuse head of porcelain having Edison thread E 16, which sticks out at the front of the block. The fuse is of standard type for current intensity between 2 and 25 A. When the switch lever in on-position is down it covers the fuse to a certain extent, so that the switch must be at break to enable the fuse to be replaced.

Below the fuse and connected to its contact sleeve, there are arranged two terminal clamps connected in parallel for connection of the apparatus or apparatuses that are to be tested etc. The clamps are made as pole screws with bakelite nuts having threaded sleeve cast on. The connection of the lines may be done either with cable shoes beneath the nut or with banana contact in the centre contact sleeve of the nut or both ways at the same time. Thus it is possible at one time to connect four tapping lines entirely independent of each other to the block.

As may be seen, all live parts are arranged at the rear of the block and are therefore entirely protected against touch when the block is fitted on the frame of the connection panel. The block is of very simple construction, with parts few and strong, and with no extra circuits, so that the number of contact transition places is brought down to a minimum.

The block is made only with single pole switch. To obtain two, three or multi-pole switches, two, three or more such blocks are fitted side by side. The switch levers are joined by one or more cylindrical connection links of bakelite, which are fitted in holes at the ends of the levers by means of screws and bolts, see Fig. 1.

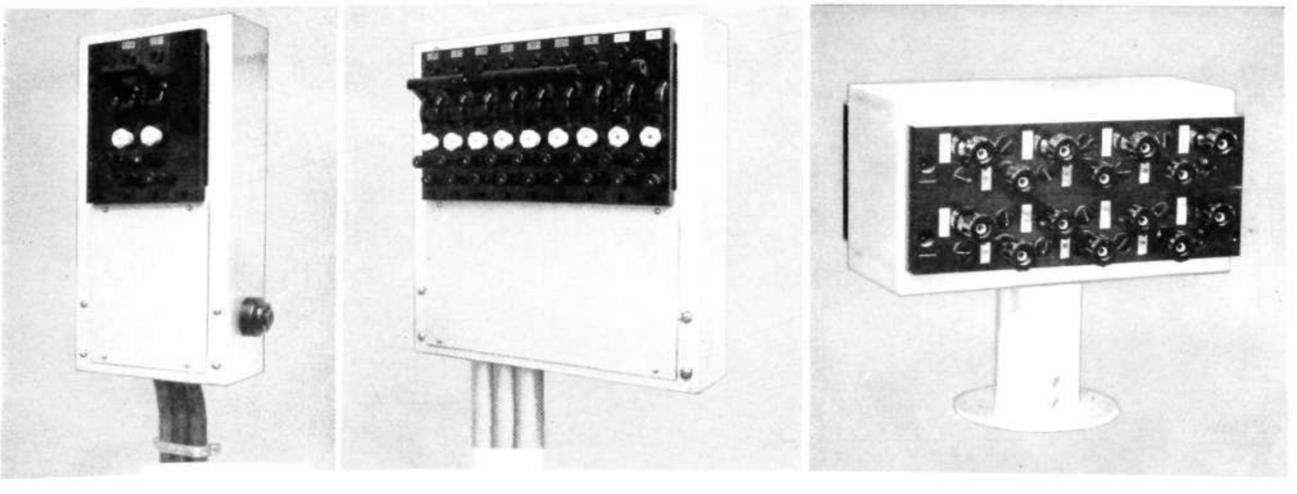
The block may be provided with spark quench at the knife breaking point if required. In addition a signal lamp, either neon or filament lamp, may be fitted in the circular projection of the bakelite above the switch lever by inserting a special lamp holder.

In certain cases it is desirable, instead of terminating the incoming line permanently to the bolt at the rear of the block, to be able to give it a moveable connection to the block. For this purpose there is a variant, BPL 1303, which is fitted with an extra terminal clamp at the front of the block above the switch lever and joined to be fixed contact springs of the knife.

Blocks with Terminal Clamps

The laboratory terminal block BPL 1207, Fig. 2, comprises seven terminal clamps each with its own fuse. The clamps are pole screws of the same type as for the knife-edge switch block. The fuses are arranged at right and left of the clamp screws. The fuse heads, which are of bakelite, are recessed in holes at the front of the block and have a slot for screwing in and out with a screwdriver or the like. Fuses are available for currents between 0.7 and

Fig. 5 X 7240
Smaller connection panels
left, with two-pole switch fitted on the wall; middle, with one, two and four pole switches, fitted on the wall; right, with terminal clamps and fuses, facing two ways on workshop bench



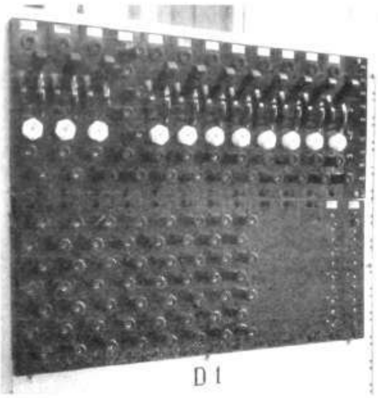


Fig. 6 X 4092
Connection panel
with knife-edge switch terminal blocks and additional terminal clamps

6 A. The incoming line is terminated in the bottom contact of the fuse, while the threaded sleeve in which the fuse head is screwed consists of a terminal strip joined on to the pole screw.

The laboratory terminal block BPL 1107, Fig. 2, which only contains seven terminal clamps, is intended partly for distribution of connection lines which do not carry current, *e. g.*, measurement lines, or lines that are not to be protected, and partly as supplement to the switch terminal block when its two terminal clamps are not sufficient for the number of tapping lines it is required to connect. In the latter case it is fitted below or alongside the switch terminal block and its clamps are connected with the clamps of the said block.

The laboratory terminal block BPL 1000, Fig. 2, consists only of the flat bakelite base with its fixing holes. In this form, *i. e.*, entirely without fittings, it is used as fill-up block in the connection panels and is put into the free spaces of the panel where it may later be desired to put in terminal strips. The block is particularly well suited, however, for the fitting of special devices not to be found on the standard blocks. For example, the figure shows the block fitted with the inset of an ordinary wall tapping for 220 V tension.

Connection Panels

The laboratory terminal blocks are fitted alongside and beneath each other in frames or racks of suitable design. Particularly to be recommended is the making of these from 2—2.5 mm bent sheet metal of design similar to that of the racks in LM Ericsson's automatic telephone switchboards on the XY-system. Fig. 3—7 show a number of such connection panels which are employed in the new laboratories and workshops.

The frames are welded throughout of bent sheet-iron with 120 mm body and 40 mm flanges. The flanges are drilled with holes at 50 mm intervals, for screwing in the fixing screws of the terminal blocks. The frame encloses the blocks from the sides completely, at the same time serving as protection and support for the incoming lines. The rear of the frame and those parts of the front not taken up by terminal blocks are filled up by suitable cover plates. In this way there is obtained a connection panel well protected against dust and mechanical stress which is moreover inexpensive and easy to mount on floor, bench or wall.

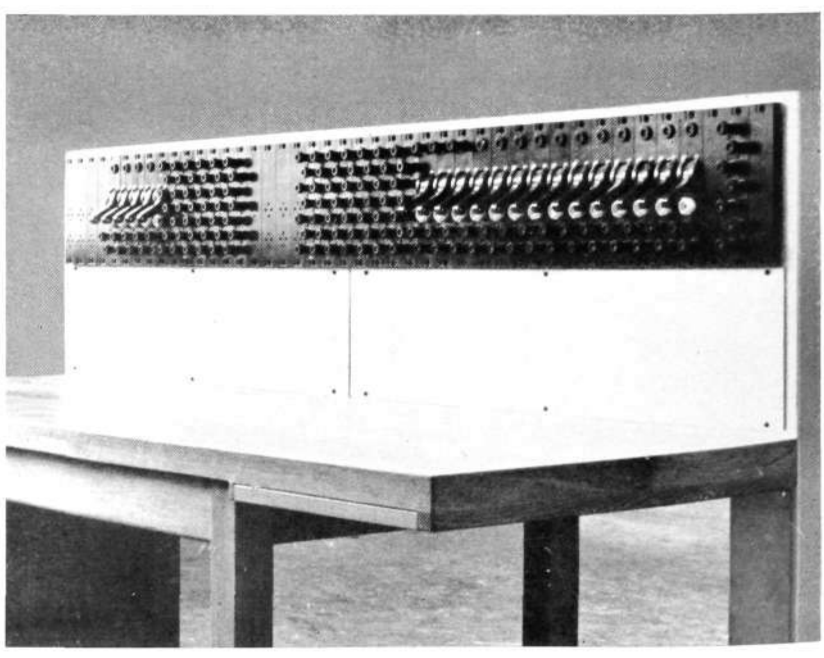


Fig. 7 X 5786
Connection panel
fitted in floor rack along laboratory bench

U.D.C. 621.395.44

BOHLIN, T: *Three-Channel Carrier Telephone System for Open-Wire Lines* Ericsson Rev. *23* (1946) No. 1 a pp. 50—70

The three-channel system is the classic solution of the problem of high grade carrier telephone communication over long distances. Growing demands as well as steady improvements of both electron valves and other elements used in carrier technics, however, justified a thorough revision of the three-channel system. The new system built by LM Ericsson and completed in 1939 is of entirely new design. Installations with this new systems have now been in satisfactory use during several years at different places. A description in detail of the system is given in the article.

U.D.C. 621.395.64

LJUNGBERG, I: *Rural Line Repeater with Negative Feed-back.* Ericsson Rev. *23* (1946) No. 1 a pp. 71—74

For lines, which are long but not long enough or with so many circuits that a normal repeater station is warranted a small repeater equipment, consisting of 2-wire repeaters, is often useful to compensate part of the line attenuation. The rural line repeater ZMK 5001, described in the article, is designed to meet the above demand and is an improvement on LM Ericsson's rural line repeater of older construction. The line repeater has smaller dimensions in its present construction.

U.D.C. 621.395.64

LJUNGBERG, J: *New Ringing Repeater.* Ericsson Rev. *23* (1946) No. 1 a pp. 75—77

With the ringing repeater types earlier used for two-and four-wire circuits with 15—50 c/s signalling current, the outgoing signal from the ringing repeaters is shorter than the incoming and furthermore the signal is delayed a comparatively long time owing to the inertia of attraction which is necessary in repeaters of older design. This has caused the inconvenience that, as regards long lines needing several ringing repeaters one after the other, the length of the ringing signal is reduced in each ringing repeater. Thus the original signal must have a length exceeding the total of these reductions.

In the article a ringing repeater is described, where the output signal has the same length as the incoming one and where the operation time has been reduced to less than a third of that for ringing repeaters of older type.

U.D.C. 656.257

INSULANDER, H: *New Press-Button Interlocking Control Machine* Ericsson Rev. *23* (1946) No. 1 a pp. 78—80

In conjunction with the ordering by the Swedish State Railways of twenty-five press-button interlocking control machines, Signalbolaget put in hand a re-designing of the press-button interlocking control machines as formerly manufactured. The construction of press-button interlocking control machines, thus arrived at, which displays a number of essential improvements in respect of facility for alterations and enlargements, is described in the article.

U.D.C. 656.05

FORCHHAMMER, N: *Street Traffic Signal Plant with Impulse Coils.* Ericsson Rev. *23* (1946) No. 1 a pp. 81—84

For many years Dansk Signal Industri A/S, Copenhagen, in collaboration with LM Ericsson's Signalaktiebolag, Stockholm, has been working on street traffic signal plants. In 1933, the company executed the plant at Fredriksberg, which aimed att the best possible adaptation to the traffic by making the different signals dependent on each other by synchronizing. In recent years a different principle has been introduced, whereby the signals are wholly or partially operated by the vehicles themselves.

The first signal constructed by Dansk Signal Industri for vehicle operation is specially designed for such conditions, as it is a type particularly suited for employment where a main street with heavy traffic is intersected by a street with traffic which, though small, is appreciable — at least at certain times of the day.

U.D.C. 656.216.2+656.25

LUNDBERG, T: *Interlocking Plant at the Bascule Bridge over the Falsterbo Canal.* Ericsson Rev. *23* (1946) No. 1 a pp. 85—87

In conjunction with the construction of the Falsterbo Canal and the bridge over the canal for railway and highway traffic to Falsterbo there was arranged an interlocking plant. The plant was ordered by Mr. Rudolf Kolm, chief of the bridge building section of the Highways and Waterways Board, from Signalbolaget and was put into service in April 1941. The interlocking machine comprised in the plant is a relay interlocking machine (or press-button interlocking machine).

U.D.C. 656.257 (487.1)

MONTELL, H: *Centralized Traffic Control on the Stockholm—Saltsjöbaden Railway.* Ericsson Rev. *23* (1946) No. 1 a pp. 88—93

In recent years systems of the kind described in the article have found increased employment abroad, especially in USA. In Sweden a plant of this type was delivered in 1938 by LM Ericssons Signalaktiebolag to the Stockholm—Saltsjöbaden Railway. The plant which has now been in service for 6 years with good results was developed in consultation and under the supervision of Mr. T. Hård, departmental chief in the Royal Swedish Board of Railways. The account was published in Nordisk Järnbanetidskrift, with whose kind permission it is reproduced.

U.D.C. 656.257 (487.1)

KULLENBERG, S: *New Interlocking Plant at Stockholm East Station.* Ericsson Rev. *23* (1946) No. 1 a pp. 94—98

The Stockholm—Roslagens Railways have for some years had a number of realy interlocking control machines (with press-buttons) in operation. As the traffic at the biggest station of this railway system, Stockholm East, had grown to such an extent that a complete reorganization of the whole station has become necessary and with it a new signal intelocking plant had to be constructed, the administration decided to equip the station with a relay interlocking control machine of Signalbolaget's manufacture. That this choice was made is due largely to the good experience obtained from earlier plants.

U.D.C. 621.317.2

BLOMBERG, H & WIKSTRÖM, J: *Laboratory Terminal Blocks.* Ericsson Rev. *23* (1946) No. 1 a pp. 99—102

In conjunction with the fitting up of laboratories and test-rooms in LM Ericsson's office and factory building at Midsommarkransen, Stockholm, the need arose for up-to-date connection panels fort the connection and distribution of current required for laboratory and working benches. As suitable arrangements were not to be had on the market and as the numbers required were large, the problem was tackled of producing special designs for the purpose. The result has been a connection unit, the laboratory terminal block, by means of which connection panels of different types and for various requirements may be built up. These should certainly find great employment in laboratories, test-rooms etc. in factories, schools and higher educational establishments, and have consequently been made available for sale.

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