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The Telephone in the Service of the Railways

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In recent years the telephone has been more and more employed in railway operation and the time should not be too far distant when all communications in railway service will be by telephone instead of by telegraph. In order to facilitate the planning of new railway telephone installations, a series of articles in this and the following issues of the Ericsson Review will give a survey of the different telephone systems made by Telefonaktiebolaget L.M. Ericsson for railways as well as their practical application by different railway administrations.

In the majority of railway enterprises the telephone has been supplanting the telegraph in recent years; this evolution which is due not only to the lower installation costs and the better economy of the telephone compared with the telegraph, but in a still higher degree to the fact that the telegraph is no longer able to give sufficiently rapid and efficient service with present day increased requirements in respect of greater train speed, denser traffic etc. The greatest disadvantage of the telegraph indeed lies in its slowness, as every communication must first be written down and thereafter sent out as Morse signals and finally received and decoded at the receiving station. The transmission of such a communication takes considerable time even with the high telegraph speeds possible with apparatus for high-speed telegraphy. A great inconvenience of the telegraph is further that the answer cannot be sent immediately, but only after an appreciable time. As long as the railway lines carried little traffic and the trains ran at a comparatively low speed, this slowness was not considered a disadvantage. However, since motor vehicles and air services have begun competing with the railways circumstances have entirely altered. In order to be able to compete successfully with other means of transport most railways have been compelled to rationalize their operation and adapt their traffic better to the exigences of modern life. This modernization would certainly not have been possible without replacing the telegraph by the telephone for the continuous communication of orders, train dispatching and in fact all communications in railway service.

In the countries where safetey regulations prevented the introduction of the telephone in place of the telegraph for communicating certain orders, the railway administration has requested the authorities to alter the regulations. Such request has invariably been acceded to and in most countries there is today nothing to prevent the substitution of the telephone for the telegraph for all communications in railway service. This also provides very good evidence of the fact that the telephone is considered superior to the telegraph even in regard to safety.

The qualities of the telephone which justify its replacing the telegraph may be summarised as follows: orders may be transmitted more rapidly without laborious conversion of the words to Morse signals with subsequent decoding at the receiving station; an answer is obtained immediately; personal contact is obtained between the sender and the receiver; it is thus possible to check immediately that the order has been correctly understood; the operating is cheaper and less staff is necessary, as telegraph operators may be entirely eliminated; no telegraph staff has to be trained and as this generally must be done at the cost of the administration quite a considerable saving is made;

the networks are better utilized, partly through the more rapid transmission of individual communications and partly through more rational construction of the network, which is rendered possible if trunk calls are established automatically instead of manually; the installation costs will be lower and the economy improved.

All these advantages of the telephone in comparison with the telegraph are sufficiently great to provide financial justification for transition from telegraph to telephone. However, they are surpassed many times by the considerable advantages derived by the railways from rational application of the telephone, which put into money would perhaps be worth ten times more than the actual monetary saving. Utilizing the rapidity of the telephone, the adaptability of the telephone system and rational train dispatching, the efficiency of the railway lines, of the rolling stock and the staff may be considerably increased and the economy of the railways still more improved. It is also easier to make up trains by means of the telephone and to reduce the empty running of trains. The most important indirect advantages obtained by the introduction of the telephone are the following: better utilization of rolling stock; better utilization of staff; better utilization of railway lines; more rapid making up of trains; less running of empty waggons; more rapid organization of emergency trains in case of accident; easier planning of extra trains.

In order to illustrate the development of the telephone in railway administration we will quote a few data from the Swedish State Railways. The first telephone system introduced by this administration was the *magneto telephone system with code signalling,* which was essentially used to supervise a track section. In the course of the years this system was very much extended and, though still more efficient systems have been designed in later years, the magneto system is still extensively used by the State Railways which had 10 500 km magneto lines with 4 050 instruments in 1935. The main disadvantage of this system is that all instruments on the same section will ring at each call. As soon as a telephone system where this disadvantage was eliminated, the *selective-calling system,* was designed the State Railways introduced this system on trial. The first selective-calling installation was put in service in 1914. Since then the State Railways had up to January 1, 1936, introduced selective-calling systems on altogether 12 000 km circuits with 1 250 instruments. Since about 1920, the State Railways have used their own circuits for establishing *long-distance service communications.* Telephone repeaters are inserted whereever necessary.

Up to 1930 the telephone could only be used to a limited extent by the State Railways as communications concerning the safety service as well as communications concerning freight and passenger traffic had to be established by the telegraph alone, in conformity with the safety regulations then prevailing. In 1930 the State Railways made an investigation concerning extension of the use of the telephone and all administrative districts were called on to submit economic reports and opinions. This investigation showed that the State Railways could make a *direct* saving of about 375 000 Kr./year by abolishing the telegraph. This sum is distributed as follows:

abolition of 62 telegraph operators	290 000 Kr.
abolition of the training of telegraph operators	78 000 Kr.
saving in paper and ink	7 000 Kr.
	375 000 Kr.

Only the direct savings are taken into account here, but the indirect gains are many times greater. After Parliament had approved the proposition of the State Railways and the necessary sums for alteration and new constructions required by the introduction of the telephone were granted, the State Railway Administration decided to abolish as soon as possible all telegraph communications inside the country and to retain them only for communications with foreign countries. In consequence the length of the telephone circuits rose

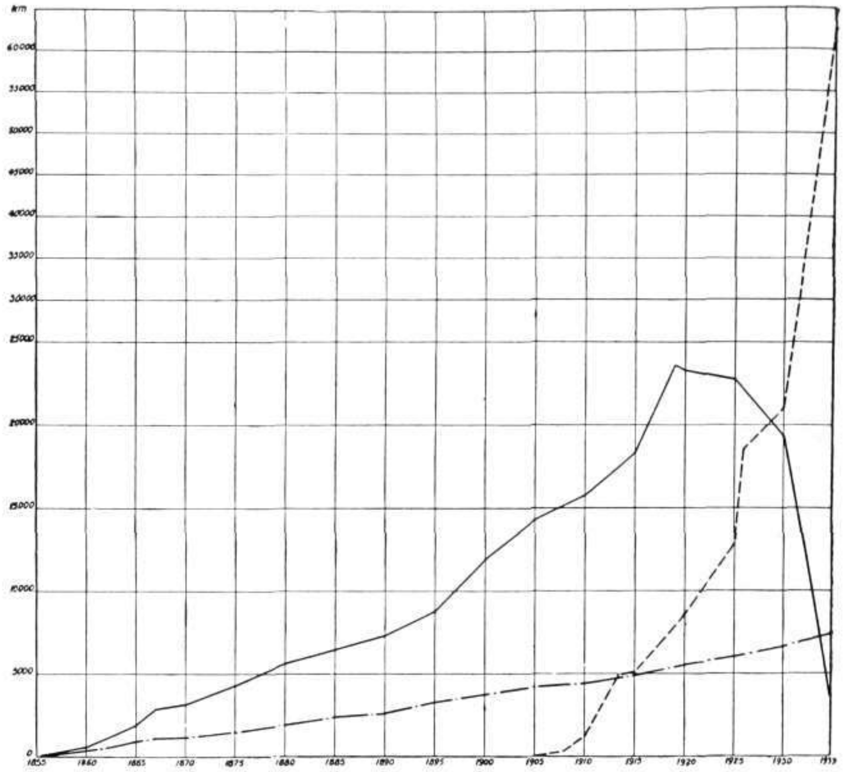


Fig. 1 X 5347

Development of the telegraph and the telephone network of the Swedish State Railways

——— telegraph circuits
— — — telephone circuits
—·—·— railroads in service

from 20 000 km to 60 000 km in the period 1931—1936. The length of the telegraph circuits was simultaneously reduced from 19 000 km to 3 500 km, see the diagram, Fig. 1. The number of telephone instruments now in service is about 8 000 against about 100 telegraph apparatus.

Railway Telephone Systems

For rational application of the telephone to the great and complicated organization of a railway the telephone systems must satisfy many requirements peculiar for railway operation and which are not found in commercial telephony. The most important domains in which the telephone has found application in railway undertakings may be distributed in the following classes:

magneto telephone for exchanging communications in a short track section, between two or several railway stations and generally without intercommunication with other line sections;

district telephone for exchanging communications on long track sections and between instruments connecting the line and the telephone installations at the stations, permitting intercommunication between the line sections;

long-distance telephone for exchange of communications over very long distances chiefly between the main points of a district;

dispatcher telephone for centralized train control and supervision of train movements along a railway line, generally without direct intercommunication with other telephone installations.

Though these four domains of utilization of the telephone in railway operation are quite distinct and require different technical solutions, they compose, as does the railway organization itself, a unit in which all parts must be adapted to each other if the telephone service is to give the best possible service and if absolute reliability is to be attained. Special consideration has been taken to this in the systems described in the following, which have been designed to avoid all difficulties when intercommunication is to be arranged between them and to make their operation as simple as possible so as to enable persons who only seldom use these systems to establish when necessary the desired communication without difficulties or delay.

Railway operation, however, is organized in very different manner in different countries and by different administrations; when an extensive introduction of the telephone for the service of the railway is to be planned, the administration will often be confronted with problems which are difficult to solve without a profound knowledge of the design and operation properties of the different telephone systems. It is in order to facilitate such planning that a survey of the different telephone systems for railways made by Ericsson as well as their practical application by different telephone administrations will be given.

Magneto Telephone

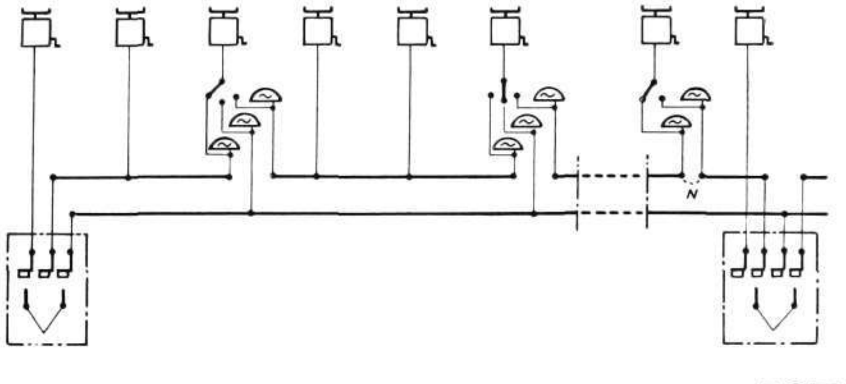
The magneto telephone is generally used by the railways to permit exchange of communications between two adjacent railway stations or several stations and the linemens' dwellings along a line section. Two parallel lines are used for this purpose, see Fig. 2. One line is divided into a great number of sections and used mainly for transmitting to adjacent stations communications concerning the arrival and departure of trains. During the night the sections are interconnected at the stations which have staff on duty only during the day. The other line on the other hand passes without being sectioned a great number of stations of which only the larger ones are connected to the line; it is used mainly for transmitting orders and other important communications relating to operation.

For such circuits the railways have for a long time been using magneto telephone systems with instruments connected in parallel. For intercommunication between two instruments connected on the same line signalling by Morse code is used, each instrument having a determined code signal. The emission of the different signals is made by means of the magneto, the dot in the Morse alphabet corresponding to, *e. g.*, one turn of the magneto crank and the dash to three. Where AC is available, current from the main is usually used instead of magneto; the AC is transformed by means of a transformer to about 100 V and transmitted on the line by a push-button with automatic release. The bells may be rendered sensible to all frequencies between 16 and 50 c/s, and main voltages having all frequencies comprised between these limits may be used.

Latterly certain railways have replaced magneto systems by selective-calling systems which offer many advantages compared with the former system. The magneto system, however, still enjoys very great popularity with the railways on account of its simple construction and great reliability and it may thus be expected that this system will continue to be largely used even in the future.

Instruments and Bells

Nowadays the lines are nearly without exception two-wire and the telephone instruments consist of magneto instruments having such electrical properties that the conversation and signalling currents will be certain to be received



X 5425

Fig. 2
Magneto telephone line
N night interconnection

Fig. 3 X 3807
Magneto telephone instrument, Type DAL 1001
table model

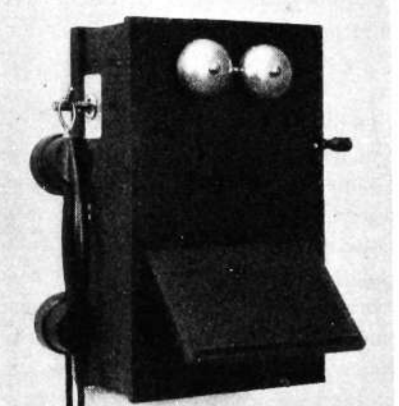


Fig. 4 X 3808
Magneto telephone instrument, Type DAS 2001
wall model

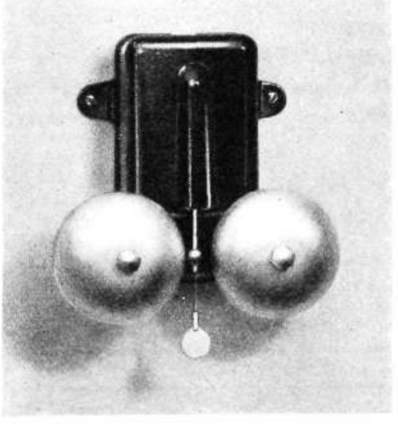


Fig. 5 X 3803
AC bell, Type KLA 1246
with vibrator

even when a great number of instruments are connected in parallel on the same line. The magnetos of the instruments have therefore extra powerful magnets and the bells a high impedance. In this way the signalling output emitted by the magnetos will be large but the current consumption in the bells small. In order to prevent an appreciable attenuation of the signalling current in case the microtelephones of a few instruments should for some reason not be replaced a small condenser of 1.0 μF has been inserted in the speech circuit of the instruments rendering their inductive resistance on lifting the microtelephone large for signalling frequencies (16—20 c/s) and small for vocal frequencies (about 800 c/s). Through these arrangements up to 20 instruments may be connected to a not too defective line without risking that the attenuation at vocal or signalling frequencies will exceed the admissible values (3—3.5 neper). In special circumstances the Swedish railway administration connect up to 27 instruments on the same line.

Suitable telephone instruments for this system are Type DAL 1001 and DAS 2001, Fig. 3 and 4, which have a very robust construction and have been very extensively employed for railway service. The former is a table instrument with metal case and bakelite microtelephone and a magneto with extra-powerful magnets as well as a high impedance bell. The batteries are situated outside the instrument in a battery box. A special bracket permits of mounting these instruments on the wall. If a specially designed wall instrument is desired, the instrument, Type DAS 2001, with case of polished oak and bakelite microtelephone should be used. It has, like the table instrument, a magneto with extra powerful magnet and high impedance bell. This instrument, however, does not require a separate battery box, a compartment for the batteries being provided in the case. If a smaller wall instrument is desired, there is an instrument, Type DAS 1201, which is designed like the above wall instrument, but without compartment for the batteries, these being situated outside in a separate battery box.

When several telephone circuits are connected to certain stations and it would therefore be unpractical and expensive to use an instrument for each circuit, separate AC bells are connected to the circuit instead and a single instrument is provided which may be connected to the desired circuit by means of a commutator when a call is to be exchanged. The bell, Type KLA 1306, which has a high impedance is generally used for this purpose. For commutator is used the two-way commutator, Type RL 201. The instrument is connected to one contact pair and the circuit to the other, which means that one commutator is required for each circuit. The same commutator allows also for the interconnection to line sections, for instance during the night when the station is without supervision. If a great number of line sections meet at a station and several bells are thus situated near each other, it may be difficult to decide which bell has rung. In such cases an AC bell with vibrator Type KLA 1246, Fig. 5, should be used. The clapper of this bell is fitted with a steel spring and a disc which continues to vibrate a short while after the bell has ceased to ring.

Manual Switchboards

When magneto lines are connected to large railway stations which also require internal telephone communications, they should be connected to small magneto switchboards which may be used partly for interconnecting the sections, partly for connecting the magneto lines to the different local instruments and finally for establishing the internal traffic. If magneto lines as well as automatic selective-calling lines are connected to the station it is often preferable to exchange the internal traffic automatically and it will then be uneconomical to provide the station also with a manual switchboard. The interconnection of magneto lines, selective calling lines and automatic ex-

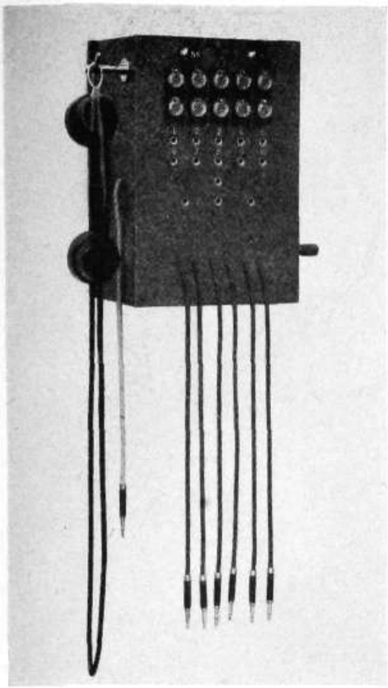


Fig. 6 X 3809
Magneto wall switch, Type ABH 12

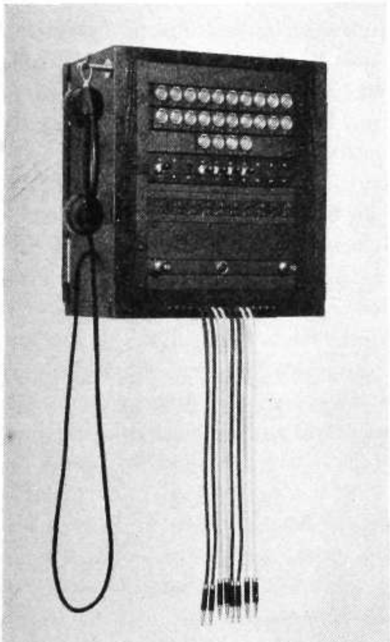


Fig. 7 X 3806
Magneto wall switch, Type ABH 13

changes may be done without using switchboards, as will be described later on. Here we suppose that the internal traffic is to be established manually and that the use of a switchboard is thus justified.

When the number of circuits to be connected to such a manual switchboard is comparatively limited, the railways generally use wall switches. Suitable for this purpose are the Ericsson wall switches, Type ABH 12, for 5 lines and 2 calls facilities, 10 lines and 3 calls facilities as well as 15 lines and 4 call facilities, Fig. 6. In stations having a great number of subscribers, a wall switch, Type ABH 13, Fig. 7, for 20 magneto lines and 4 call facilities or 30 lines and 6 call facilities should be chosen. The switchboards are of a very robust construction with case of dark polished oak. Drop indicators are used as calling signals, those connected to magneto lines having high-impedance coils.

Portable Telephone Instruments

Railway operation requires portable instruments which can be taken with the trains or on inspection tours. These instruments should allow of easy connection to the telephone line, thus enabling any instruments connected to the line to be called. When the magneto lines consist of bare wires on poles along the track the connection is made by means of a special hook mounted on a rod. The hooks and rods are available in various designs, the essential differences being in the material. If the magneto lines are led in cables, this simple connecting device cannot be used; instead a cable is fitted at regular intervals, for instance 1 km, with watertight contact boxes. If it is required to connect telephone instruments to the cable at any place along the track, the trains and the linemen must carry special portable cable drums with extension cable, *e. g.*, Type MH 2005. This cable must obviously be at least as long as half the distance between the contact boxes. Rapid determination of the direction in which the nearest contact box lies is facilitated by arrows mounted on poles along the track. Certain railway administrations also use arrows to indicate the direction towards the nearest permanent telephone station.

Ericsson has designed a suitable portable magneto telephone instrument, Type DPA 10, Fig. 8. In order to make the instrument as light as possible, the case is of bakelite, which has permitted a reduction of the total weight of the instrument to 4.2 kg. The microtelephone is of normal design, but fitted with a key for closing the microphone current. A dry cell battery of 3 V is used for microphone feeding and may be exchanged without taking the instrument chassis out of the case. The magneto is of a new design with cobalt steel magnets allowing of making the magneto smaller and lighter although it gives the same output as ordinary magnetos. The bells have a high impedance.

Line Protection Devices

When magneto telephone lines are made as open wire lines, the telephone instruments must have protecting devices. An efficient lighting arrester and overvoltage protector is obtained by means of a three-pole rare-gas tube, the circuit branches being connected each to one exterior pole, the mid point being connected to earth.

Delayed-Action Relays

As all instruments and bells along a magneto line are connected in parallel each calling signal actuates all bells connected to the line as well as all drop indicators in the switchboards. This, the greatest inconvenience of the magneto telephone system, has also been a cause of replacement of this system by the selective-calling system. There are, however, two methods permitting of making the calling signals individual; according to the first one certain instruments are called over the earth and both circuit branches connected

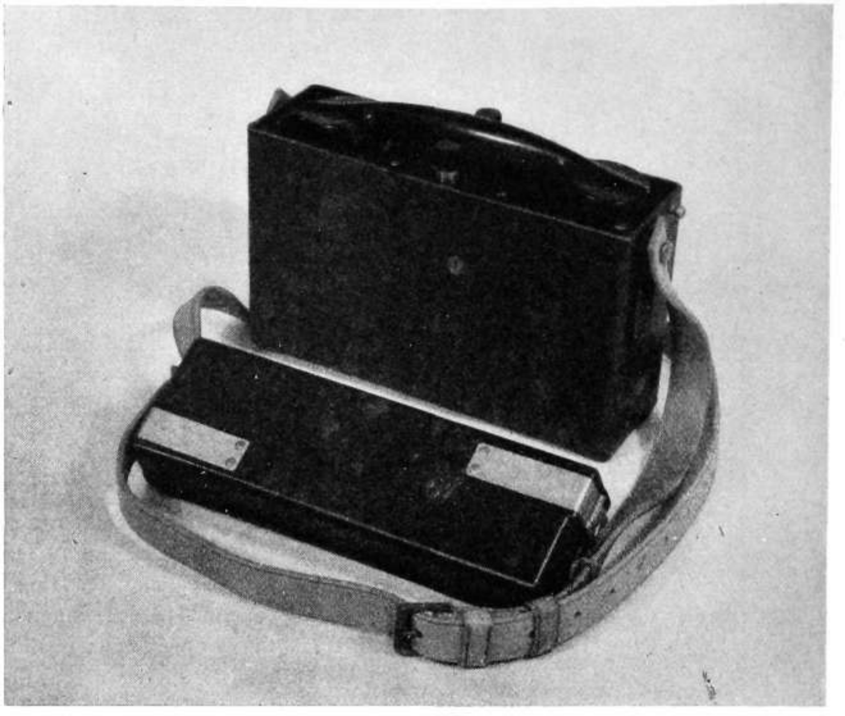


Fig. 8 X 5428
Magneto telephone instrument, Type DPA 10
portable model

in parallel, according to the other delayed action or code relays are inserted before certain instruments, admitting only determined signals. The disadvantage of a general calling signal is particularly disturbing at manual switchboards when the drop indicator falls (or the bell rings) for each signal, the operator being thus now and then disturbed by calls which do not concern her; for this reason it is in first place these signals which are separated from all other calls on the line.

When signalling over earth a choke coil is inserted between the branches of the circuit at the instrument and the switchboard. The mid point of the choke is connected to earth at the switchboard over the drop indicator (or bell) and at the instruments over the magneto and a push button. The push-buttons are designed in such a way that the magneto is normally connected between the branches but connected to earth when the button is pushed. All calls from the instruments to the switchboards are made by pushing the button and then only the drop indicator of the switchboard will be actuated, while calls to the other instruments on the line are made with the magneto only. This method requires comparatively good lines and has also several disadvantages, *e. g.*, only one instrument may be freed from the signal concerning the others; for this reason the railways have recently used delayed-action relays more and more. These relays make no demands on the quality of the lines, neither do they require any earth circuit. The introduction of these relays in an existing installation is very simple and they only have to be connected before the instruments which shall not be disturbed while the other instruments remain unchanged. Two kinds of such delayed-action relays, Type RN 135 229 and RN 143 828, Fig. 10, have been designed, of which the first should be used when only one point is to be freed from the calling signals touching the others, while the latter is required when several points along the same magneto line shall have individual calling signals.

Fig. 9 X 3804
Diagram for delayed-action relay, Type RN 135 229
L line
S signalling circuit

The delayed-action relay, Type RN 135 229, works as shown in Fig. 9. The signalling current actuates relay *R1*, which closes current to relay *R2* and when this latter has been attracted, also to relay *R3*. This relay is energized over its own make contact and breaks the holding current for relay *R2* which, however, still remains attracted some time on account of current received from the pendulum contact of relay *R3*, which vibrates when the relay is attracted. The vibration time of the pendulum contact may be adjusted between

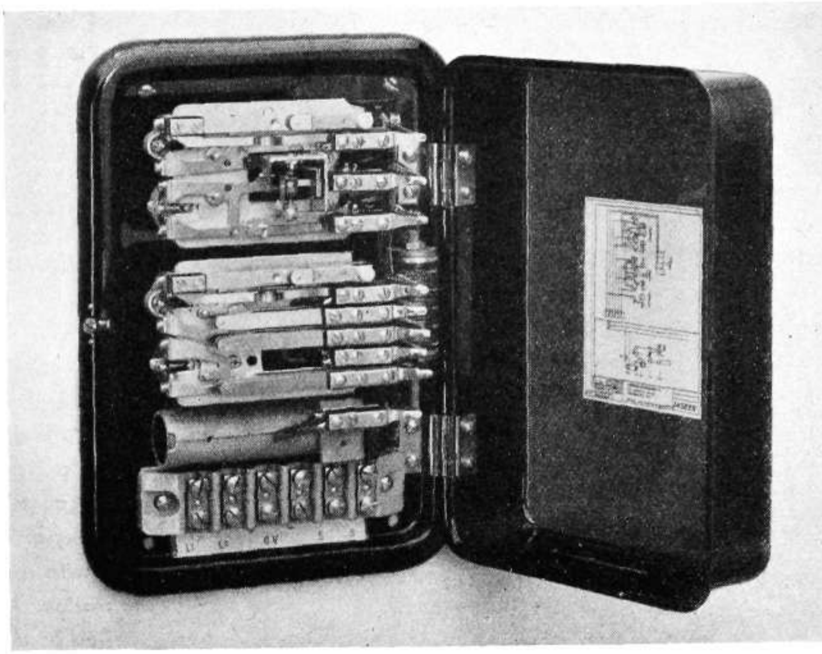


Fig. 10 X 5426
Delayed-action relay for selective calling, Type RN 143 828

1 and 3 s. If the duration of the calling signal is shorter than this time, the break contact of relay *R2* in the signalling circuit is broken and no signal will be transmitted to the bell or drop indicator inserted in this circuit. If, on the contrary, the calling signal has a longer duration than the vibration time of the pendulum contact, relay *R2* is released and a circuit is closed to the calling device connected in the circuit. A 6 V dry-cell battery is used to provide current for this signal. If the delayed action relay is connected as calling signal to a manual switchboard, the calling signals of this latter will be influenced only by a long signal having a duration of 3 to 4 s, sent out from an instrument on the line but not of code signals consisting of signals of short duration used for calls between the other instruments.

This delayed-action relay thus can only separate a long signal from short signals, and it cannot be adjusted for different kinds of code signals. The application of this relay is therefore comparatively limited and it must be replaced by the relay, Type RN 143 828, as soon as two or more points along the magneto line must receive individual calling numbers. This device contains the same delayed-action relays as before, which only admit signals of long duration and in addition a selector, which is made to progress by the different calling signals. The device can be adjusted for a certain number of short signals and a signal having a duration of 3 to 4 s, see Fig. 11. A calling signal actuates the magnet *S1* which in its turn energizes magnet *S2*. Simultaneously the selector progresses one step. When the signal is interrupted the magnet *S1* is released but *S2* remains attracted still for some time, obtaining current through its own pendulum contact as long as this latter vibrates. The next calling signal actuates the magnet *S1* anew and the selector progresses one step further. If this device is adjusted for two short signals and a long one, current is closed after two signals to the relays *R1* and *R2* which actuate in the same manner as before a calling device, bell or drop indicator, if the last calling signal has a sufficient duration, 3 to 4 s. A 6 V dry-cell battery should be used in this case also for operation.

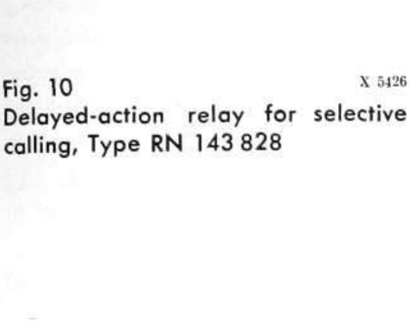


Fig. 11 X 3805
Diagram for delayed-action relay, Type RN 143 828
L line
S signalling circuit

Railway Interlocking Plant in Portugal

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Ermezinde is an important junction on the Minho and Douro lines and, after the opening of the Ermezinde—Leixoẽs line, tracks from four directions meet there; since the station was taked over by the Portuguese State it has been necessary for it to undergo a radical modernization. One of the arrangements necessary in this connection was a modern signalling and interlocking system, and the technical department of the Companhia dos Caminhos de Portugueses was charged with investigation of this question in conjunction with the extension of the station. Among the tenders asked for, the conditions prescribed were best satisfied by the project submitted by Compañía Española Ericsson for an electric interlocking plant of Signalbolaget's system. This company therefore was asked to supply the installation which was put in service on August 6, 1937.

The following description of the installation is reproduced by kind permission from »Boletim da CP», September 1937.

After a serious study of the different tenders which were received from specialized firms as well as existing similar installations installed by foreign railway administrations, the Portuguese State Railways decided to provide the station with one single interlocking cabin and to use electric local operation of certain points under the supervision of the cabin. All dependences between the signals, the points and the track circuits as well as the supervision devices on the interlocking machine are purely electrical and obtained by means of relays. In this manner an economic solution of the problem was also obtained from the point of view of operating costs, as it proved that the interlocking machine could be attended to by a single man per shift. Under the control of this operator, who acts as train dispatcher, were placed all the elements necessary for an efficient supervision of all train movements inside the station.

Fig. 1 X 3800
Interlocking cabin at Ermezinde

Interlocking Cabin

The interlocking cabin, Fig. 1, is an attractive building of reinforced concrete with modern lines. It was designed and constructed by the railway's own staff. The building has three stories. On the ground floor there are the cable intakes, a distribution panel, a reserve power plant and a room for the mechanic. On the first floor there are the relay group and lockers for the staff. Finally the second floor which is entirely surrounded by glass windows contains the interlocking machine room, Fig. 2. The machine comprises three panels and a table-top. On the panels there is on a black background a diagrammatic track plan of the station, made up of chromium-plated bars and small electric lamps which reproduce the position of the signals and the points inside the station and indicate whether the track circuits are occupied. Under the diagram there are three rows of operating switches; the upper row is used for operating the different points and for giving permission for their local operation; in the second row there are road switches, *i. e.*, a series of switches which check that all conditions necessary for setting a certain signal at »clear» have been fulfilled; finally small signal switches are mounted in the lower row. On the table there

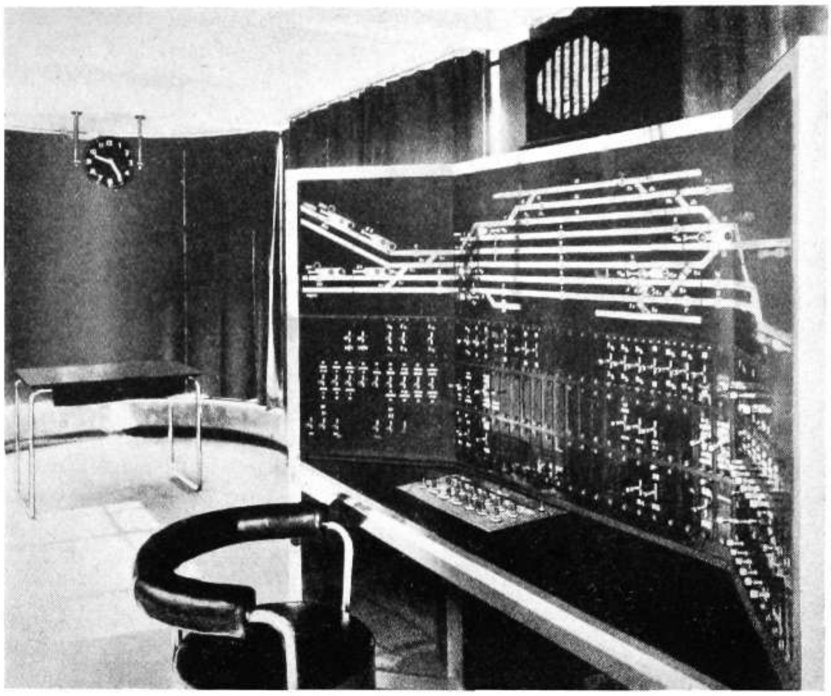

Fig. 2 X 5424

Interlocking machine

above track diagram, below point switches, road switches and signal switches; on the table-top telephone exchange

is a telephone exchange which is connected with adjacent stations, the station master's office and the telephone instruments mounted near the different tracks and platforms inside the station.

Track Circuits

The track diagram over Ermezinde station, Fig. 3, shows the disposition of the interlocking cabin, the signals and the points, and the division of the track system into insulated sections, *i. e.*, track circuits. The track sections are normally insulated from each other through insulating junctions of wood or through fibre junctions where there is no place for wood junctions. All electric circuits outside the cabin are of insulated signal cable of normal type. These cables are buried in the road-bed over a layer of sand to facilitate drainage and are protected above by bricks.

Each point or group of points composes a track circuit which is interlocked with the signals and prevents these being set at »clear» when the section in which they are comprised is occupied by vehicles; at the same time the track circuit locks the point or the group of points when it is passed by trains, also signalling to the cabin that the section is occupied. The track circuits are fed by low tension AC; in this manner the interlocking plant is protected against DC disturbance from adjacent traction circuits.

Track circuits are also arranged in the whole stretch of the tracks I, II, III, IV and V, partly to signal to the cabin when the tracks are occupied, partly to prevent a signal being put to »clear» for a track which is already occupied. The tracks VI, VII and VIII and the platform tracks are not

Fig. 3 X 7132

Track diagram of Ermezinde railway station

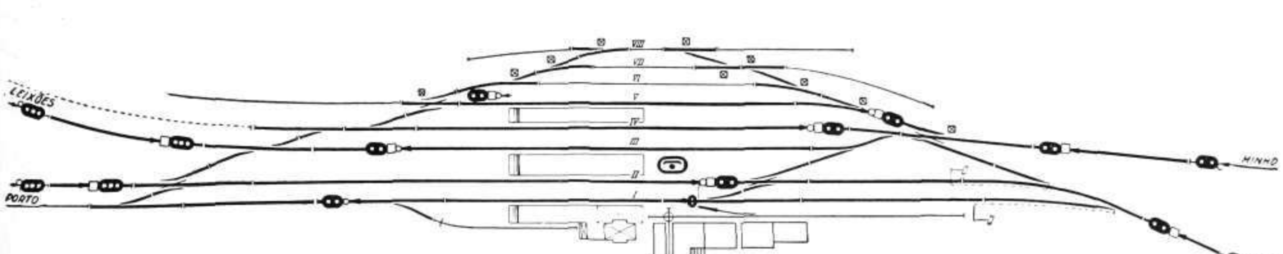

Fig. 4 X 3801
Main signal with luminous sign

provided with track circuits, being used as side tracks which are generally occupied by vehicles and never used for train movements. Finally a track circuit is arranged before the main signal at the entrance of each track to the station in order to signal to the cabin when a vehicle passes a signal or when shunting movements are going on outside the entrance signal.

Roads

When it is required to make up a road to receive or send off a train, all signals which are comprised in the road must be set at »clear». However, before it is possible to set at »clear» a signal which controls any of the entrance or departure roads to the station it is necessary that all points which are comprised in the road or give access to it should be in the right position, that these points are duly locked and that their position has been electrically supervised from the interlocking plant. There should be no vehicles on the track section which are comprised in the road, and all signals belonging to an opposed road should be set at »stop». If for some reason any of these safety measures has not been fulfilled, it is not possible to set the signal at »clear». A road which has been made up but which is not to be used may be cancelled in the interlocking plant by means of an emergency key which is normally sealed. When, however, the road has been made up and the train passes through the points, these are released one after another and the corresponding signals are automatically set at »stop».

The signals which control the shunting movements are not interlocked with the track circuits, which allows of carrying out shunting movements on sections already occupied by rolling stock.

Signals

The signals are luminous daylight signals with coloured lights in two or three positions and consist of a lamp with a two-lamp system, of which the external one is uncoloured and the internal one coloured. The electric lamp is situated at the focus of the optical system and gives a light with very great visibility even in strong sunlight. The main signals, Fig. 4, are provided with luminous signs made up as small lamps which compose a number or a letter indicating the entrance track or the departure direction. The signals have screens which prevent the reflexion of sunlight and are mounted on plates coloured black. Each signal with luminous sign is mounted on a tubular steel pole which stands on a concrete base and is fitted with a ladder and inspection platform.

Points

All the points inside the station are operated directly from the interlocking cabin, but certain points have a device for electric local operation, Fig. 5; this latter can be used only after permission has been obtained from the cabin, which always has the possibility to cancel the permission in case of emergency, *e. g.*, if the point is to be used in an entrance or departure road or if the cabin wants to take charge of the direct operation of the points. Near the points intended for local operation there is a pillar which supports a cabinet containing operating switches and a lamp which lights up when local operation is permitted by the interlocking cabin. The switch is operated by means of keys which are distributed to the employees who have the right of local operation.

Fig. 5 X 3799
Point driving machine with local switch

The point driving machines are fed by 220 V AC and provided with internal locking; when the points are moved to one or the other position, they are locked in this position and simultaneously it is supervised by

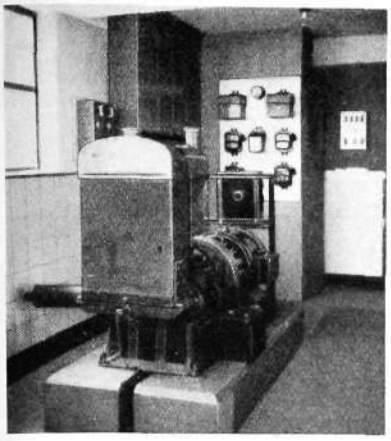

Fig. 6
Reserve power plant

X 3802

the interlocking machine that the point is in the correct position and that the point proper has come to the extreme position. In case of faults or current interruptions of long duration the point driving machines may be operated by hand by means of cranks which are usually stored in the cabin under the supervision of the operator.

Power Plant

The installation is normally fed from the electricity mains, but in case of interruption of that source of current there is a reserve power plant, Fig. 6, consisting of a motor generator group, composed of a petrol motor, direct coupled to an AC generator. This group is installed on the ground floor of the cabin and starts automatically in case of interruption on the mains current or in case of abnormal voltage drop. When automatic start is not used the group is started with a key.

In order to give an idea of the extent of the interlocking installation at Ermezinde station, it may be mentioned that it controls 28 points and 21 signals and comprises about 300 relays and over 20 000 connections. The electric junctions in the interlocking machine are about 8 600 and comprise 15 150 m insulated copper wire. The earth cables outside the cabin of which two are hundred-wire have a length of 7 840 m and represent 140 300 m single wire.

It is desirable that similar installations be generally introduced in all great stations, not so much for the facility of operation they offer, but above all for the increase in the traffic safety which they represent. This claim which might seem exaggerated to those not quite familiar with railway operation, is entirely confirmed by the following words, expressed by the French minister of public works in a speech which he delivered in Paris over the remains of the two hundred victims of the railway accident at Lagny on Christmas Eve 1933: »In everything that concerns the traffic safety of railways, whether it be question of material, brakes or signals, there should be no mention of any economy except that of human life.»

Utilization of the Centralograph in Textile Mills

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The profits of textile undertakings depend primarily on the attainment of the highest degree of efficiency from the various machines. To obtain this it is necessary to supervise the machines as comprehensively and exactly as possible. The centralograph, which provides at a central point — e. g., in the mill manager's office — an easily surveyable record always available of the output of a large number of machines, constitutes a valuable aid to the efficiency engineer. With the centralograph a surprisingly perfect technical solution has been given to the problem of machine control and the production engineer has received a reliable and impartial instrument of supervision.
In the following some examples are given of quantity and quality supervision of cotton spinning and printing machines by means of the centralograph.

Control of Slubbing Frames

It is well known that the slubbing frames constitute one of the most important factors in a cotton mill, because the slightest variation in the physical condition of the cotton, the humidity of the atmosphere or the mixing necessitate immediate adjustment of the machines to prevent increase in the number of broken ends. Increase in the number of broken ends on the slubbers cause corresponding increases on the intermediate and roving frames, which means quite considerable production losses. Furthermore, a greater number of broken ends is caused on the ring spinning machines, that is to say deterioration arises in the quality of the finished goods. It is thus particularly important to ascertain continually the number of broken ends per hank and 100 spindles or per hour and 100 spindles on these machines. For a spinning expert no further explanation is necessary, the importance of an efficient and continuous control of the number of broken ends on slubbing frames being so evident that keen appreciation is felt that one has through the centralograph for the first time obtained a reliable instrument for providing such control.

Fig. 1 X 3746
Centralograph contact
fitted on the feed roller of a slubbing frame

The contact devices of the centralograph are fitted on the feed rollers, see Fig. 1. The impulse intervals should be chosen so that close recording is obtained; the stoppages caused by broken ends can then be easily distinguished.

In practice this mode of control has proved its worth remarkably well, inasmuch as it provides the means of establishing exactly the duration of every stoppage due to broken ends; the centralograph is thus the first to give not only a true picture of the working of the slubbing frames, but also of the work of the minders and of the correct setting of the machines.

It is possible by means of the centralograph to detect at once all setting faults, small or large, thus providing opportunity to carry out any necessary adjustments without delay. When changing the setting of a machine for spinning a fresh quality or another count it can be immediately checked whether the new setting has been made correctly. Furthermore, the centralograph diagram shows the exact point of the bobbin length at which break-

Fig. 2
Diagram of the main causes of production losses in ring spinning frames

- total loss
  - losses in speed
  - losses due to stoppage
    - repairs, lack of bobbins, lack of minders, lack of yarn, broken ends
    - doffing time, oiling, cleaning, piecing
    - change of yarn, change of count, change of draft, change of traveller

ages occur, which gives an indication as to where the setting faults are to be found. Finally, centralograph control on slubbing frames has proved valuable in connection with wages calculations; thanks to the exact times given for stoppages, reliable figures are obtainable for bonus calculations, with the result that the protests and claims which frequently occurred in the past are eliminated.

In conclusion it can be mentioned that, thanks to the easy and continuous control provided by the centralograph, the production on the slubbing frames can be increased by 15 to 25 %, reversion to the old faults has been made impossible and still further improved results are to be expected.

Supervision of Ring-Spinning Frames

A ring-spinning mill which is correctly planned works in such a way that the output increases from one machine in the production chain to the next, all along the line from the ring-spinning frame to the scutcher. The narrowest cross-section of the mill lies therefore at the ring-spinning frames, the capacity of which determines the output of the mill as a whole. The production costs, therefore, depend directly on the output of these machines, losses here amounting in the end to from 300 to 600 % of the direct cost of wages, according to the count spun.

The above indicates the importance of checking losses on ring-spinning frames. The possibilities of loss on these machines vary greatly as is apparent from the tabulation of the main causes, Fig. 2. All these losses are recorded by the centralograph, Fig. 3. The contact devices for ring-spinning frames should be connected to the front roller, see Fig. 4. It is advisable to choose the gearing of the contacts so that the number of markings per centimetre can easily be read on the diagram, Fig. 5.

To derive full benefit from the centralograph diagrams, production report forms are necessary, Fig. 6. Against the horizontal lines the machine numbers have been arranged in numerical order, with in the vertical columns hours and minutes according to shifts. Such a form is made up every day for each department and shift by the foreman on duty. The duration

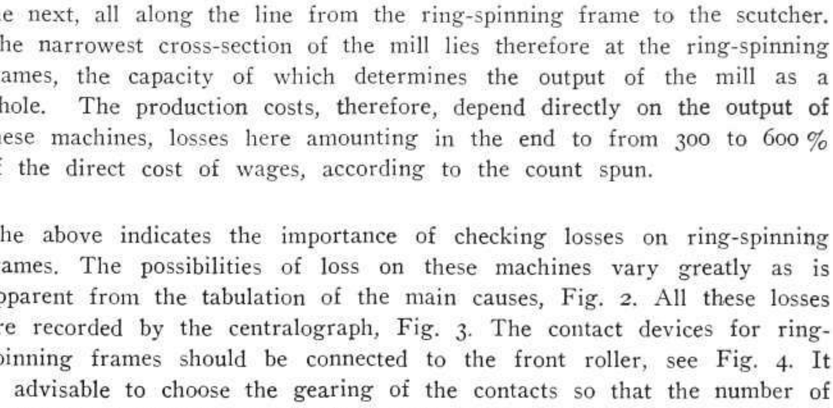

Fig. 3
Centralograph equipment
for the supervision of 90 machines

X 5393

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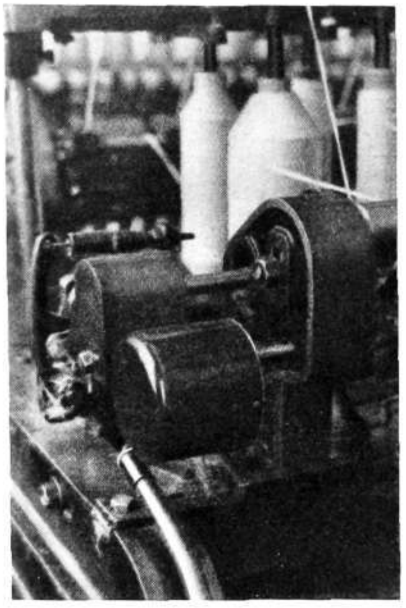

Fig. 4 X 3747
Centralograph contact
fitted on the front roller of a ring-spinning frame

of all stoppages, except for doffing, is marked by lines in the columns of the respective machines, and the reason for each stop is indicated by the corresponding reference letter. The centralograph diagrams are checked daily by comparing them with the entries by the foremen on the report forms; the figures thus obtained are tabulated according to machines or machine groups and reasons for stops. The tabulated summaries are then used for further check of time losses, thus giving a picture of the extent of the stoppages in a certain period (week or month) for each machine or machine group, as well as for each particular kind of stoppages.

Speed Losses

To check the stoppages occasioned by slowing down of machines with variable speed motors, the number of markings per centimetre is noted for each machine where the markings are most infrequent. It can thus be determined whether the machines have been working at the prescribed speed.

Stoppage Losses

Stoppages for doffing, cleaning etc. are regulary recurrent and the extent of the normal loss should therefore be ascertained with exactness by time studies. Where a doffing gang is used, their earnings should be calculated according to a bonus calculated on the basis of average doffing time, see Fig. 7. Surprisingly good results are often obtained with a bonus system of this kind.

The average times for change of yarn, draft, travellers etc. should also be ascertained by time study. The relation between actual and calculated times for these operations can be illustrated graphically per week and shift on the basis of the figures obtained through time studies as compared with those found in the diagram; this relation gives a good illustration of the average efficiency of foremen and operators.

The calculated duration of stops for repairs, lack of material etc. cannot be fixed by time study and must therefore be ascertained in graphical or tabulated form, divided over individual causes. The result will indicate to the mill manager any defects in the organisation.

Only when an exact picture of the development, nature and extent of the various stops is obtained through daily analyses of the tabulated information is it possible to reduce these to a minimum and increase the profits of the business. The means to attaining this end is the centralograph diagram and the application of time studies.

Control of Rotary Printing Machines

Exact control of printing machines constitutes one of the most difficult problems in a cotton mill. It has, however, been entirely solved by applying the centralograph system. The working time of printing machines is divided into running or printing time and fitting or stopping time. In most printing departments one must reckon with a total stopping time of 20 to 40 % of the total working time, or up to 50—60 % if multicolour printing is used; it is thus evident that a decrease of this percentage is of great importance. To bring about such a decrease it is, however, necessary to possess exact knowledge of the progress of the work, such as is obtained through the centralograph.

On printing machines the contact devices are fitted on the feed rollers, which rotate only when material passes through the machine. No centralograph registration will therefore be made, should the machine be running empty.

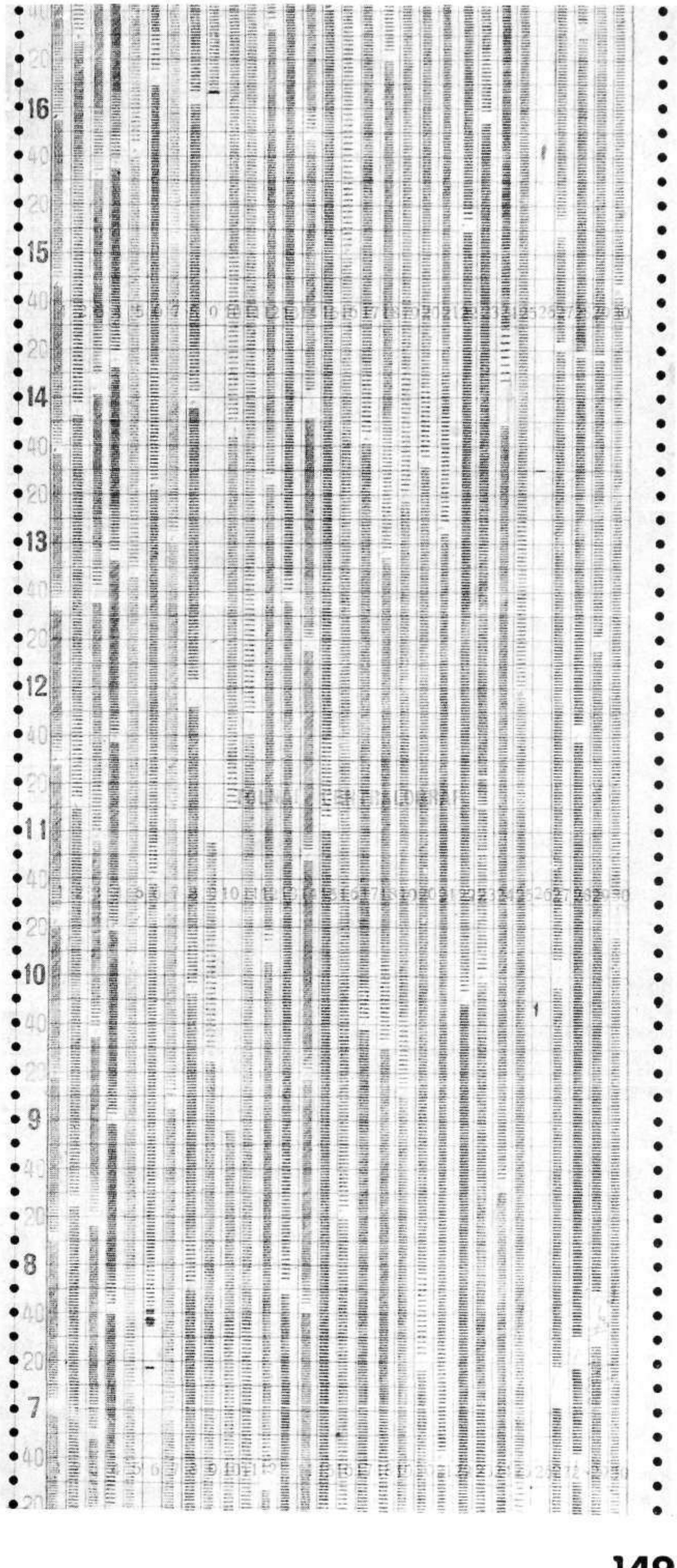

Fig. 5 X 5395
Centralograph diagram
showing the working of ring-spinning frames

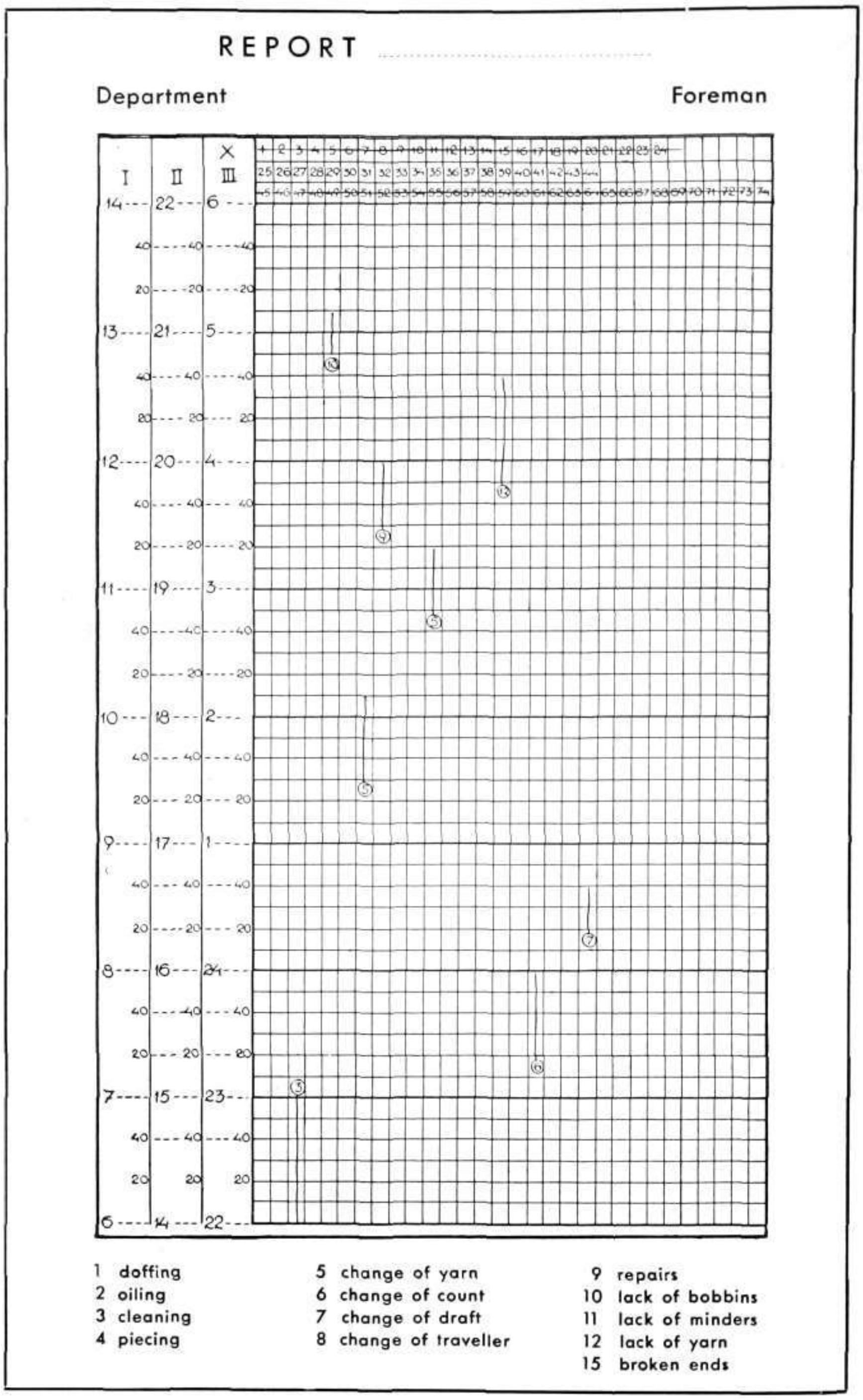

Fig. 6 X 5394

Report forms

stoppages of the different machines are marked in the columns of the respective machines, the reason for each stop being indicated by a reference letter

Fig. 7 X 3757

Bonus for the doffing gang

as function of the ratio real time to average time

Running Control

The density of the diagram gives an indication of the running speed of the machines, whereby it can be ascertained if they have been working at the prescribed speed.

Stoppage Control

The stoppages which occur on printing machines can be detailed as change of one or several colours, change of one or several rollers, insertion of new material, change of the printing order of the different colours, change of the colour scraper, etc. To ascertain these times it is necessary to calculate their normal duration, which is a somewhat complicated matter. In an eight-colour machine, *e. g.*, the material first printed with five rollers, and afterwards the pattern printed with seven rollers. The number

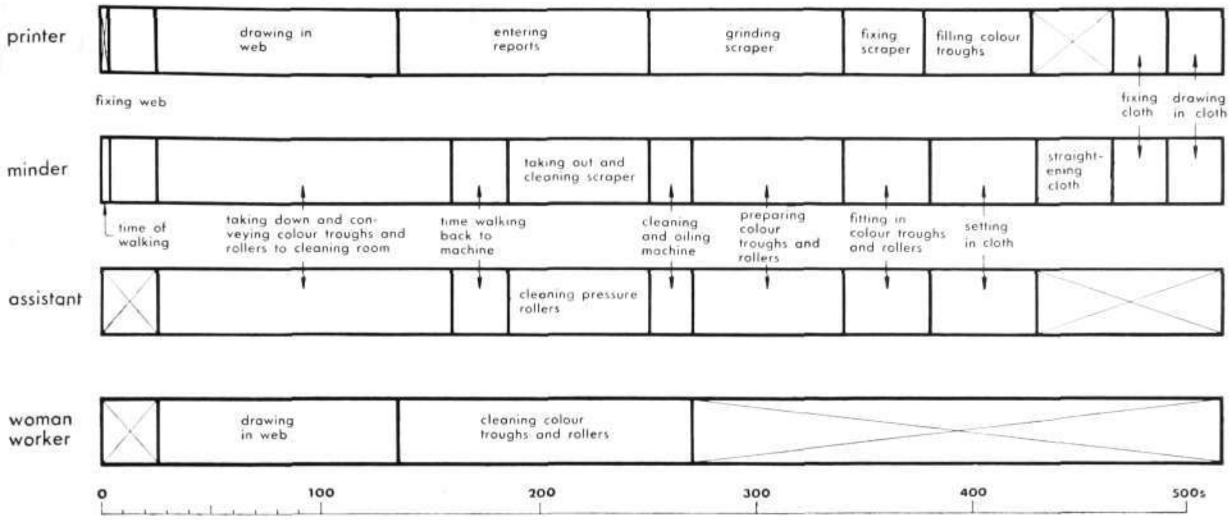

Fig. 8 X 7143

Graphic illustration of the average time

of changing from one colour to another

of combinations is therefore the square of the number of colours; in a twelve-colour machine, *e. g.*, 144 normal times for colour change and 144 for roller change would have to be calculated to cover all possibilities. This work appears at first to be rather formidable, but once these normal figures are established they provide for the future a very valuable aid.

A further complication in connection with the determination of the normal times for these operations is that they are carried out simultaneously by several persons (printers and assistants). The most practical method is therefore to ascertain all normal times graphically, see Fig. 8. After fixing the normal times for all combinations, a bonus system on the basis of the relation between actual time and normal time can be introduced for the printers and their assistants. The printers should fill in report forms on the same lines as those used in the spinning department, giving the duration of stoppages and the reasons.

The further reasons occurring for stoppages on printing machines, such as waiting for material, colours and rollers, repairs to rollers etc. should be classified and arranged graphically or in tabulated form as described in connection with the ring-spinning frames. By means of this control, made possible by the centralograph, the efficiency of the printing machines can be increased to a surprising degree.

Use of the Duration Meter at a Small Electricity Plant

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A consumer of electrical energy who buys his power according to an excess-supply tariff has in the duration meter an excellent means of determining the most favourable subscription limit. The following article gives the experience obtained by a small municipal electricity plant after one and a half years' use of a duration meter for this purpose.

The electricity plant in question distributes energy to subscribers living in a town in the neighbourhood of Stockholm, but it does not produce any energy of its own, all energy being bought from the network of the State over its substation. From there 50 c/s three phase energy is transmitted at 3 300 V to twenty-two transformer stations where the voltage is transformed to 220 V, the energy being afterwards distributed through an overhead line of 220/127 V. The high-tension line has a total length of about 18 km which is quite considerable compared with the low number of subscribers, not quite 200, but it is explained to a certain extent by the unfavourable position of the town on both sides of a lake. Most of the subscribers are cottage owners but there are also a few industrial enterprises, a flour mill and a few retail tradesman. There are further a dozen electrified farms and quite a number of the many gardeners of the town have electrically driven irrigation. Electric cooking has not yet been introduced to any great extent, but the subscribers show a distinct tendency to utilize the comparatively low prices of the current, viz: 0.09 Kr./kWh during the eight winter months and 0.045 kr./kWh during the summer (May—August), for household purposes.

On account of the character of the consumption the electricity plant has purchased the energy according to what is known as the »rural tariff», *i. e.*, an excess-supply tariff, to which comes a fixed charge of kr. 2:— per tariff unit. From January 1, 1936, the charges were:

for base power	175 Kr./kW/year
for excess power	
during the period January 1—April 30 and	
September 1—December 31	
below 10 kWh, per tariff unit	0.07 Kr./kWh
above 10 kWh, per tariff unit	0.05 Kr./kWh
during the time May 1—August 31	0.035 Kr./kWh

By tariff unit is understood in the case of agricultural subscribers the number of hectares of soil under cultivation and in the case of purely residential subscribers the number of rooms including kitchen. The number of tariff units for which the electricity plant pays a fixed price is about 2 000; as the total overconsumption during the eight winter months is considerably above 20 000 kWh, one may reckon with a charge for the current of 0.05 Kr. during the winter and transfer the additional price of 0.02 Kr./kWh for the above-mentioned 20 000 kWh to the fixed charge which is then increased to Kr. 2.20 per tariff unit. Thus, the base power will cost 175 Kr./kW/year, while the excess power costs 0.05 Kr./kWh during the winter and 0.035 Kr./kWh during the summer. The problem of the electricity plant is then to find the subscription limit for the base power which gives the lowest possible cost for the electrical energy purchased.

Fig. 1 X 3759

Duration-metering installation

from left to right: above duration meter, maximum impulse counter; below impulse transmitter, rectifier and programme clock

A problem of this kind is solved in the easiest and most correct way by studying the *duration curve* of the installation. By the duration of a load is understood the total time during which the load in question has been equalled or exceeded;

if a graphical compilation of the durations of all loads occurring in a certain plant is made and the charges are arranged according to their magnitude without taking into consideration the actual chronological succession a duration curve is obtained which gives a very clear and easily interpretable form and image of the magnitude and variation of the load during a certain period, e. g., a month, a half-year or a year. The management of the electricity plant decided therefore to obtain information as to the duration curve of the plant for which purpose they procured an installation for duration metering; this installation consists of a duration meter, a maximum impulse counter, a programme clock, a rectifier and a master electricity meter with impulse contacts, all fitted on the front of a black polished oak panel, Fig. 1. The terminal blocks are at the back of the panel and are easily accessible when this latter is swung out.

In October 1935 this installation was mounted in the substation and connected to the current and voltage transformers of the power supply, see diagram, Fig. 2. In series with the demand limit meter *6* of the power supplier which is used as an accounting meter for the consumer there is connected an Ericsson three-phase meter *5*, Type T2, for 3 300/110 V, 3 × 30/5 A, 50 c/s, containing impulse contacts which transmit the load values to the duration meter and the maximum impulse counter. The impulse contacts could, of course, have been incorporated in the existing demand-limit meter, but this method has been avoided partly because it would then have been necessary to take down the meter and send it to the works for reconstruction — a comparatively long and quite expensive procedure — partly because the meter would after this alteration have required a careful re-adjustment and calibration. By using as master meter the Ericsson meter, Type T2, originally designed to include impulse contacts there is saving of work, time and money and moreover the advantage is gained that the error of the existing meter once adjusted is not altered. The installation contains also a rectifier *4* for feeding the operating magnets of the duration meter, which are made for DC. The rectifier can without inconvenience be connected to an existing voltage transformer, and this was done in the present case.

Duration Meter

The Ericsson duration meter, Type VM1, Fig. 3, consists of twelve counters, driven by a quite complicated mechanism which will be described here only

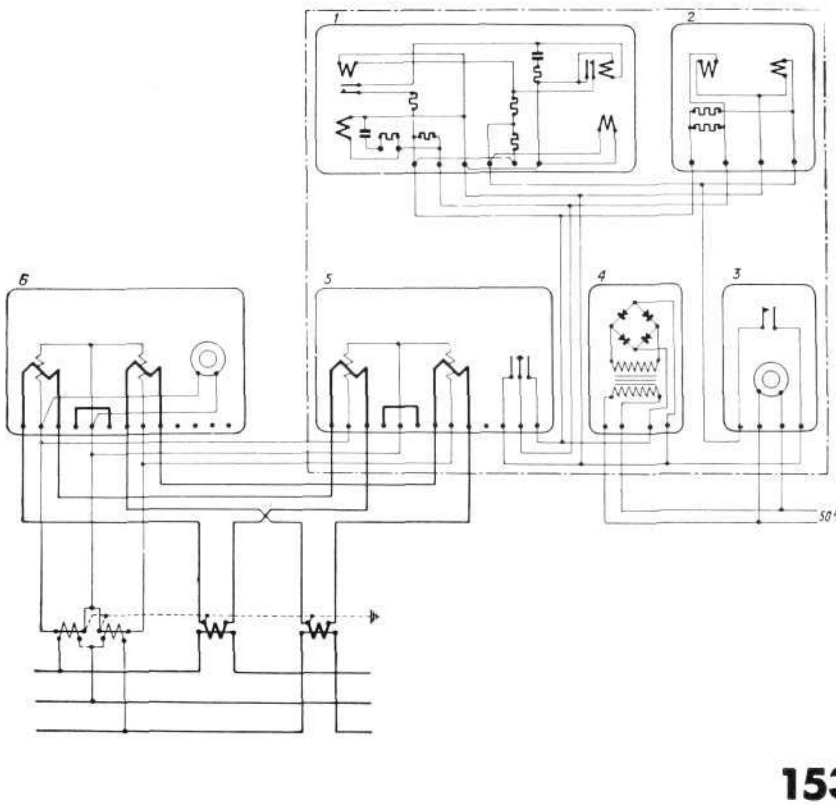


Fig. 2 X 5397

Diagram of duration-metering installation

1 duration meter
2 maximum impulse counter
3 programme clock
4 rectifier
5 impulse transmitter (three-phase kWh meter)
6 accounting meter (limit-demand meter)

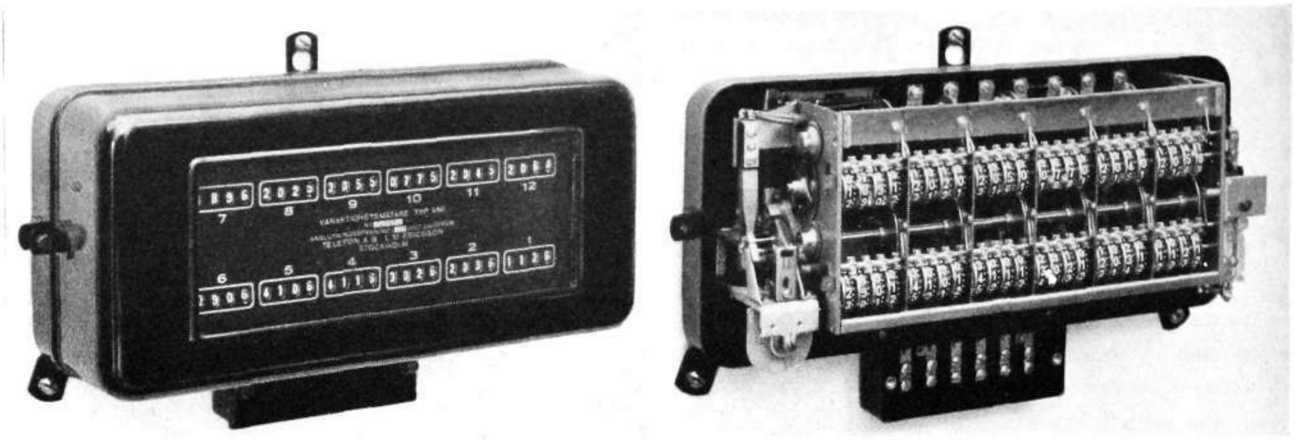


Fig. 3 X 7119
Duration meter
left with cover, right without

in so far as is necessary for a correct comprehension of the metering process. One of the counter shafts of the master meter *5* supports an impulse contact driven by the meter in the way shown diagramatically, Fig. 4. During the progress of the meter the impulse contact emits impulses to the duration meter, each impulse corresponding to a certain number of kWh, determined by the number of revolutions of the counter shaft per kWh and by the number of teeth on the gear-wheel of the impulse contact. These impulses, or primary impulses, are collected and stored by a mechanism in the duration meter, called the impulse collector. After this latter has received a certain number of impulses, which may be adjusted to suit different service conditions, it emits in its turn a secondary impulse which is registered by counter No 1 of the duration meter. The next secondary impulse actuates the counter No 2, the next counter No 3 and so on. After a certain time, or registering period, the contacts of the programme clock *3* are closed, and the impulse collector returns to home position. The next secondary impulse emitted by the impulse collector will thus actuate counter No 1 anew. The number of counters actuated during a registering period thus depends on the speed with which the secondary impulses are emitted, *i. e.* the magnitude of the load in kW.

In the above case the master meter was emitting a primary impulse for each 0.4 kWh metered energy; a secondary impulse corresponded to four primary impulses and the registering period was 15 min. If the duration meter has during a registering period emitted only one secondary impulse, the energy consumed in the same time in the installation has been $4.0 \cdot 4 = 1.6$ kWh. The mean load during the same time has thus been $\frac{60}{15} \cdot 1.6 = 6.4$ kW. On the other hand, if, *e. g.*, 5 secondary impulses have been sent out during the registering period, this would signify that $5 \cdot 1.6 = 8$ kWh have been consumed during the period at a mean load of $5 \cdot 6.4 = 32$ kW.

It has been mentioned before that a counter cannot be actuated more than once during the same 15 min. period and that the higher the load the more counters move one step forward. The relation between the number of counters actuated and the magnitude of the load is the following, *viz.*, that counter No 1 registers at 6.4 kW mean load, counter No 5 at $5 \cdot 6.4$ kW etc. Thus if counter No 5 is read after, *e. g.*, one month, it will be found during how many quarter hours the mean load has been equal to or greater than 32 kW. Counter No n thus indicates how long, expressed in registering periods, the load has been at least $nab \frac{60}{t}$ kW where a is the number of primary impulses per secondary impulse, b the number of kWh per primary impulse and t the duration of the registering period in min.

In other words the twelve counters of the meter indicate the duration of their respective loads, the load corresponding to each counter being equal to the load of the first counter, multiplied by the sequence number of the counter. The 12 readings of the duration meter make it possible to draw a duration curve. In the present case there are evidently obtained the durations for the

Fig. 4 X 3760
Contact device of the duration meter

12 loads, *viz.*, 6.4, 12.8, 19.2 .... 64.0, 70.4 and 76.8 kW. A thirteenth value which can always be obtained, *viz.*, for the load zero, is the total time covered by the investigation, and a fourteenth value, corresponding to the maximum load having the duration 15 min, are obtained by means of the above-mentioned maximum impulse counter *2*. This latter registers all the primary impulses emitted during a quarter of an hour, in such a way that the counter stops at the highest numerical value attained during the quarter of an hour in question. Thus, if the counter has during a certain quarter of an hour received 49 impulses, the figures will not be altered if the next quarter of an hour only gives, *e. g.*, 45 impulses; but if at a later moment the load should attain a value corresponding to 56 impulses, the counter will move forward seven steps, corresponding to the new maximum value. The counter thus only replaces a maximum-demand indicator and should be used when such an indicator is not included in the normal equipment of the installation.

Calculation of the Subscription Limit

As mentioned before, the installation was put in service in October, 1935, and the duration meter was at the beginning read off each fortnight. However, it was soon found sufficient to take a reading each month. In this case it was agreed that the power supplier should simultaneously with the monthly reading of the accounting meter also read the duration meter and communicate the result to the electricity plant. Along with each reading the following data were also furnished: the serial number of the duration meter; day and hour for the reading; positions of the 12 counters; position of the master meter; registering of the maximum meter; duration of the registering period. The values read were subsequently arranged in a table, *e. g.*, according to Fig. 5. The table is made up from the bottom to facilitate the subtraction between two successive counter values.

Thereafter a curve was drawn for each reading on the basis of the values obtained from the table, see Fig. 6 a which shows the duration curve for June 1936. The curve shows among other things that the constant load (no-load losses and base consumption) was about 7.5 kW, that the maximum load was 77.5 kW and that the load curve has fallen quite rapidly so that, *e. g.*, the load during half of the period, 350 h, did not exceed 26 kW. The total energy consumed during the period investigated may be obtained by planimetering the area bounded by the axes and the duration curve; the value obtained in this manner conforms very well, if the curve is accurately drawn, with the value shown by the master meter. Fig. 6 b shows the duration curve of the same electricity plant for December, 1936, and it is evident how much more ample

Fig. 5
Table of the duration-meter readings

counters			*1*			*2*			*3*		
kW			6.4			12.8			19.2		
date	time	period h	position	quarter hours	hours	position	quarter hours	hours	position	quarter hours	hours
28/12	11.00	674	2 398	2 688	672	7 069	2 342	585.50	1 432	2 098	524.50
30/11	9.00	767.75	9 710	3 057	764.25	4 727	2 472	618	9 334	2 307	576.75
29/10	9.15	720.50	6 653	3 839	709.75	2 255	2 161	540.25	7 027	1 946	486.50
29/9	8.45	768.50	3 814	3 074	768.50	94	2 393	598.25	5 081	2 031	507.75
28/8	8.15	669.75	740	2 020	505	7 703	1 735	433.75	3 050	1 449	362.25
31/7	10.30	817.50	8 720	3 269	817.25	5 968	2 591	647.75	1 601	2 232	558
27/6	9.00	696.50	5 451	2 780	695	3 377	2 262	565.50	9 369	1 892	473
29/5	8.30	744	2 671	2 974	743.50	1 115	2 497	624.25	7 477	2 032	508
28/4	8.30	697	9 697	2 788	697	8 618	2 300	575	5 445	1 902	475.50
30/3	7.30	712.50	6 909	2 828	707	6 318	2 347	586.75	3 543	2 022	505.50
29/2	15.00	—	4 081	—	—	3 971	—	—	1 521	—	—

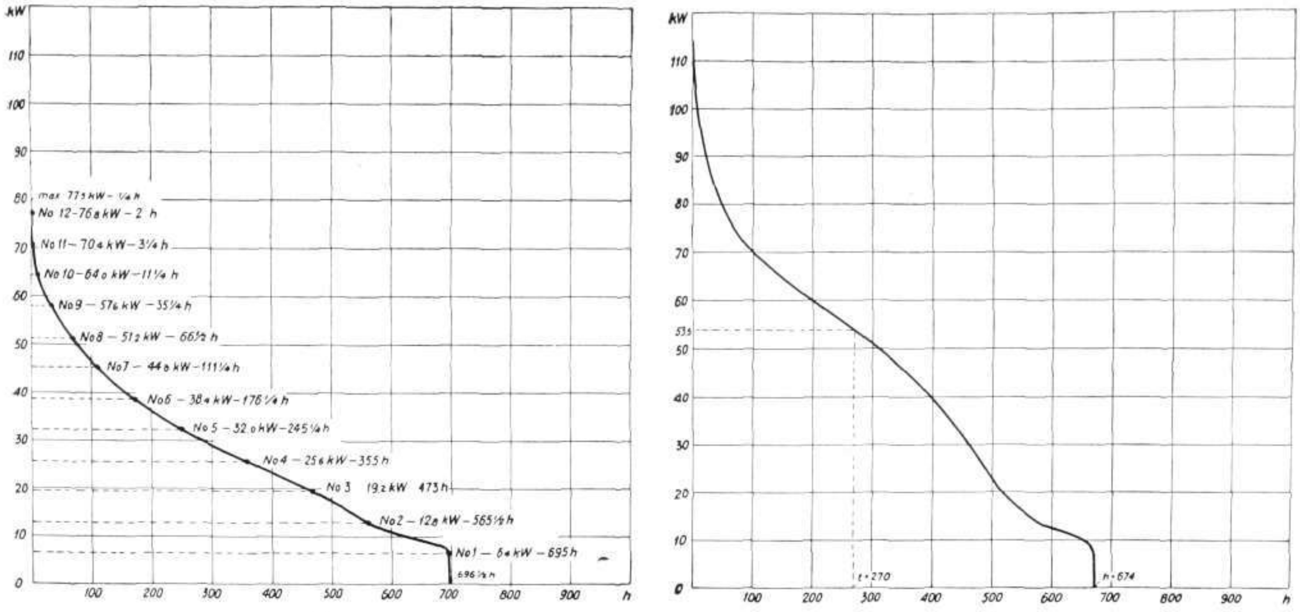


Fig. 6
Duration curves
a June 1936
b December 1936

X 1566
X 1567

this curve is in comparison with the curve from June. During half the time this load amounted to 47 kW. While the constant load has been nearly constant, a peak of 115 kW has arisen and the load has during not less than 60 h been higher than the highest load occurring in June.

For the calculation of the subscription limit giving minimum cost we introduce the following designations:

P = total cost of the power during the period investigated, in S. Kr.,
P_1 = cost of base power in Kr./kW/year,
p_2 = charge for excess power in Kr./kWh,
A_2 = excess consumption in kWh,
T = duration of the period investigated in h,
y = subscribed input in kW,
t = duration of this input in h.

If the duration of the period investigated is one year and P thus represents the yearly cost of the power, we obtain

$$P = P_1 y + p_2 A_2$$

If the period investigated only comprises part of the year, *i. e.*, T h, we obtain instead the equation, considering that one year has 8 760 h

$$P = P_1 \cdot y \cdot \frac{T}{8760} + p_2 A_2$$

Derivating this equation we obtain, see Fig. 7

$$\frac{dP}{dy} = \frac{P_1 T}{8760} + p_2 \frac{dA_2}{dy}$$

The condition for P giving minimum cost is $\frac{dP}{dy} = 0$

thus $$\frac{P_1 T}{8760} = -p_2 \frac{dA_2}{dy}$$

but $$t\, dy = -dA_2$$

then $$\frac{P_1 T}{8760} = p_2 t$$

or $$t = \frac{P_1 T}{8760\, p_2}.$$

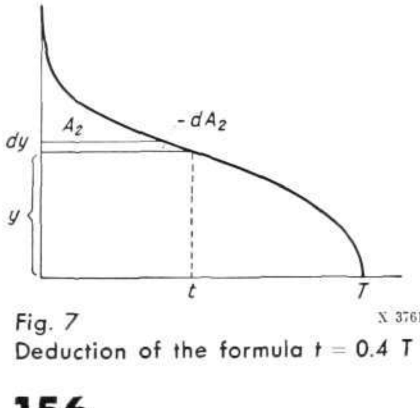


Fig. 7
Deduction of the formula $t = 0.4\ T$

X 3761

If the actual values for the winter season are inserted in this equation we obtain

$$t = \frac{175\ T}{8760 \cdot 0.05}$$

or

$$t = 0.4\ T$$

Applying this result to the curve, Fig. 6 b, which comprises 674 h, we obtain $t = 270$ h. The curve shows that the input the duration of which is 270 h amounts to 53.5 kW. If the subscription had only comprised December, 1936, the subscription limit could have conveniently been placed at 53.5 kW. However, subscriptions are generally entered per half year, beginning on January 1 or July 1 and it is therefore necessary to evaluate the probable optimum subscription limit for the next half year on the basis of the duration curve of the preceding half year. A difficulty then arises, *viz.*, that p_2 has one value 0.05 Kr. for four months and another, *viz.*, 0.035 Kr. for the other two months.

We will first investigate this question theoretically and then insert the actual figures in the formula obtained. We suppose that a duration curve has been drawn for the four winter months and another for all the six months, see Fig. 8. The area enclosed between the curves evidently represents the consumption during the summer months. Put

p_2 = winter charge in Kr./kWh,
p_3 = summer charge in Kr./kWh,
A_2 = excess consumption during the winter in kWh,
A_3 = excess consumption during the summer in kWh,

obtaining

$$P = \frac{P_1 T}{8760} y + p_2 A_2 + P_3 A_3$$

which gives by derivation

$$\frac{dP}{dy} = \frac{P_1 T}{8760} + p_2 \frac{dA_2}{dy} + p_3 \frac{dA_3}{dy}$$

At minimum costs we have $\frac{dP}{dy} = 0$ and then

$$\frac{P_1 T}{8760} = - p_2 \frac{dA_2}{dy} - p_3 \frac{dA_3}{dy}$$

From Fig. 8 is evident that

$$-dA_2 = t_2\, dy$$

and

$$-dA_3 - t_3\, dy$$

where t_2 and t_3 are the durations of the optimal subscription limit for a half year during the four winter months and the two summer months respectively. We further obtain

$$\frac{P_1 T}{8760} = p_2 t_2 + p_3 t_3$$

Inserting the actual figures we obtain

$$\frac{175\ T}{8760} = 0.05\ t_2 + 0.035\ t_3 \qquad (5)$$

or

$$0.4\ T - t_2 + 0.7\ t_3 \qquad (6)$$

This shows that the subscription limit required is situated at the load having a duration of 0.4 T h in a corrected duration curve, where the duration of each load corresponds to the total duration of this load during the four winter months augmented by 70 % of its duration for the two summer months.

X 3762

Fig. 8
Deduction of the formula $t_2 + 0.7\ t_3 = 0.4\ T$

Such a corrected duration curve has been designed for the first half of 1937, assembling first the values of the table, Fig. 5, in the way shown Fig. 9. Subsequently the duration curves for the periods January—April and January—

June were drawn, which gave an image of the actual distribution of the load, see Fig. 10. As T was 4 366.25 h in this case, 0.4 T had the value 1 746.5 and this time coordinate was drawn in the diagram. It is then evident that the limit required must be situated somewhere between the fifth and sixth counters and it is then only necessary to calculate the »reduced» values for counters No 5 and No 6, adding also No 4 and No 7 to obtain the correct form of the curve. From the table, Fig. 9, the following values are obtained

duration	counters			
	4	5	6	7
t_3	764.25	551.75	374.5	232
$0.7\ t_3$	535	386.25	262.25	162.5
t_2	1 819.5	1 617.25	1 380.5	1 072.25
$t_2 + 0.7\ t_3$	2 354.5	2 003.5	1 642.75	1 234.75

On the basis of these values part of the reduced curve was introduced in the diagram and was found to bisect the time coordinate 1 746.5 at an input value of 37 kW. Thus, the power charge would have been a minimum for the electricity plant, had this latter subscribed to a base power of 37 kW during the first part of 1936. Of course, it could not be predicted with certainty how the consumption would fluctuate during the latter part of the year but as the circumstances indicated in this special case that the both halves of the year would have about the same duration curve the electricity plant subscribed to the value found, *i. e.*, 37 kW. It was also found at the end of the year that the limit had been correctly chosen, see Fig. 10 b. In this assembly curve for the last half of 1936 the duration curve for the summer months has been drawn in first and the curve for the winter months added later. The reduced curve is drawn as before on the basis of the last equation, which is divided by 0.7, and may thus be written

$$\frac{4}{7} T = t_3 + \frac{10}{7} t_2$$

As T in this case was 4 418.25 h and $\frac{4}{7}\ T$ was thus 2 525 h the optimum subscription limit passes through the intersection between the time coordinate 2 525 h and a duration curve where all values of the actual half-year curve have been increased by $\frac{3}{7}$ of the actual winter values. The result conforms very well as may be seen with the limit valid for the first half of the year.

Fig. 9
Compilation of the duration-meter readings

counter		1	2	3	4	5	6	7	8	9	10	11	12
kW		6.4	12.8	19.2	25.6	32	38.4	44.8	51.2	57.6	64	70.4	76.8
month	total time h	readings h											
January	670	654.25	563	507.25	467.25	424	379.50	319	248.25	164.25	99.50	56	32.75
February	846.25	831.75	630.25	528	482.25	432.50	360	279.75	192.25	124.50	64	35.50	18
March	712.50	707	586.75	505.50	449	393.75	333.25	258.25	137.75	59	31.75	17.75	12
April	697	697	575	475.50	421	367	307.75	215.25	122	59.75	31	14.25	5.50
January—April	2 925.75	2 890	2 355	2 016.25	1 819.50	1 617.25	1 380.50	1 072.25	700.25	407.50	226.25	123.50	68.25
May	744	743.50	624.25	508	409.25	306.50	198.25	120.75	77.25	45.50	20.25	9.75	3.75
June	696.50	695	565.50	473	355	245.25	176.25	111.25	66.50	35.25	11.25	3.25	0.50
May—June	1 440.50	1 438.50	1 189.75	981	764.25	551.75	374.50	232	143.75	80.75	31.50	13	4.25
January—June	4 366.25	4 328.50	3 544.75	2 997.25	2 583.75	2 169	1 755	1 304.25	844	488.25	257.25	136.50	72.50

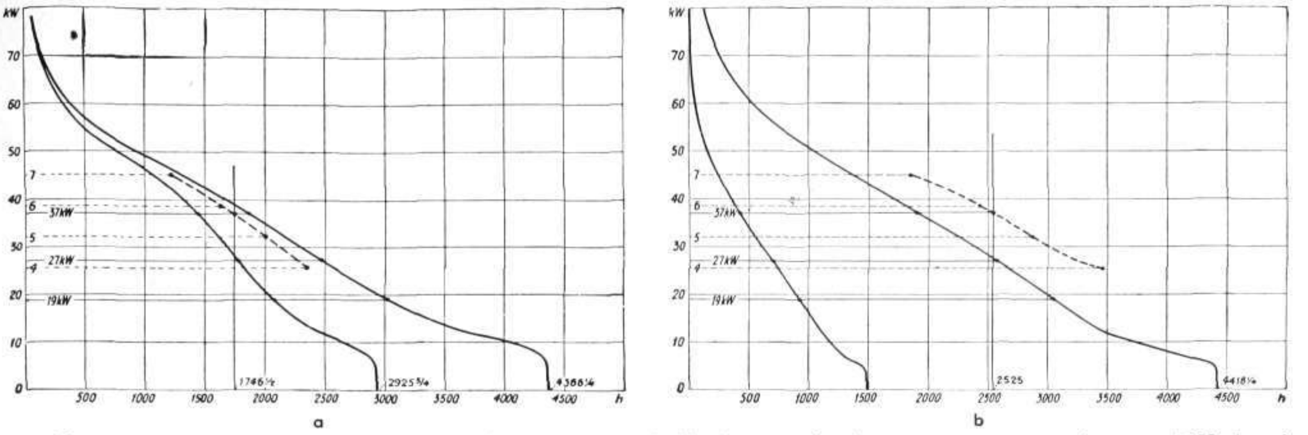


Fig. 10

Duration curves

a January—April and January—July
b July—August and July—December
--- reduced duration curve

X 1569
X 1568

During the latter half of 1935 the base power amounted to 19 kW, but it seems that this was far too low a subscription limit, considering the curves obtained for the months October—December. However, as the influence of the summer months could not be evaluated, it was decided that the subscription should not be increased beyond 27 kW for the first half of 1936. Eventually, for the next half-year this figure was increased to 37 kW.

Calculation of the Profit

On basis of the diagrams, Fig. 10, it is possible to calculate with a quite considerable accuracy the profit made by the electricity plant by altering the subscription limit. With the scale chosen for drawing both half-year diagrams 1 mm^2 corresponded to 10 kWh, and it was then only necessary to calculate the area comprised between the different output zones. Considering the curve for the first half-year 1936, Fig. 10 a, it is evident that if the subscription limit had remained at 19 kW the entire part of the power consumption comprised between 19 and 27 kW would have been registered on the surplus counter of the demand-limit meter. This consumption, counted in area according to the diagram and without claiming absolute precision, amounted during the winter months to 1 536 mm^2 and during the summer months to 656 mm^2. The cost of the excess power would thus have been increased by

$$1536 \cdot 10 \cdot 0.05 + 656 \cdot 10 \cdot 0.035 \cong 1\,000 \text{ Kr.}$$

By increasing the limit by 8 kW from 19 to 27 kW the electricity plant has thus saved 1 000 Kr. in excess power, but had to pay instead an increased charge for the base power, with $\frac{1}{2} \cdot 8 \cdot 175 = 700$ Kr. The net gain is thus 300 Kr. for the first half-year. If the limit had immediately been increased to 37 kW there would have been realized a further gain of

$$1\,620 \cdot 10 \cdot 0.05 + 570 \cdot 10 \cdot 0.035 - \frac{1}{2} \cdot 10 \times 175 \cong 130 \text{ Kr.}$$

In the same manner it is found from the curve, Fig. 10 b, that the gain during the second half of the year through increase of the subscription limit to 37 kW instead of 27 or 19 kW amounted to 160 and 495 Kr. respectively. The total gain for the electricity works during the whole year would thus have been 925 Kr. if the limit had been at 37 kW right from the beginning instead of at 19 kW.

However, it has to be admitted that the whole of this gain cannot be attributed to the duration meter, as there are approximate methods which allow an experienced and attentive observer of load conditions to evaluate whereabouts the subscription limit should be situated and it is therefore probable that the limit would have been increased even without the duration meter. However, the advantage with the duration meter is that it permits its user to obtain knowledge about the actual duration curve, which renders him independent of schematic standard curves which can only give approximate average values. It also eliminates all suspicion on the part of the customer, who is generally not very experienced in these questions, that the power seller is not judging the problem in a sufficiently unbiassed manner. The duration meter thus facilitates co-operation between seller and buyer and in this way serves both parties.

Mining Telephones

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

In Great Britain the use of telephones in coal mines is governed by the statutory orders and regulations made by the Mines Department under the Coal Mines Act of 1911. By these regulations telephone communication is compulsory between the end of the haulage road and the pit bottom and the surface where the distance of the main haulage from the shaft exceeds 1 000 yards. The telephone is however an essential to efficient working in the modern pit and most pits have a complete system. The range of efficient yet safe equipment available to-day encourages the industry to obtain the ful advantages of telephony, rather than to restrict to the statutory obligations.

Principle

There are two distinct systems of mine communication, the flameproof, usually designated »FLP» and the intrinsically safe, generally referred to in the industry as »certified». Instruments and apparatus of a type certified by the Mines Department as safe are marked in a distinctive manner. Flameproof instruments bear on the case the letters »FLP» enclosed in a crown, with the certificate number underneath. Intrinsically safe apparatus bears a label with the name and type number followed by the words »certified by the Mines Department» and the date of the certificate. Where the apparatus is approved for use on either system, both methods of marking are employed.

The two systems are quite distinct in the means of preventing sparks from causing ignitions of firedamp. The *flameproof* method is so to enclose the places where sparking may occur that any flame which may result from ignition of the enclosed gas mixture — methane and air — either cannot pass to the outside atmosphere or is so cooled on its passage to the exterior that it cannot produce ignition of the most sensitive surrounding methane atmosphere. The usual means are to provide wide machined flanges for cooling, to limit unoccupied internal space and to attend specially to strength of materials and construction. All apparatus must be flameproof and the lines fully insulated armoured cable led into the apparatus via sealing glands. Good maintenance is an essential, as damage to casework, incorrect re-fitting of flanged joints or a line fault immediately introduces the element of risk. Flameproof enclosure of instruments does not preclude incendive sparking elsewhere and is useless, therefore, as a safeguard on bare-wire circuits.

The *intrinsically safe* method is to incorporate a safety device in each instrument and so provide an alternative path for part of the energy that otherwise would be concentrated in the spark. If necessary a limitation is also placed on the amount of current that can pass. Thus if an electrical spark occurs, inside or outside the apparatus, whether in normal working or as a result of any fault in the wiring system then ignition cannot occur. Bare-wire signalling is common in pits and, where signalling and telephones are associated, the intrinsically safe system is indicated. Automatic and other central-battery systems are not available in the intrinsically safe class. Battery power is limited to a maximum of 25 V and for intrinsic safety to the 3-pint Leclenché cell or its certified equivalent, and the precautions against incendive sparking make reliable service impracticable. Where such systems exist on the surface and it is desired to extend them into the mine for direct operation, then flameproof instruments and armoured cable must be used.

Design

The Ericsson flameproof instruments follow the principle of placing each contact or switch point in its own flameproof enclosure. These individual enclosures allow the volume of gas enclosed to be so low that the effects of ignition can be made very small. When apparatus is surrounded by an atmosphere of explosives gas for any length of time, this gas gradually replaces the air in the internal spaces. Slow gas diffusion and movement due to temperature changes are the two means by which the dangerous gas enters the apparatus. Also when gas is present it would enter if the cover were removed for inspection. Should a spark occur within the apparatus to ignite the explosive mixture, the pressure produced is released by the passage of the burning gases through the cooling flanges. These are so designed that the heat is absorbed before the outer atmosphere is reached and there is no possibility therefore of the ignition being communicated. The efficiency of the enclosure depends to a great extent on the ratio of cooling surface to total heat generated. The small volumes of space obtained by the individual enclosures of the Ericsson instruments result in correspondingly low heat generation and explosive pressure. In addition, the total mass of cooling metal is proportionately high to the volume of possible explosive mixture.

CB and Automatic Telephones

The central-battery mining telephone, Type N 1470, and the automatic mining telephone, Type N 1087, Fig. 1, are similar in appearance, but the inner door of the CB-instrument is plain. The terminal chamber is arranged for armoured cable as standard, the sealing gland being both simple and effective. Fittings are available for screwed conduit for industrial use where that system of wiring is preferred. With this system the conduit must be taken to a sealing box outside the danger zone and sealed also at each instrument terminal chamber, to eliminate risk of flame propagation along the conduit.

The terminal chamber connections are taken directly into an isolating switch enclosure, so arranged that opening the inner door for examination of the interior disconnects the lines from the internal wiring. This is essential where the lines are always under tension. The receiver switch on the inner door has its own flanged flameproof enclosure, the bearing itself having an ade-

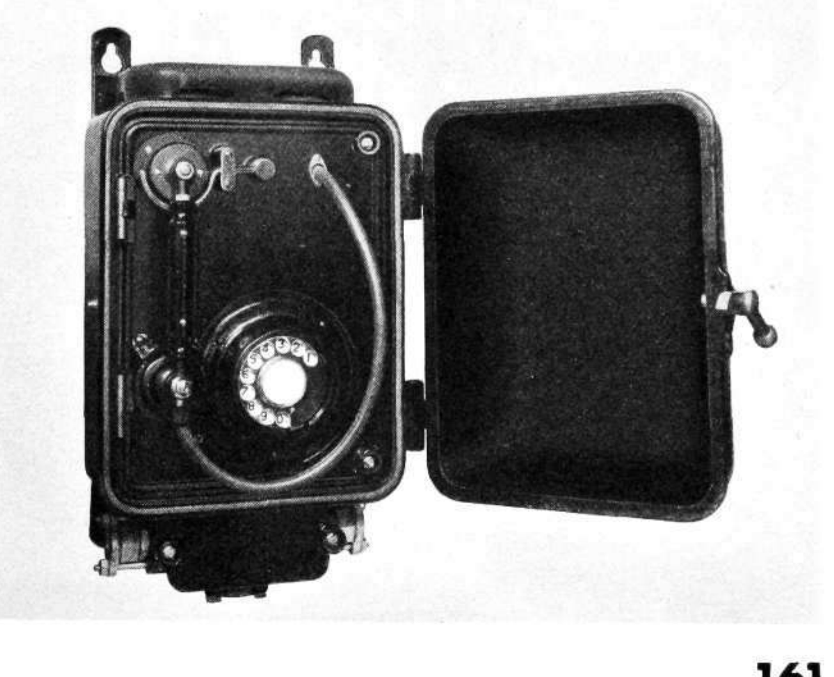


Fig. 1 X 5382
Automatic mining telephone, Type N 1087

quate flame-path. The atmosphere content of isolating and receiver switch enclosures is respectively 95 and 102 cm^3, which with the generous design affords a high factor of safety.

The dial assembly of the automatic mining telephone has the fingerplate independent of the dialling mechanism. Thus the safety of the enclosure does not depend on the light bearing shaft, but the movement is transmitted from finger-plate to mechanism by a clutch-shaft of generous proportions, coupled with a locking device which prevents damage to the dial mechanism by over-rapid dialling. Between the mechanism and the front casting carrying the flameproof bearing a gauze is inserted as a diffuser to prevent a cone of pressure being exerted upon the bearing in the event of ignition. This, while not an essential, provides an additional factor of safety of particular value where hydrogen mixtures and similar vapours are encountered. The back cover is of massive proportions and forms a spigot joint on the front housing.

Magneto Telephones

The magneto mining telephones, Type N 2974 with handmicrotelephone and Type N 2984 with receiver-arm, Fig. 2 and 3, are the original Ericsson flameproof design. The switch enclosure of the first type is the same as that of the preceding instruments, but in that of the other type the atmosphere volume has been reduced to 39 cm^3. The other point of possible incendive sparking is the hand generator cut-out, which has a special end-bearing plate and flanged cover. Here again the atmosphere content is kept low at 95 cm^3. The terminal chamber is the same as that of the previously described instruments. These two magneto instruments are certified for use on both flameproof and intrinsically safe systems, so that for a colliery group or a pit where both systems are already in use, or where a possible change-over of system is to be anticipated, the dual purpose instrument is an advantage from a stock point of view.

It might be mentioned that all four above-mentioned flameproof telephones are approved by the Mines Department for use in firedamp (methane) as well as in petrol and acetone atmosphere.

For the magneto telephone system the Ericsson intrinsically safe apparatus is throughout of the high-impedance type, so that the effects of line resistance

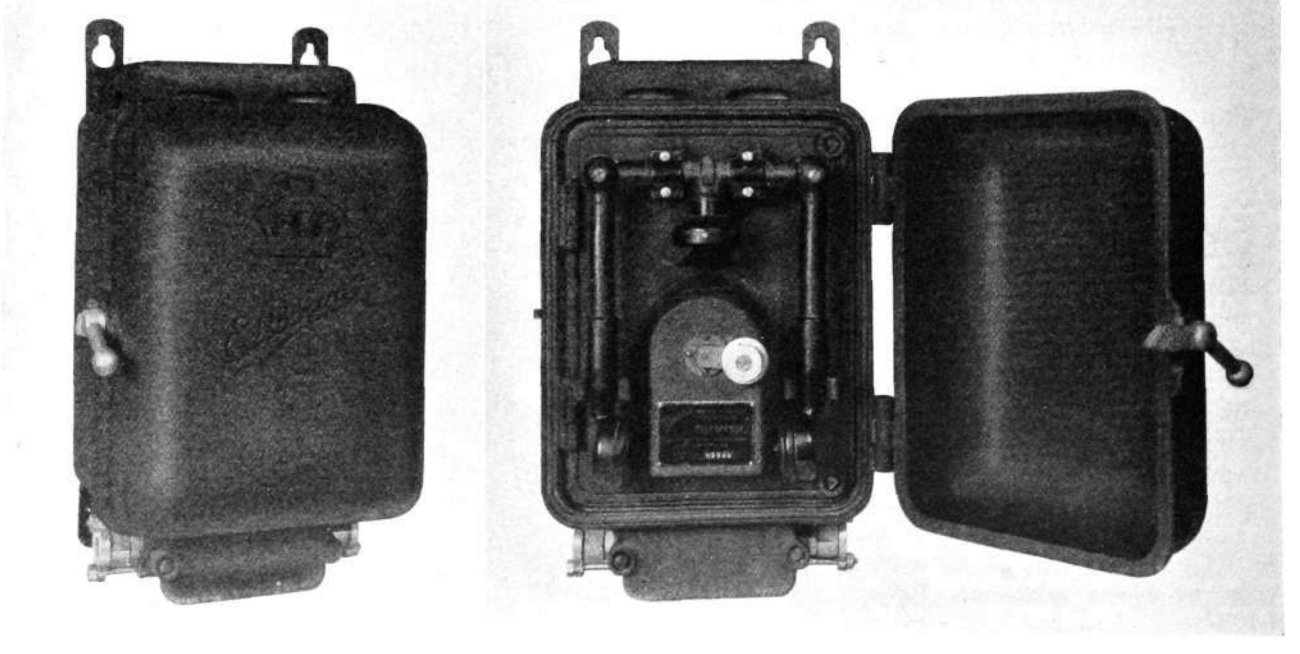


Fig. 2 X 7118
Magneto mining telephone, Type N 2984
with receiver-arm

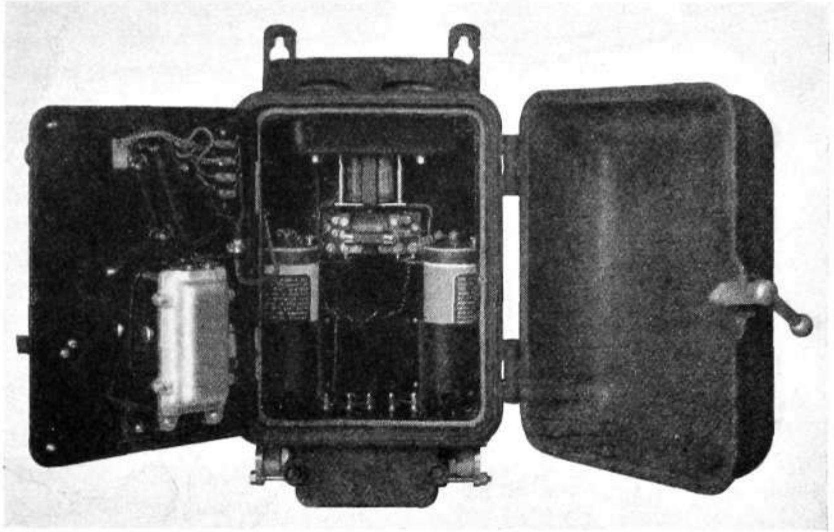


Fig. 3 X 5383
Interior of magneto mining telephone
on inner door receiver switch and magneto, inside the instrument bell with safety condenser and batteries

on the working of instruments in parallel is at a minimum and the general efficiency under adverse conditions is high. The specially designed hand generator used in the switchboards and instruments is wound strictly to turns and the two powerful magnets conform to strict limits of flux. The safety device consists of a resistance winding of 1 000 ohms superimposed on and directly connected in parallel with the nominal 300 ohm active winding. This generator has a particularly good output characteristic on varying resistance loads and compares very favourably with the lower impedance types of mining generator. Development tests have shown that this generator, even when machine driven at double speed in synchronism with and connected in parallel to a similar generator, will not ignite the most sensitive methane-air mixture, so that there is a sure margin of safety under all service conditions. This generator is used in all cases except the table telephone, where a generator of similar electrical characteristics but modified dimensions is fitted. The calling bells have 2 000 ohms DC resistance, with an impedance of the order of 7 200 ohms at 50 V, 16.6 c/s. The Mines Department devoted considerable research to the possibility of rendering various makes of apparatus safely interconnectable and found that by placing a condenser of approx. 0.01 μF across each calling bell etc., the desired object could be obtained. The condenser is of special manufacture to ensure permanence in service. All instruments are now fitted with such a safety condenser across the magneto bell, so that they can be used with any other certified types, of whatever manufacture, providing these are similarly fitted. The introduction of this small condenser has no appreciable effect on performance yet permits safe mixing of all certified types.

In manager's and officials' offices a table telephone may be preferable and there are also positions in surface offices or engines houses where the usual ironclad instrument is not essential. For such cases the table instrument, Type N 2155 D or the wall instrument, Type N 2504, certified for surface use under cover, provide a suitable alternative.

Switchboards

The most suitable type of switchboard for use in a mine is the *cordless switchboard,* which can be constructed to withstand adverse climatic conditions, dust and heavy usage. The normal working conditions of coal mines tend to much heavier and less considerate use than is generally accorded telephone equipment. The majority of switchboards in mines are only required to connect a few lines and for this purpose the small pyramid board, Type N 510, Fig. 4, is particularly suitable. The robust hardwood case has a

Fig. 4 X 3742
Mining switchboard, Type N 510
for 4 lines

sloping top reinforced by a heavy-gauge steel plate to protect from falling roof material and water. The front plate is of steel and carries the indicators under a waterproof cover furnished with a resetting knob. Beneath these, arranged in the pyramid formation from which the board takes its name, are the stout metal »push and pull» plunger keys for interconnecting the circuits.

For operating, a telephone such as Type N 2974 or N 2984 is required to be fitted alongside the switchboard. Where more lines have to be accommodated the switchboard, Type N 550, Fig. 5, is indicated; this can be arranged for from 10 to 30 lines. The connecting keys are in horizontal rows, the indicators are totally enclosed units, individually reset by push button. A calling generator and handmicrotelephone for operating are incorporated in these boards, which are usually under constant supervision and not exposed to unauthorised interference.

Where more than thirty lines are required a floor pattern *cord switchboard*, Type N 570, may be used, or if specially desired another cordless section could be placed at the side of the board, Type N 550. The cord board has enclosed, push-restored indicators for both calling and clearing and the connections are made by means of plugs, cords and keys. It accommodates equipment up to 100 lines. In practice, however, large mining switchboards are rare, and the tendency will be for them to become rarer. Mining conditions in most pits are best catered for by small switchboards, interconnected when necessary.

Coupling Unit

Where the administrative office telephone network was required to have free interconnection with the underground system, for safety all telephones had to be of certified type, and a certified switchboard at the surface was necessary. The number of tie lines to the pit might be very low compared with the surface lines connected.

By the recent introduction of the Ericsson mining telephone coupling unit a considerable advance has been made in mine communication. Hitherto

Fig. 5 X 5421
Mining switchboard, Type N 550
for 20 lines

Fig. 6 X 3744
Battery-call mining telephone, Type N 1150

intrinsically safe magneto systems could not be connected to ordinary surface systems because of the risk of dangerous energy being injected into the circuit. By a combination of series impedances with a shunt resistance composed of dry rectifier units, a protective device is obtained which has very little effect upon speech current, a small absorbtion from weak ringing currents, yet progressively absorbs energy as the danger rises. To do this, advantage is taken of the curved voltage-resistance characteristic in the forward direction of dry-plate rectifier units which are placed back to back. For low voltages of speech magnitude the shunt is of the order of a few megohms, for minimum ringing voltages the shunt becomes say 2 000—3 000 ohms or more, dropping in resistance steeply as the voltage across the pair rises. As the resistance drops the proportion of voltage drop over the series resistance increases, so that the device is to a large extent self compensating.

Calling Devices for Magneto Signalling

The extension bell, Type N 3109 D, is of the large-gong oscillating-coil type used by the British Post Office, but specially wound. The impedance is of the order of 5 000 ohms at 50 V, 16.6 c/s. A bell of similar design, Type N 3109 H, is adapted for AC working with a certified transformer from the supply mains. This is used on signalling systems in the same manner as the battery bells, but obviates the maintenance of batteries.

The indicator relay, Type N 8652, is the standard push-button restored indicator of the certified switchboard in a wood case. It is provided with a local bell contact. The relay, Type N 7236, is noteworthy as operating on the split-phase principle. The split-phase power is applied via a lever-arm and materially assists in producing a sensitive relay, suitable for use as an intermediate relay when it is wished to operate audible or visual signal, etc.

All this apparatus is of robust construction, those for use in the pit being specially finished to meet atmospheric conditions and provided with shrouded triangular tamper-proof screws to discourage unauthorised interference with working parts.

Battery-Call Telephones

All battery-call telephones, signalling bells and relays are necessarily of the intrinsically safe type, as they are primarily for use with bare-wire signalling. A flameproof bell signal system would be unduly expensive, difficult to maintain and would have no advantage over the normal system. The Mines Department only grant intrinsically safe certificates for apparatus of this class. Battery voltage is limited to a maximum of 25 V and the battery must be a standard 3-pint Leclanché cell or of a type specifically certified by the Mines Department; only one such battery per electrical circuit is permissible. This restricts the energy available within known limits. The safety devices on Ericsson instruments and switchboards consist of shunts of appropriate resistance across the active windings of bells, relays and indicators.

The speech circuits in both magneto and battery-call systems are normal LB-circuits and the amount of energy that can become available under worst fault conditions is definitely below that necessary for ignition, so that the safety devices are found associated solely with the calling apparatus. The battery-call telephone, Type N 1150, Fig. 6, is of simple and robust construction, with inset transmitter and loudspeaking type receiver associated with external flexible listening tube.

An external certified bell, Type N 3030, with a resistance of 20 or 30 ohms, or relay and bell is used for signalling. The battery-call switchboard, Type N 530, is of the same general design and mechanical construction as the magneto board, Type N 550, previously

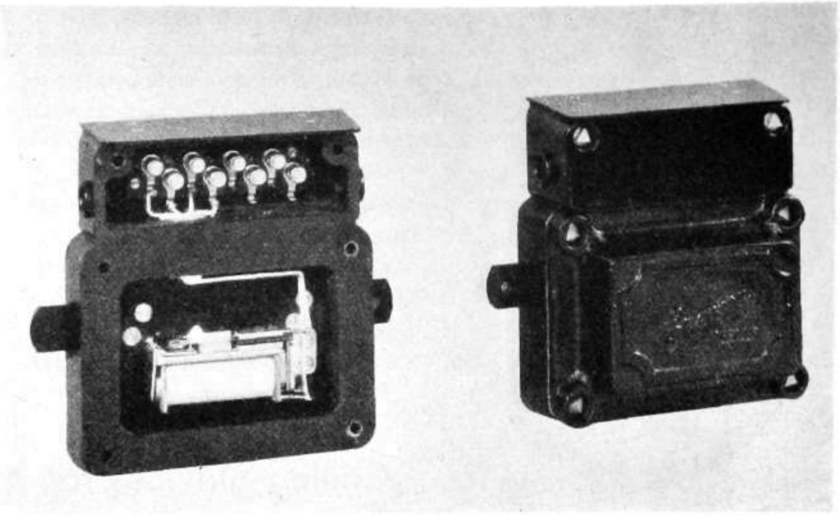


Fig. 7 X 5429
Battery-call mining telephone relay, Type N 7240

described, the electrical circuit and the indicators and relays being suitably proportioned and the generator replaced by the common signalling battery.

The relay, Type N 7240, consists of the latest type of telephone relay with integral safety resistance, mounted in a stout iron case having a watertight joint between wide machined flanges. A separate terminal chamber is provided with substantial connectors and a drip proof cover. Provision is made for from one to three sets of contacts. The same design of housing is used for the magneto-telephone relay also.

Use

The principal division of mines apparatus on the score of suitability for the service required is magneto telephone system for all general telephone communication and battery-call system for all haulage road signalling and the transmission of instructions by code rings. In small undertakings the addition of battery-call telephones to the existing bell system may be favoured, and local circumstances may make them preferable. Generally, however, the magneto system is distinctly preferable for its flexibility, reliability and high efficiency under adverse conditions of service. The range of equipment available is evidence of the popularity of the system. It may perhaps be noted that the same type of switchboard is used for both intrinsically safe and flameproof systems, but in the latter case the board must be placed out of the danger zone and provision made for terminating the armoured cable via sealing glands well outside the danger zone, and preferably at or near the board. The cost of a flameproof switchboard would in most cases be considered prohibitive and the demand negligible, while with the exception perhaps of the smallest boards it is rare that they cannot be placed in a position free from risk of gas.

The Latest British Post Office Telephone Instrument

F. ENGBLOM, ERICSSON TELEPHONES LTD, LONDON-BEESTON

The normal Ericsson telephone instrument in bakelite which was described in Ericsson Review No 1, 1933, has received a flattering recognition from the telephone administrations as well as from private enterprises of several countries on account of its attractive appearance and excellent electrical and mechanical qualities.

It was awarded a new and honourable distinction when the British Post Office adopted the table instrument as one of its standard types for automatic and manual CB systems.

The new British instruments have been designed by Ericsson Telephones Ltd in co-operation with technical departments of the British Post Office. The English instrument has the same form as the normal Ericsson instrument but is somewhat wider on account of the requirements of the British Post Office which stipulated that certain standard parts as induction coil, condenser, bell and cord connection block should be used in the new instrument, as these parts should be interchangeable with similar parts which were already stocked by the British Post Office.

The size of the instrument has also been increased on account of a telephone register or pad having been inserted in the base plate of the instrument. Access to the register is obtained by pulling out a sliding tray with a moulded knob at the front. The pad may be used as a directory for several hundred numbers and should prove a great boon to the telephone user at home or at the office for calling friends or business relations. The pad consists of a booklet with alphabetical index which may be renewed in a few seconds simply by opening a locking device. The pad is protected by a hinged metal flap on which are chemically engraved instructions for using the telephone for trunk calls etc. Between the flap and the pad there is further inserted a hinged pocket of transparent sheet material which may be used as a holder for a printed card with suitable text, *e. g.*, special numbers, long-distance rates etc.

The British Post Office has this year ordered over 350 000 instruments of this type, of which Ericsson Telephones Ltd secured the order for nearly 100 000 instruments.

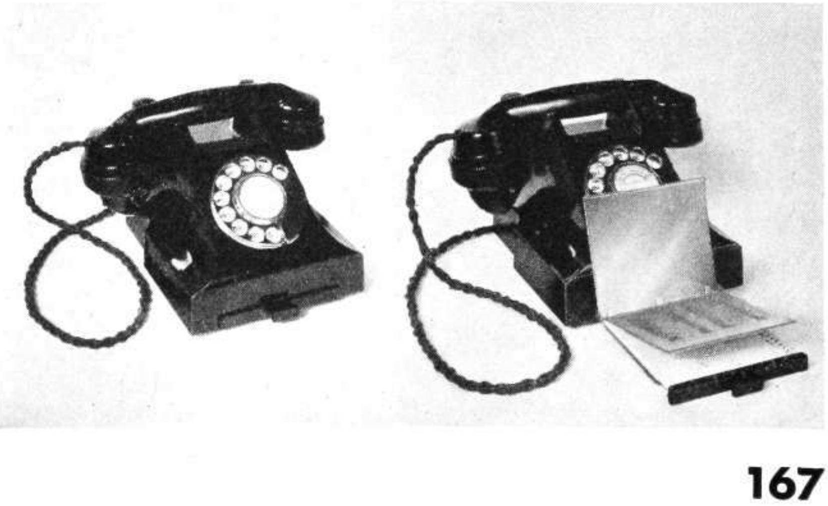


Fig. 1 X 5423
British Post Office telephone instrument
right with the register pulled out for use

New Ericsson Wireless Sets

B. ARVIDSON & C. FREDIN, SVENSKA RADIOAKTIEBOLAGET, STOCKHOLM

The construction program of Svenska Radioaktiebolaget for 1937—1938 comprises, compared with the preceding year, a greater number of types in the lower price class and a corresponding reduction in the higher one. The table models Ericsson 373 and Ericsson 375 are superheterodyne receivers of normal design while Ericsson 376 is a more developed type at a somewhat higher price. Ericsson 372 is essentially intended for local reception. One console model only, Ericsson 379, fitted with automatic record changer is manufactured. All these models are made for connection to the main AC or universal current. Ericsson 374, a long-distance receiver with short-wave band, is made for battery feed.

The development of wireless receivers is characterized this year chiefly by a general adoption of short-wave reception. During the 15 years or so which have elapsed since the favorable propagation properties of short-waves were discovered, the name short-wave has nearly always been associated with the activities of wireless transmitting amateurs. In the last three years the public also has begun to take interest in short-wave reception due partly to the steadily growing number of broadcasting transmitters in the short-wave band, partly to the sensational results attained under favourable receiving conditions. Most wireless receivers intended for long distance reception are now equipped for the short-wave band, 17—50 m, which has proved most suitable for broadcasting and in which certain bands have been allocated to this kind of transmission through international agreement. In spite of the fact that as regards frequency these bands are comparatively wide and allow ample place for many transmitters, yet they constitute an insignificant part of the whole wave-length band and the stations are actually compressed into four or five hardly more than one millimeter large zones on the dial of the wireless receivers.

It is thus not very easy to tune the receiver for a short-wave transmitter or to find a station on the dial in case no special devices are provided for it. The tuning may be considerably facilitated by a gearing between the driving knob and the tuning device and such a vernier is found nowadays on most receivers; the larger Ericsson Receiver this year has a planet gear which may be connected in when desired. However, a device which indicates in a reliable and precise manner the position of a station on the tuning dial has not ordinarily been used. A few American manufacturers and recently also European manufacturers have used for this purpose a vernier indicator which is driven from the tuning condenser shaft over a gear. Most devices of this kind have, however, the inconvenience that the indicator does not follow closely the movement of the condenser so that there is quite an appreciable play. This is of course due to the difficulty in obtaining a sufficiently good mechanical gearing at moderate cost. A solution of the problem where the moment of the tuning condenser is magnified optically is ideal as regards elimination of play.

X 3785

Fig. 1
Ericsson 379

Two of the Ericsson receivers of this year, *viz.*, Ericsson 379 and Ericsson 376, have an optical short-wave dial designed on to this principle. The movement is magnified ten times, which signifies that the apparent total length of the dial is 1.3 m. These devices makes the tuning very simple and it is further facilitated by the orthoscope which in Ericsson 379 and Ericsson 376 consists of a cathode-ray tube which gives a very distinct and extraordinarily sensitive indication of correct tuning of the broadcasting station desired.

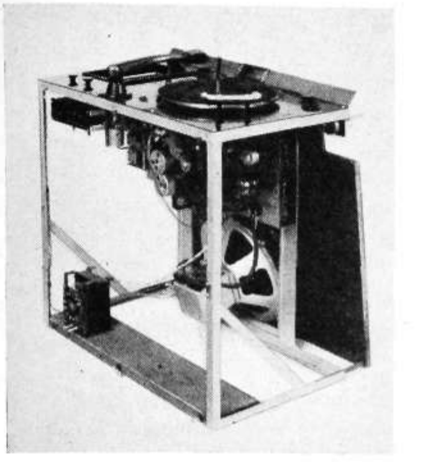


Fig. 2 X 3786
Chassis for Ericsson 379

European valves of new type with lower filament input than has hitherto been possible are used in all main-connected receivers. The input and thus also the operation cost are lower than was previously the case.

Ericsson 379

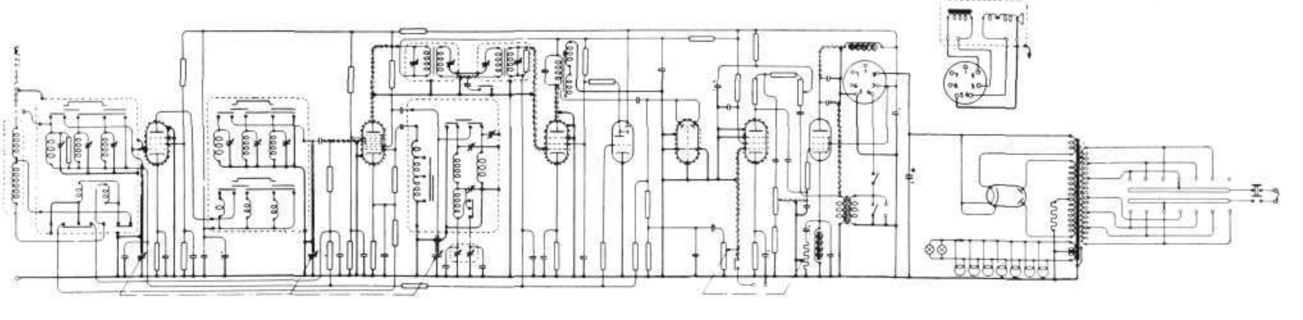
This receiver, Fig. 1, is the largest of the six new models. The entire set with loud-speaker and radio grammophone with automatic record changer is mounted on a welded frame, Fig. 2, and thus entirely independent of the cabinet. The chassis is supplied in this state also for building into furniture. This design has great advantages, as all parts are fully accessible for testing and adjustment during final inspection. The acoustic disadvantages of the cabinet have been eliminated in a very simple manner. Instead of reducing the resonant frequencies of the cabinet by means of acoustic chambers or the like, these have been entirely suppressed by replacing the sides of the cabinets by plaited cane. The sloping front of the cabinet composes in this way an ideal acoustic baffle.

The DC receiver has eight valves with the following functions: HF-amplifier MEF 5, frequency shifter MEK 2, IF-amplifier MEF 5, IF-rectifier MEB 4, LF-amplifier MEF 6, output valve MEL 5, orthoscope MEM 1 and rectifier MEZ 4. The universal receiver has the same valves, excepting that the rectification of the intermediate frequency and the LF-amplification are done in a combined valve MEBC 3 and that the output stage has two valves MCL 4 in push-pull connection. With 220 V mains voltage, both receivers give an output of 8 V, they have both the same sensibility, *viz.*, 2 μV at 50 mW output and the same selectivity.

As may be seen from the diagram, Fig. 3, the receiver is based on the superheterodyne principle. The arrangement of the aerial circuit is an increase of from three to eight times the voltage of the aerial signals as received. The HF-valve together with a tuned intermediate circuit augments the voltage thirty times more, at which it is fed to the control grid of the frequency shifter. The main anode of this last is connected to the input side of a four-circuit band-pass filter which is tuned to the frequency range 109 000—117 000 c/s. The signal voltage over the anode circuit which is now transformed to intermediate frequency has been multiplied thirty times by the amplification in the frequency shifter. The IF-valve, which is fed from the band-pass filter, terminates the total HF and IF-amplification by amplifying the signals 150 times. The rectification is made in the IF-rectifier and the LF-composant goes through a resistance condenser filter through the volume control on the grid of the LF-valve. The DC tension and the DC output of the IF-rectifier, which is negative in relation to the cathode, is transmitted through resistances to the grid circuits of the three first valves to be used as control tension for the automatic volume control. The total LF-gain is 1 000. The final stage gives 8 W output at 10 % distortion.

The tone control is continuously variable for the upper as well as the lower half of the register and regulated by means of two separate devices operating similarly to the bass and treble keys on an organ.

Fig. 3 X 7128
Diagram of superheterodyne receiver, Type 379 V
for AC, 8 valves incl. rectifier, 7 tuned circuits and oscillator circuit, wave-length range 17—50, 200—570 and 725—2 000 m, intermediate frequency 115 000 c/s, output 8 W



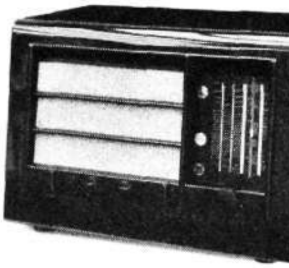


Fig. 4 X 3787
Ericsson 376

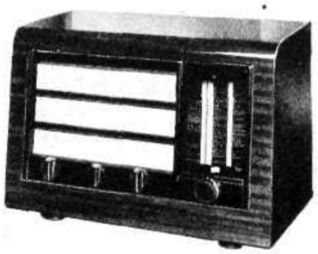


Fig. 5 X 3790
Ericsson 373

The orthoscope consists of a miniature cathode-ray tube with incorporated amplifier triode valve. The gauge of the cathode ray bundles and thus the extent of the luminous angles on the screen of the tube are determined by the potential of the control electrode, which depends in its turn on the operating tensions of the triode valve. The grid voltage of this latter is taken from the IF-rectifier and the anode tension from the auxiliary grid of the IF-valve, the potential of which is increased by the volume of the incoming signal. Thus the regulating range of the orthoscope is increased so that it gives a deflection for tensions between 0.5—30 V without the luminous angle exceeding 90°; the orthoscope therefore gives equally distinct deflection for both of the stations which induce in the aerial tensions between 2 μV and 6 V.

The grammophone has an automatic record changer of new type for eight 25 cm or eight 30 cm records. The record changer is very simple and reliable in operation. The records are threaded on a bent steel spindle which is fixed to the centre of the turntable. A knee on the spindle and a holder at the rim of the records serve as support. When the motor is started, the holder pushes the first record against the centre of the turntable; the record then loses its support on the knee of the spindle and falls down on the turntable. Meanwhile the pick-up which rested in its starting position outside the rim of the record has been turned to the correct starting position for play. When the record has been played, the pick-up is returned to its initial position, and the whole process is repeated until the last record has been played, when the grammophone motor is automatically cut off.

Ericsson 376

This receiver, an eight-valve superheterodyne with eight tuned circuits, has the same chassis as Ericsson 379. It is a table model, built in a cabinet of horizontal type, see Fig. 4. The lower part of the bakelite frame at the front of the cabinet is extended in a plate which protects the cabinet from being scratched or soiled when the dials are operated.

Ericsson 375

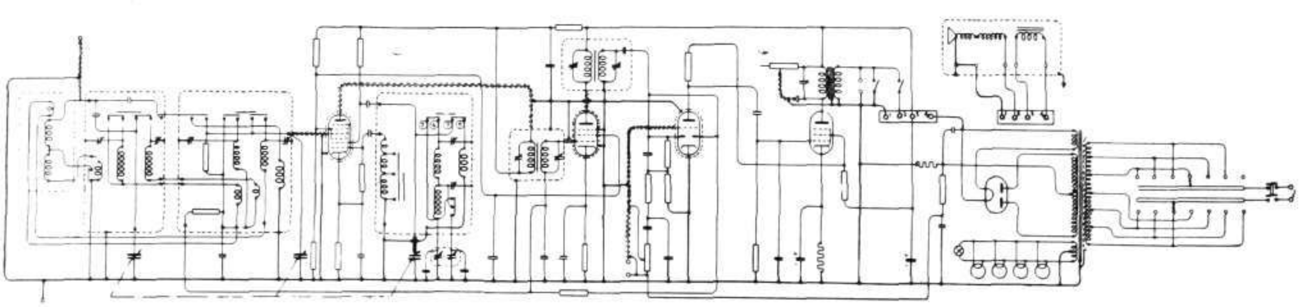
This receiver is an improvement on last year's model, Ericsson 365. It is a five-valve superheterodyne with eight circuits, made as a table model. The AC receiver has the following valves: MEK 2, MEF 5, MEBC 3 MEL 3 and MAZ 1, and the universal receiver MEK 2, MEF 5, MEBC 3, MCL 4 and MCL 2. The wave length ranges are: 17—50, 200—570 and 725—2 000 m. Special care has been taken regarding the quality of the sound and the short-wave reception, the efficiency of which has been increased quite considerably.

Ericsson 373

This model is the smallest in size of the superheterodyne receivers this year and is similar as regards exterior, Fig. 5, to Ericsson 376. Ericsson 373 is a five-valve superheterodyne with seven circuits including the oscillator

Fig. 6 X 7129
Diagram of superheterodyne receiver, Type 373 V

for AC, 5 valves incl. rectifier, 6 tuned circuits and oscillator circuit, wave-length range 17—50, 200—570 and 725—2 000 m, intermediate frequency 115 000 c/s, output 3 W



circuit, see diagram, Fig. 6. It has the same valves as Ericsson 376 and its receiving qualities are nearly as perfect as those of this latter receiver. Despite this the price is low enough to correspond to what has previously been the price for a two-circuit receiver. For low main voltages it is supplied in a special design with the final stage in push-pull connection.

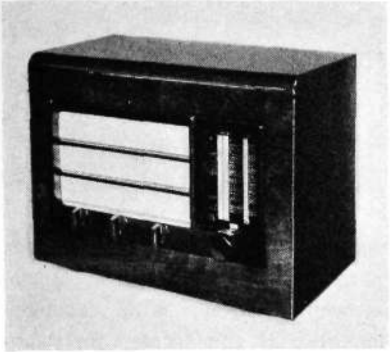


Fig. 7 X 3788
Ericsson 374

Ericsson 374

This receiver is a three-valve two-circuit battery receiver with short-wave range. The batteries, a 2 V accumulator and a 150 V anode battery are mounted in the cabinet, Fig. 7. At an output of 50 mW the sensibility is 40 μV. The receiver has three wave ranges: 17—52, 190—575 and 700—1 970 m. The principle used for the diagram, Fig. 8, one stage HF-amplification, screen-grid detector and final penthode gives, with the new current-saving valves, two VS 24 m with output valve PT 2, a very good sensibility and selectivity.

Ericsson 372

This three-valve single-circuit receiver is mounted on the same chassis and in the same cabinet as Ericsson 373. The AC-receiver has the following valves: MEF 6, MEL 3 and MAZ 1, and the universal receiver MEF 6, MCL 4 and MCY 2. The detector is a penthode in feed-back connection which controls directly a 9 W final penthode. The wave-length ranges are: 190—575 and 700—1 970 m. The sensibility at an output of 50 mV is 2 000 μV. The arrangement of the aerial circuit is such that the tuning is independent of the size of the aerial.

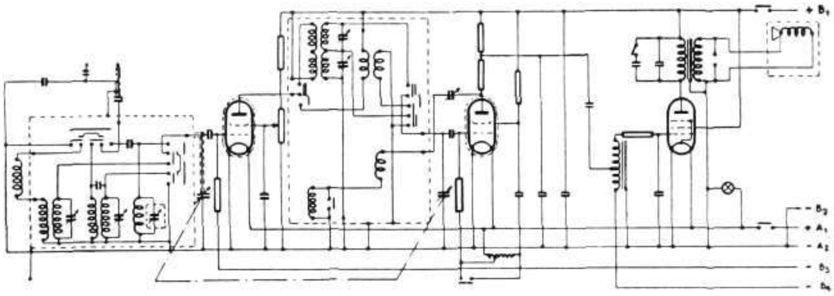


Fig. 8 X 5422
Diagram of two-circuit receiver, Type 374
for battery feed, wave-length range 17—52, 190—575 and 700—1 970 m, output 25 W

New Catalogues

Catalogue 603: Manual Switchboards for Magneto System

Following a complete standardization of manual telephone switchboards for magneto system and the corresponding parts, a special catalogue of the new improved types of switchboards has been published. This catalogue includes wall switches as well as switchboards. Of the former there are cordless switches for up to 6 lines, non extensible cord switches for up to 15 lines and finally switches which are extensible with detachable units, which may be very easily built into the switches. These units are line units for 10 lines as well as units comprising cord circuits, keys and other parts for one call. Different types of extensible wall switches are to be found for 30 and 50 lines max. All wall switches have drop indicators as calling signals. There are different types of switchboards with drop indicators, combined drop indicators and jacks, indicator jacks and visual indicators as calling signals. They are extensible in the same manner as the larger wall switches and made for 19 simultaneous cords and 160 lines, with the exception of the indicator jack switches which may be made for up to 200 lines. The switchboards have a multiple capacity of 800 lines with four-panel multiplication and 400 lines with two-panel multiplication. The switches with multiple are made only with lower portion of wood, but the switchboards without multiple may also be obtained with open lower portion of iron, enamelled in wood colour.

Supplement 5 to the General Catalogue

This supplement contains some new apparatus designed since Supplement 4 to the General Catalogue was published. Nearly all these apparatus have already been described in Ericsson Review and we may restrict ourselves to an enumeration of them. Thus the supplement contains the home telephone, which has been described in Ericsson Review No 3, 1935, as well as instructions for its connection for different purposes. Further there are described a wall telephone instrument with magneto, mounted in the same bakelit case as used for the Ericsson normal wall telephone instrument, see Ericsson Review No 3, 1936, as well as a watertight telephone instrument for use outdoors, see Ericsson Review No 1, 1937. Further there are dealt with watertight AC bells, see Ericsson Review No 1, 1937, for which there is a table indicating voltage and resistance for the different bells designed by Ericsson. One page describes frequency-control equipments for mounting in power stations in order to regulate the AC frequency, see Ericsson Review No 3, 1936, and No 2, 1937. Finally, this catalogue contains some new, modificated constructions of later apparatus (redesigned apparatus), *e. g.*, a new head-phone for program distribution system etc. and new thermo-contacts for fire-alarm installations.

Ericsson Technics

Ericsson Technics No 3, 1937

T. Laurent: Calcul des processus non stationnaires à l'aide des transformations fréquentielles

In the present work it is first shown how the theories which are valid for phenomena arising when sinusoidal alternating tensions are introduced in linear passive quadripoles may be considered as a superstructure of the theory of stationary alternating tensions. To this effect a quadripole of special composition is used, which is better adapted to the constructive mind of the engineer than purely mathematical abstractions.

The properties of this quadripole are characterized by a propagation time function which is easier to handle for practical computations of oscillation process than the well-known formula valid for the properties of quadripoles. The *Heaviside* expansion theorem and the limitation of it shown by *Wagner* are deduced. Finally the influence of frequency transformations on the expansion theorem is shown as well as the new possibilities this opens for practical work.

The different problems arising when quadripoles are composed are treated and the formulæ deduced are illustrated by sixteen examples. The theoretical treatment of filtered quadripoles shows also an interesting phenomenon, *i. e.*, that a band-pass filter attenuation having an arbitrary number of attenuation peaks may be obtained through successive frequency transformations of a simple cross-filter link and that minimum attenuations comprised between the attenuation peaks may obtain the desired values directly without preliminary approximative computations.

Finally a universal method for the computation of transients in linear passive quadripoles is presented. This method is certainly better adapted to practical needs of telephone and telegraph engineers than the methods hitherto used as it is based essentially on the knowledge that these engineers must have in order to solve the problems meeting them in their daily work.

Ericsson Technics No 4, 1937

T. Laurent: Calcul général des affaiblissements de filtres à l'aide des transformations fréquentielles

The general filter-attenuation problem, *i. e.*, the computation of the attenuation curve of a band-pass filter, situated outside the passing band and over a minimum attenuation curve giving at the same time the least possible surplus of attenuation has not yet been solved. Reference has therefore been limited to the tentative composition of simple attenuation curves, excepting a few special cases where *W. Cauer* has established a collection of curves on the basis of approximative computation.

In the present article it is shown how frequency transformations allow for a systematic solution of the general filter attenuation problem. *Cauer's* special problem then receives a particularly simple solution and may be treated without approximation in the majority of cases.

On this account, the frequency transformations have given a new proof of their ability to disentangle complicated problems which arise in telecommunication and it seems that they will soon be considered as an indispensable theoretical tool to the technicians in this domain. The word »frequency transformation» has generally a larger scope than that meant in the present work and the particular signification of »*bdmn* transformations» in comparison with analogous transformation methods is therefore emphasised.

Finally it is shown how it is possible to solve the filter attenuation problems by introducing by transformation the desired attenuation curve in the imaginary negative frequency range. This curve is subsequently used as a model for the composition of a technically attainable attenuation curve. This curve is in turn introduced by transformation in the physical frequency range, using a method the reverse of that used for the first transformation.

Ericsson Technics No 5 & 6, 1937

S. Ekelöf: The Transient of an Inductively Shunted Electric Transmission Line — with Special Reference to the Impulse Transmission in Selective-Calling Telephone Systems

The aim of the present work is to investigate the transients obtained on impulse transmission in selective-calling telephone systems. In the first part the problem is set forth and discussed; it is shown how it can be reduced to the calculation of the transients of an ordinary transmission line possessing a uniformly distributed inductive leakage. Beside this uniform smooth line the uniform lumped line, *i. e.*, a transmission line furnished with equally spaced leakage coils, is also given some consideration.

The *Heaviside* operational calculus gives us a suitable mathematical tool for solving our problem and an attempt has been made to give an exposition of this method, which should be at the same time mathematically acceptable and simple enough to be useful to the engineer. After these preliminaries we formulate and solve the problem mathematically, treating first different types of infinite lines in their response to a suddenly impressed constant EMF. The results obtained allow for a simply study of the finite line as well as of the response to an EMF of arbitrary form.

In the second part of the work a series of numerical computations have been carried out; their results are discussed and presented graphically. Finally an account is given of some measurements, the purpose of which was to confirm the practical applicability of the theoretical results.

In preparing this presentation of his investigation, the writer has had in view that it should be easily accessible to different classes of readers. Thus the purely mathematical parts are essentially concentrated to Part I. Those who are mainly interested in the practical results will therefore do best by proceeding directly to Part II, first reading, however, the exposition of the problem in Chapter 1.

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