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Omnibus telephone circuits - Regulations for construction and equipment

Circuits téléphoniques omnibus - Règles de construction et d'équipement
Gesellschafts- (Omnibus-) Fernsprechverbindungen - Regeln für Aufbau und Ausrüstung

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Contents

Summary

This leaflet concerns the technical aspects of railway telephony, dealing with omnibus circuits as defined in *UIC Leaflet 750, Chapter II, B*.

The principles defined in this leaflet are old in conception, but have in most cases remained valid to this day.

The systems have benefited from technological advances and their performance has improved.

Fibre optics and new transmission equipment ensure better-quality service on omnibus circuits.

Point 2 is dedicated to transmission channels (overhead lines, copper cables and fibre optics), frequency band widths, attenuation and connections.

Point 3 is devoted to call systems; those most generally used being centralised call lines (many railways having replaced their decentralised call systems with an automatic telephone network).

This point also deals with the various call modes, the nature of call pulses and different call current sources (generators, receivers and repeaters).

Point 4 covers the classification of telephones according to the method of use and defines the technical and operating conditions.

Points 5 and 6 contain recommendations for the construction of new omnibus circuits and their maintenance.

This leaflet does not consider the possible future replacement of omnibus circuits by radio services furnished by GSM-R.

1 - Foreword

1.1 - General

Although the principles set out in the present leaflet are on the whole based on superseded concepts, they have in most cases retained their general usefulness to the present day.

However, it should be noted that whilst retaining their functionality, the systems have benefited from recent technological advances, resulting in enhanced performance.

Future transmission links becoming available with the introduction of GSM-R can be expected to change some systems significantly, particularly on high-speed lines.

This leaflet deals only with the telephonic aspects of the omnibus circuits described in *UIC Leaflet 750, Chapter II, B* used for various purposes.

The circuits listed below are referred to as "omnibus circuits".

1.2 - Definition

An omnibus circuit is understood to be a telephone circuit to which a number of points are shunt-connected to meet the service requirements, bearing in mind the characteristics of the call system of the telephone and the need to avoid overloading the circuit.

1.3 - Classification of omnibus circuits

The omnibus circuits referred to in *UIC Leaflet 750, Chapter II, B* can be classified in four separate categories.

1.3.1 - Omnibus circuits reserved for operating links

These are used to supervise and regulate the running of trains (*UIC Leaflet 750, B 5*). On many railways they are referred to as control circuits. Signalling circuits also come within this category (*UIC Leaflet 750, B 2*), together with circuits for train advice (*UIC Leaflet 750, B 6*) and omnibus circuits alongside remotely controlled lines, e.g. signalling circuits with identified call.

1.3.2 - Omnibus circuits suitable for connecting to the general network

These are generally used for operating or traffic purposes, and by the administrative departments (*UIC Leaflet 750, B 3*). Semi-direct circuits also come within this category (*UIC Leaflet 750, B 4*).

1.3.3 - Omnibus circuits for technical maintenance departments

- Track maintenance circuits (*UIC Leaflet 750, B 8*).
- Signalling maintenance circuits (*UIC Leaflet 750, B 7*).
- Catenary maintenance circuits (*UIC Leaflet 750, B 12*).

It may be advisable to be able to connect these circuits to the general network.

1.3.4 - Omnibus circuits for special purposes

- Warning circuits (*UIC Leaflet 750, B 9*).
- Sub-station control circuits (*UIC Leaflet 750, B 10*).
- Sub-station omnibus circuits (*UIC Leaflet 750, B 11*).

2 - Characteristics of telephonic transmission

2.1 - Transmission channel

The transmission channel used for omnibus circuits can be either:

- overhead lines, or

- cables (copper, fibre optics).

For economic reasons, it may be advisable to increase the number of links of each elementary circuit in the form of cables or overhead lines. This is known as "multiplexing" and enables several simultaneous communications to be transmitted using phantom circuits and analogue or digital transmission systems.

To avoid interference from electrified lines, it is recommended that cables should be used.

2.1.1 - The maximum length and the average length of omnibus circuits differ on the various Railway Undertakings (RU). They depend on the geographical extension of the RU, on the density of the rail centres situated along a line, on the average density of the traffic, and on the transmission characteristics of the circuit used.

2.1.2 - The number of points to be connected depends on the nature of the omnibus circuit and the operating requirements.

2.1.3 - Sometimes, the operating requirements make it necessary to shunt-connect secondary lines with the main circuit. For the purpose of linking points with the main circuit, shunts of any length can be used. When the electrical capacity of the shunt is very great, or when safety measures are necessary because of electrical interference, it is advisable to make the connection with the main circuit by means of retransmitters with a large impedance on the main circuit side.

2.1.4 - Consideration can be given to linking circuits on a provisional basis for operating purposes. When connecting the circuits, it is necessary to take into account the transmission characteristics and the possibility of all the points shunted being able to call each other (see point 2.3.1 - page 6).

2.1.5 - The use of short sections of cable in overhead circuits should be avoided.

When it is not possible to avoid the use of input or intermediate cables, the impedance characteristic of the various sections must be adapted.

2.1.6 - Omnibus circuits may be two, four or six-wire circuits, or equivalent systems (analogue or digital channels).

Generally speaking, in the case of overhead lines two-wire circuits are used; in the case of cable circuits, four or six-wire circuits can also be used.

2.1.6.1 - The use of a two-wire circuit allows telephonic points to be connected easily; in addition, it is not necessary to provide a connecting device between four or two-wire circuits for conversations with a user of the general telephone network.

For these reasons, those railways which possess omnibus circuits with two and four wires (or even six wires) at the same time use two-wire circuits for circuits suitable for connecting to the general network.

When omnibus circuits are in the form of cables, it is recommended that coil-loaded circuits should be used. In many cases, in view of the reduced attenuation, this enables the use of line amplifiers to be dispensed with.

2.1.6.2 - Omnibus circuits with four wires can only be used for a conversation between two connected points on the circuit when a connecting device between the two existing electrical circuits (transmission and reception) is provided.

In order to avoid reaction effects, the connection of the coupling device is done at to the end of the circuit. For this purpose, an acoustic connection between a loudspeaker connected to the micro circuit and a microphone connected to the loudspeaker circuit, will suffice.

This permits simultaneous checking of both directions of conversation on the omnibus circuit at the connecting point. There are few cases where it is worthwhile, from an operating point of view, to allow for conversations to take place between two points connected to the same circuit, even if the equipment would permit this type of interconnection. It may even be advisable to prohibit such conversations and only to allow conversations between the points connected to the circuit on the one hand, and the control point, on the other.

For these reasons, those railways with four-wire omnibus circuits often use this system for electric traction warning circuits and for controlling traction sub-stations, in view of the fact that such circuits must necessarily give access to a responsible person. In the case of four-wire omnibus circuits, calls are made using two wires over the combined circuit of the quad. The system of using alternating current for calling sometimes permits the use of simple transformers and thus allows for total sectioning of the cable (combining circuits and combined circuits) from place to place; this kind of sectioning is essential in the case of high voltage electrification using industrial current, to maintain the induced longitudinal voltages in the cable at an acceptable value.

2.1.6.3 - Six-wire circuits can be established in two ways:

1. A two-wire main circuit coil-loaded and amplified by two-wire repeaters runs the whole length of the line and is supplemented by a four-wire auxiliary distribution circuit with larger non-coil-loaded conductors; this circuit serves the points in advance and in rear of each repeater station up to a point half way from the adjacent stations; at the repeater station, both pairs are shunted to the main circuit by the insertion of a four-wire repeater and a four-wire/two-wire isolating transformer. The telephone of the person in charge of the line is connected to the end of the two-wire main circuit.

   Calls are made via the combined circuit of the quad of the distribution circuit, as in the case of four-wire circuits.

2. A main four-wire conversation circuit coil-loaded and equipped with four-wire repeaters; this circuit is supplemented by a separate two-wire call circuit which is not coil-loaded. In the case of more recent installations, it has often been found that four-wire circuits are preferable to six-wire circuits, since four-wire circuits of good design give better functioning stability.

2.1.7 - Concentration turnouts

These concentration turnouts are useful when, in the case of light traffic, it is possible to disconnect certain circuits from the desk in question and to connect them to the desk of another controller at the same centre.

2.2 - Transmission range

To guarantee a suitable quality of transmission, the audio frequency band transmitted should be as wide as possible, in order to improve the quality of reception. Wherever possible, the frequency range transmitted should have a band width of 300 to 3 400 Hz.

The influence of shunts on the width of the band transmitted can be ascertained by means of Appendix A - page 19.

2.3 - Attenuation and connections

2.3.1 - The total equivalent (telephones included) of a communication between a point connected to an omnibus circuit with access to the general network, and a point on the general network, in the most unfavourable circumstances, should not exceed 40,0 dB at 800 Hz.

2.3.2 - The total equivalent (telephones included) of a communication between 2 points connected to the same omnibus circuit and which do not have access to the general network, should not exceed 30,4 dB at 800 Hz.

2.3.3 - Any connection to a telephone on the omnibus circuit produces a reflection point at the connection point. This reflection point gives rise, at each point connected, to an input attenuation which depends on the ratio between the input resistance of the connected point and the wave resistance of the omnibus circuit. For this reason, connection of the points to the line is carried out as follows:

2.3.3.1 - The points can be connected direct to the omnibus circuits. In this case, when a point is in the rest position, the input impedance at 800 Hz in shunt on the line should be the highest possible (at least 10 k Ω and preferably a multiple of this value). Generally speaking, it is desirable only to connect to the circuit those elements receiving the coil currents. In the case of the control point, the impedance at 800 Hz should be more than 1 M Ω if possible.

In the conversation position, the impedance of the point at 800 Hz is generally about 1 000 Ω ± 400 Ω. Direct connection of the points to the line gives rise to considerable fluctuations in the impedance of the latter, depending on the dispersion at any given time, of the points at rest or engaged in conversation. This type of connection is not therefore suited to the use of repeaters and is reserved either for overhead circuits, or for relatively short cable circuits.

2.3.3.2 - In certain cases (e.g. when the circuit is subject to electrical interference) it is necessary to recommend the insertion of a translator in the connection of the point to the omnibus circuit. In the case of connections using translators, there are two solutions:

1. When the input impedance of the points is very high, the sum of the input attenuations in general, and thus the total attenuation of the omnibus circuit can be kept very low.

   This however gives rise to a greater loss in power by the different points. This solution involves certain slight differences in level between the various conversations held over the omnibus circuit.

2. When the impedance on the line side of the translators is not too high, a greater attenuation should be accepted on the omnibus circuits. In this case, each point should be equipped, both for transmission and for reception, with devices for raising the power levels so that they all work under the same conditions (amplifiers and variable ratio induction coils). This method permits more accurate adjustment of the power levels, but is more costly to install.

   In this case also, only the call equipment is connected to the line when the point is in the rest position.

2.3.3.3 - When amplifiers are used at the telephone points, transformers are always used for the connection to the omnibus circuit.

2.3.4 - In order to ensure adequate transmission quality and acceptable attenuation, special measures are often necessary for circuits in cables.

The transmission conditions are unfavourably influenced by the existence of turnouts and shunts of different lengths to the main circuit. In addition, points connected in parallel to the main circuit are distributed irregularly over a section between two loading coils. For this reason, normal coil-loading, such as that used in direct circuits, is insufficient.

In the case of omnibus circuits of great length connected to a large number of points, as is the case for example, with train control circuits, the following solutions are used as special measures:

2.3.4.1 - Solution with an auxiliary four-wire circuit which is not coil-loaded

A two-wire main circuit, consisting of a coil-loaded pair of 0,9 mm diameter, serves the omnibus circuits from end to end; it is amplified at the repeater stations and has no high impedance shunts moreover, other than in these stations. It is therefore stable if it does not exceed a certain length and can be adjusted under the same conditions as a direct circuit.

A four-wire auxiliary circuit, consisting of two non-coil-loaded pairs of 1,3 mm diameter, serves the local points in advance and in rear of each repeater station, half way to the stations on either side. One of the pairs, known as the "conversation" pair, is connected to the microphones of the telephone points; the other, known as the "listening" pair, is connected to the receivers.

These two pairs are combined and shunted on the main circuit at the repeater station, by means of an isolating transformer and a four-wire repeater. The transformer provides the junction between the four-wire circuit with two specialised pairs and the two-wire circuit; it possesses a high impedance which does not appreciably change the line characteristics. The repeaters compensate the attenuation of the main circuit and of the isolating transformer.

The calls are transmitted by the combined circuit of the two pairs of the auxiliary circuit: the sections of this circuit are negotiated by means of impulse repeaters (or retransmitters). The main circuit is not affected by the length, poor distribution, or variations in shunts.

This solution, which makes use of three pairs of conductors, presents the following advantage: it enables the effect of a breakdown of a shunt to be limited to one section of the line only. Only the section is then placed out of service, and the remainder of the line continues to function without the need for emergency circuits.

2.3.4.2 - Solution with coil-loaded four-wire main circuit

The four-wire circuit, which runs alongside the whole of the line controlled, is amplified as necessary by four-wire repeaters. Both pairs of conductors are used to connect the microphones and receivers of the points on the track respectively, to the omnibus circuit. In order not to interfere with transmission over the coil-loaded four-wire main circuit, the points are connected by isolating translators which effect the desired uncoupling between the telephone points and the line, and permit connection to the combined circuit used for transmission of the call impulses. To enable the telephone points to be placed anywhere between the loading coils (charging point) the impedance of the shunt should be as high as possible (at least 10 k Ω).

This impedance is obtained by inserted translators and resistances supplementing the uncoupling, or by multiple connection induction coils.

The calls are transmitted over the combined circuit, and the four-wire repeaters are by-passed by special impulse indicators (or retransmitters).

This solution uses two pairs of conductors only.

2.3.5 - Use of line amplifiers

2.3.5.1 - The use of repeaters in long distance omnibus circuits often becomes necessary in order to maintain the total attenuation of the circuit within the permissible limits.

2.3.5.2 - When repeaters are used on two-wire circuits, it is particularly necessary to ensure suitable adaptation of the impedance of the repeaters to the impedance of the circuits and optimum balancing.

2.3.5.3 - For reasons of stability, the use of two-wire intermediate repeaters in an omnibus circuit should be avoided as far as possible.

2.3.5.4 - When four or six-wire circuits are available, the use of terminal or intermediate repeaters is governed by the compensation necessary and sufficient for the attenuation of the circuits.

2.3.6 - Use of transmission circuits

Transmission systems today enable the quality of services provided with omnibus circuits to be improved.

3 - Call systems

3.1 - General

Various call-signal devices are used for omnibus circuits. There are two call systems:

3.1.1 - Centralised call systems

In this case, the call is made exclusively from a telephone point; e.g. from the central control point in the case of the traffic control circuit (*UIC Leaflet 750, B 5*).

3.1.2 - Decentralised call systems

In this case, it is possible to call from all points connected to the omnibus circuit, e.g. in the case of omnibus circuits (*UIC Leaflet 750, B 3*) which often have access to the general network.

NB : Many railways have replaced their decentralised call circuits with an automatic telephone network.

3.2 - Call methods

Depending on whether a call is transmitted to all the points connected to the omnibus circuit simultaneously, or to a certain number of them only, a distinction is made between:

3.2.1 - Call methods by general call

In this case, the call signal is received by all the points connected to the omnibus circuit. The information combined with the call signal only applies to the point corresponding to this call signal.

There are special call signals to call several or all of the points simultaneously (general call or group calls).

Confidential messages are not possible.

In order to ensure that only the point for which the call is intended receives the call signal, it is possible to attach to the bell circuit of each point, a discriminating or selecting device; the latter only reacts to its own special code and then closes a local bell circuit only. Generally speaking, a selector operates with three call codes (special call, general call and group call).

3.2.2 - Call methods with selective calling

In the case of omnibus circuits with selective calling, the call is received by the selected point only, without affecting the other points. Confidential messages are possible using special technical devices.

Generally speaking, the device should enable a certain number of points to be called simultaneously; it is then beneficial to provide general or group call systems.

In the case of omnibus circuits with selective calling, the use of technical devices enabling the call impulses to be transmitted very rapidly is earnestly recommended.

3.3 - Nature of call impulses

For omnibus circuits different impulses acting on the reception devices of the various points connected are used, i.e.:

3.3.1 - Direct current impulses or direct current impulse trains produced by automatic dials which control the device direct.

3.3.2 - Direct current impulses which act in the first place on a direct current loop, are received by a central reception device and retransmitted by it with a reversed polarity.

3.3.3 - Inductive impulses brought about on the primary circuit of a translator by the opening and closing of a direct current circuit by means of an automatic dial and retransmitted by the secondary circuit to the circuit itself. Where inductive impulses are used, by reason of the likelihood of interference, the transformation of the impulses should comply with certain conditions.

3.3.4 - Alternating current impulses produced by a call device (magneto, call buttons, automatic dial, call generator).

3.3.5 - Frequency impulses below or within the phonic frequency range transmitted.

Where frequency impulses within the phonic frequency range transmitted are used, it is necessary to ensure adequate protection of conversations when no special circuit is used for transmission of the signals. Conversation protection depends on the following factors:

- position of the phonic frequency in the range transmitted,
- number of frequencies forming the call signal,
- position of the signal frequencies in relation to each other,
- conversation protection factor,
- duration of protection of the identification,
- sensitivity of the signal receiver,
- band width of the signal receiver and ratio between the level of the signal and the phonic level.

3.3.6 - Vocal call

In the case of omnibus circuits, certain procedures where the call is effected vocally have proved satisfactory. Generally speaking, an additional device releases the call at the central point only.

3.4 - Sources of the call current and call impulse generator

The various kinds of call current can be produced and transmitted by:

- direct current,
- 25 or 50 Hz alternating current or
- by phonic frequencies,

using various devices:

3.4.1 - Using call inductors, polarity reversers, call current generators, transformers with direct impulse creation, generally with frequencies of 25 or 50 Hz.

3.4.2 - Using special automatic dials which transmit the call impulses direct through the direct current potentials, circuit disconnectors or induction impulses, or produce frequency impulses.

3.4.3 - Using relay or automatic dial equipment controlled by individual push buttons, by levers or by delayed action push buttons which transmit the call impulses direct or after storage of the number selected.

3.5 - Call impulse receivers

The points connected to the omnibus circuit are generally equipped with call signal receivers corresponding to the call systems and to the call signal transmitters selected:

3.5.1 - Alternating current bell system, with direct reaction to signals given at a frequency of 25 or 50 Hz.

3.5.2 - Neutral or polarised relay devices or selectors which react to call impulses on the basis of direct current potentials, circuit breakers or induced impulses, verify the application to the point connected to them and which may release the optical and/or acoustic local call.

3.5.3 - Signal receivers receiving phonic call impulses store the information, study it and release the local call in the event of identity.

3.6 - Call impulse repeaters

Call impulse repeaters are used when the attenuation of the line is too great for the call current or to negotiate devices attenuating or interrupting the call current (amplifiers, overhead cables, translators separating sections of line with very different insulation values). The call impulse repeaters should retransmit the call impulses with the same amplitude and the same characteristics.

3.7 - Call impulse voltage

Different call impulse voltages are available for the various call systems, depending on the total attenuation of the circuit, the existence of amplifiers on the circuit, the nature of the call impulses and the sensitivity of the call impulse receivers. When determining the size and characteristics of the call impulse voltage, it is particularly necessary to ensure that there is no interference with other telephonic communications and to observe the regulations concerning protection against electrical contacts.

In the case of overhead circuits or those in the same cable as circuits belonging to the Telecommunications Operators, the voltages prescribed by the ITU must be complied with.

4 - Telephones

4.1 - Telephone specifications

The telephones employed vary according to their method of use. The differences are dictated by both technical and operating conditions. Thus we have:

- main telephones or control points for installations with centralised calling;
- secondary telephones for installations with centralised calling;
- telephones with decentralised calling;
- multiple use telephones.

Generally speaking, communication is by means of a handset. However, telephones suitable for communication by loudspeaker or by microphone and separate loudspeaker can also be used.

4.1.1 - Main telephones or control points with centralised calling

These points are provided with loudspeakers suitable for use in both directions or with separate microphones and loudspeakers. In alternating (simplex) working, a pedal can be used as a switching device. It is advisable to use a call return device giving an acoustic and optical indication to the "controller" that the call he has initiated has reached the point called. It is important for the call return to emanate direct from the operation of the call reception device at the point called.

When working with a loudspeaker, a handset or headset with microphone can be used as an emergency expedient. It is recommended that special desks fitted with control equipment such as switches, push buttons, automatic dial or keyboard, touch-screen, loudspeaker, microphone and clock, should be used.

The use of telephones with loudspeakers necessitates special conditions to avoid acoustic reverberations, in order to obtain:

- a good quality announcement by the controller at the points along the line, and
- efficient decoupling of microphone and loudspeaker.

When several loudspeaker points are situated in the same room, it is generally necessary to provide a separate box or niche for each one, which guarantees the necessary acoustic disconnection.

Supervision of the various control circuits is carried out by the chief controller by observing and listening to the various circuits, e.g. by means of a loudspeaker for testing purposes. The necessary technical devices should be provided for this purpose.

These installations are used particularly for omnibus circuit links, in accordance with point 1.3.1 - page 2.

4.1.2 - Secondary telephones for installations with centralised calling

4.1.2.1 - Auxiliary telephones where only the call equipment is connected in the rest position.

Communication can be established automatically by a call from the control point or by a call from the individual at the auxiliary point.

For conversing, microphone-loudspeakers are used for intercommunication, or handsets for duplex transmission. When microphone-loudspeakers are used, it is possible, immediately after the call, to communicate from the central point to the person called. Generally speaking, the link is cut after the end of the conversation, by the person at the auxiliary point. This equipment is used particularly for the omnibus circuits referred to in point 1.3.1 - page 2.

4.1.2.2 - In certain cases, wall telephones with automatic dial for two or four-wire circuits can be called only.

4.1.2.3 - Two or four-wire table telephones (possibly in several directions) associated with one or more wall telephones with selectors, can be called only.

4.1.2.4 - Two or four-wire wall telephones with no call device (either for transmission or reception) which are reserved for staff required to give information to the person in charge of the line according to a pre-established programme.

4.1.3 - Telephones with decentralised calling

4.1.3.1 - Portable telephones with or without magneto for local battery omnibus circuits with points connected along the line. These telephones can call or be called. They are generally two-wire.

These telephones are used for the omnibus circuits referred to in point 1.3.4 - page 3.

4.1.3.2 - Four-wire portable telephones with no calling equipment (either for transmission or reception) except a bell, can be connected to points along the line; at the nearest station the four-wire circuit is connected to a fixed call selector telephone so that the portable telephone can be called via the fixed telephone.

4.1.3.3 - Fixed telephones with a magneto can call and be called (table or wall telephone with local battery). This equipment is used particularly for the omnibus circuits referred to in point 1.3.1, and in the case of fixed use according to point 1.3.4.

4.1.3.4 - Wall telephones with selectors, equipped with a special automatic dial, can call and be called.

4.1.3.5 - Two-wire table or wall telephones with selective calling can call or be called. They can be fitted with a line occupation indicator and a clear button permitting intervention on an occupied line. They are connected to a relay box.

4.1.3.6 - Four-wire protected telephones for outside use, which are semi-waterproof with a moveable arm and a central battery, can call and be called; this equipment is used on cable circuits.

4.1.3.7 - The only system which is readily suited to a line occupation indication is that with selective calling and automatic dial. As soon as a telephone receiver has been lifted, it prevents access to the line by all the other telephones; a small lamp indicates occupation at each point. Each telephone also has a normally sealed button for gaining access to the line in case of necessity. Correspondents occupying the line can then be asked to free it. In certain cases of extreme urgency, some devices even enable the line to be cleared compulsorily by interrupting a communication in progress officially.

This equipment is fitted to omnibus circuits used for confidential communications, as referred to in point 1.3.2 - page 2.

NB : As indicated in point 3.1.2 - page 9, a number of railways have replaced their decentralised call circuits with an automatic telephone network.

4.1.4 - Multiple telephones

4.1.4.1 - External push button telephones enabling two different circuits to be connected.

4.1.4.2 - Centralised or working points. These combine the connections to the omnibus circuits with associated equipment and connections to other circuits; these points can call and be called, or possess only one of these two possibilities depending on the type of circuit in question. Connection to the line is by lifting of the handset and operating a key or a push button associated with the circuit selected. In certain cases, the centralising points permit the establishing of communications with other incoming lines. The centralising points can also include connections to overhead lines as well as connections with cable circuits. Technological advances allow the use of digital control units equipped with touch-screens giving overall coverage to omnibus circuits, automatic circuits and ground - train radio systems.

4.1.4.3 - A main point can have two or four wires; in this latter case, preference is given to the use of loudspeakers for reception purposes, since security is usually the concern of a centralising point and all communications are received there. In certain cases, the person in charge of the line has the facility of transferring a call coming in for a particular individual (e.g. a deputy belonging to a different department). Generally speaking, the main point is listening permanently, so that line telephones with no calling equipment can be used to advantage. In other cases, the person on duty, although always present, is not permanently listening; the calls then reach him by means of bells and lights, and the conversation takes place by prior operation of a push button or a key connecting the line to the microtelephonic handset of the centralising point. With older equipment (two-wire type), the person at the main point does not have a reception loudspeaker, and uses headphones and a microphone similar to that used by telephonists at manual switchboards.

Depending on the equipment, the centralising point can also serve for the connection of several omnibus circuits or other circuits to the same working point, so that it is only necessary to take one telephone into consideration instead of several table telephones which require much room and are difficult to supervise.

The centralising point also enables one conversation to be held at the same time without anyone else in contact being able to listen in.

The centralising point can be used either as a control point or an auxiliary point.

All the equipment listed below can be used for all the transmission channels mentioned in point 2.1 - page 4, failing any special reference to the contrary.

4.2 - Microphone supply

The microphone is often supplied from a 1,5 to 3 volt dry cell battery; when the point is associated with relays for the reception or transmission of calls, supply is from batteries of accumulators generally functioning on the buffer principle with dry rectifiers. The batteries are 6, 12 or 24 volts, with an increasing tendency to use 12 or 24 volts.

When several local battery points are to be supplied from a central battery, in order to avoid interference, it is necessary to provide voltage dividers with a condenser or supply cut-off induction coils for each connection.

Systems supplying lineside telephones from a central battery naturally use higher voltages (e.g. 48 V or 60 V), also supplied by rectifiers with buffer-batteries. The call currents can be taken either from the local 50 Hz network, or, as specified at the beginning of this paragraph, from 6, 12, or 24 volt batteries, or even from the catenary network via reducing transformers.

4.3 - Auxiliary points

In order to avoid interference and for the purpose of maintenance work, it is often advantageous to be able to connect to the omnibus circuit a point which is not normally connected thereto. This is generally a magneto telephone (portable local battery telephone). For connection to an overhead circuit, it is necessary to use special connecting clamps. It is preferable to mark the overhead line to which the connection is made, by pointed metal discs, fixed to the insulators at regular intervals, by symbols, by painted signs or by coloured circles attached to the insulators. In the case of cable lines, the circuits are provided with sockets for the rapid connection of the telephones.

It is also possible, when the omnibus circuit is connected to a person in charge of the line who is permanently listening, either to connect a portable telephone with no call equipment to the line, or to provide circuits permitting phonic calling only.

5 - Construction measures

When placing in service new equipment for omnibus circuits, preference should be given to components with the following characteristics:

- high reliability of functioning,
- use of constructional components, particularly semi-conductor components, with a high reliability of functioning,
- sets of uniform construction,
- low cost of assembly,
- rapid interchangeability of construction sets,
- rapid call systems,
- low supply consumption,
- small size,
- little maintenance,
- possibility of extension and
- ease of use.

6 - Maintenance

To facilitate the finding of defects and the maintenance of the installations, the following conditions can be recommended:

- sectioning of very long circuits, (the sections can be remotely controlled, e.g. by the person in charge of the line),
- fitting of sectioning devices at the beginning of long shunts,
- provision of testing equipment for the repeaters (for four or six-wire circuits on which they are used),
- use of special recording and control boxes for the components and construction sets, e.g. on the polarised relays of selector call circuits,
- fitting of devices for supervising the circuits, for controlling cuts, short circuits or insulation,
- use of interchangeable construction sets (plug-in spare components),
- centralised repair and testing of components, construction sets and equipment.

Appendix A - Influence of shunts on the width of the band transmitted

a) A coil-loaded circuit with coils of L_s millihenrys spaced at regular intervals of d km possesses a high cut-off frequency given by the formula:

$$f_s = \frac{1}{\pi\sqrt{L_s \cdot d \cdot C}} \cdot 10^6 \text{ Hz} \qquad (1)$$

in which C represents the mutual capacity of the circuit expressed in nano-farads per km.

b) If, on the other hand, the circuit was fitted with induction coils L_a regularly connected in parallel on the two conductors every d km, the circuit would give rise to a low cut-off frequency given by the formula:

$$f_i = \frac{1}{2\pi\sqrt{L_a \cdot d \cdot C}} \cdot 10^6 \text{ Hz}$$

c) If the circuit was equipped at the same time with shunts spaced regularly along the line and with loading coils, the structure of the line becomes similar to that of a moving band filter.

Two cut-off frequencies then appear:

- a low frequency:

$$f_{ci} = \frac{1}{2\pi\sqrt{L_a \cdot d \cdot C}} \cdot 10^6 \text{ Hz} \qquad (2)$$

which corresponds to the anti-resonance frequency of the shunt inductance L_a (millihenrys per load section) and of the capacity C.d of a section;

- a high frequency:

$$f_{es} = \frac{1}{2\pi}\sqrt{\frac{\frac{L_s}{L_a} + 4}{L_s \cdot d \cdot C}} \cdot 10^6 \text{ Hz} \qquad (3)$$

which is slightly higher than that given by formula (1).

It will be seen that if L_a tends towards infinity, we have:

$$f_{ci} = 0 \qquad f_{cs} = \frac{1}{\pi\sqrt{L_s \cdot d \cdot C}} \cdot 10^6 \text{ Hz}$$

The stronger the shunt inductance, the nearer one comes to the conventional formula (1) of the coil-loaded circuit.

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