5i’

SECTION 4

INTERREGISTER SIGNALLING

Recommendation Q.440

4.1 GENERAL

Interregister signals are of the multifrequency type using a 2-out-of-6 in-band code in both directions. The multifrequency combinations are sent and received by multifrequency signalling equipment which is assumed to be associated with the registers used to control the switching equipment at both ends of the inter-exchange link.

4.1.1 *End-to-end signalling method*

In System R2 interregister signalling is generally performed end-to-end by a compelled procedure between the outgoing register and the incoming registers which come into action one after another. Signalling takes place over one or more links in tandem without signal regeneration in intermediate exchanges. With this signalling method only the address information needed for routing the call through an intermediate exchange is transferred from the outgoing register to the incoming registers. In an intermediate exchange the speech path is immediately through-connected and the incoming register released, then the outgoing register can exchange information directly with the incoming register of the next exchange (see Figure 11/Q.440). If any intermediate exchange has to carry out charging operations, additional address information can be transferred from the outgoing register to the incoming register of that exchange as required.

FIGURE 11/Q.440, p.

In circumstances where transmission conditions do not comply with the requirements specified for System R2 (see Recommendation Q.457) or where System R2 is used in a satellite link, and thus the exchange of the interregister signals over the complete System R2 connection is not permitted, the overall multi-link connection is divided into end-to-end signalling sections. When the number of multifrequency combinations available is not the same on all parts of the connection, the division should be made at an exchange between links having different numbers of multifrequency combinations to improve the transfer of information.

The outgoing R2 register is situated at the outgoing end of a signalling section on which System R2 interregister signalling according to the present specifications is used. It controls the call set-up over the whole signalling section. It sends forward interregister signals and receives backward interregister signals.

The outgoing R2 register receives information via the preceding links of the connection in a form used by the signalling system applied over the last of these links; this system may be System R2, a decadic pulse system, or any other system. The preceding link may also be a subscriber's line. When an R2 register in a transit exchange is working according to this definition, it is also called an *outgoing R2 register*.

Special cases of the outgoing R2 register are the outgoing international R2 register (see § 4.1.2) and the outgoing R2 register at the incoming end of a satellite link.

The incoming R2 register is situated at the incoming end of a link on which System R2 multifrequency interregister signalling according to the present specification is used. It receives forward interregister signals via the preceding link(s) and sends backward interregister signals. The information received is used completely or in part for the control of selection stages and may be sent in its entirety or in part to the succeeding equipment, in which case the signalling used for retransmission is never System R2. Interworking then takes place between System R2 and the other system. Thus every register not situated at the outgoing end of a System R2 signalling section is called an *incoming R2 register* independently of the exchange type.

The term *incoming R2 register* | ay be applied also to devices controlling one or more selection stages, for example *markers* etc. It should be noted that in such equipment no provision is made for further transfer of the information received.

4.1.2 *International end-to-end working*

The inclusion of a special *outgoing international R2 register* | s shown in Figure 11/Q.440 is dictated by a number of considerations. An outgoing international R2 register is an outgoing R2 register which controls the call set-up on a signalling section which comprises at least one international link and possibly national links in tandem.

Even when System R2 is used in the national network of the originating country an outgoing international R2 register must always be provided in the country of origin to divide the connection into two signalling sections for the following reasons:

— to prevent the maximum number of links in a signalling section over which System R2 can function from being exceeded on international calls;

— to permit the use of fewer signalling frequencies in the country of origin (e.g. 5 forward and 5 or 4 backward signalling frequencies);

— to enable non-standardized meanings to be allocated to the spare national multifrequency combinations for use solely in the country of origin;

— to provide criteria for distinction, at the incoming end, between national and international calls;

— to have the facilities for routing and charging of international calls concentrated in one place if it is more economical than to equip every normal outgoing R2 register to perform these functions.

In general the outgoing international R2 register is situated at the outgoing international exchange. However, it may be situated in a national exchange preceding the international exchange provided that the transmission requirements specified are fulfilled.

End-to-end signalling from the outgoing international R2 register can be extended beyond the incoming international exchange even if a reduced number of signalling frequencies is used. However, such international/national

end-to-end signalling requires:

— that the transmission conditions in the national destination network comply with the System R2 specifications, and

— that the routing principles employed in the national destination network are compatible with the System R2 signalling procedures for end-to-end transmission of address digits from the outgoing international R2 register to an incoming R2 register in a national exchange.

4.1.3 *Register requirements*

Apart from signalling procedures specified in Section 5 the following characteristics of R2 registers are specified.

4.1.3.1 *Outgoing R2 registers*

The multifrequency signalling equipment associated with outgoing R2 registers in national exchanges may be of the 2-wire or 4-wire type (see Recommendation Q.451).

The multifrequency signalling equipment associated with outgoing international R2 registers must be of the 4-wire type. This is dictated by transmission constraints (see Recommendation Q.452).

The outgoing R2 register controlling a given multi-link signalling section must be able to recognize at least all the backward signals used on that section.

The outgoing international R2 register must be able to send all 15 forward multifrequency combinations with the meanings specified for international working. It must be able to receive all 15 backward multifrequency combinations and act upon the received information in the specified manner. In the case when System R2 is used on the preceding link the calling party’s category signals have to be translated by the outgoing international R2 register as specified (see Recommendation Q.480).

The outgoing R2 register must start call set-up as soon as it has received the minimum requisite information. Therefore signal transfer starts before the complete address information is received, i.e. before the caller finishes dialling. This *overlapping interregister signalling* particularly applies at an outgoing R2 register where the complete address information from a subscriber or operator is stored (e.g. local registers). This is in contrast to *en bloc register signalling* i.e. the transmission of all the address information as a whole in one sequence starting only after the complete reception of the address information.

4.1.3.2 *Incoming R2 registers*

The multifrequency signalling equipment associated with incoming R2 registers may be of the 2-wire or 4-wire type (see Recommendation Q.451).

The multifrequency signalling equipment associated with the incoming R2 register in an international exchange must be of the 4-wire type and equipped to send and receive all 15 multifrequency combinations.

Every incoming R2 register in a multi-link signalling section must be able to recognize at least the forward signals used on that section and directed to that register.

4.1.4 *System R2 compelled signalling method*

The compelled signalling operates as follows (see Figure 12/Q.440):

— on seizure of a link, the outgoing R2 register automatically starts sending the first forward interregister signal;

— as soon as the incoming R2 register recognizes this signal, it starts sending a backward interregister signal which has its own meaning and at the same time serves as an acknowledgement signal;

— as soon as the outgoing R2 register recognizes the acknowledging signal, it stops sending the forward interregister signal;

— as soon as the incoming R2 register recognizes the cessation of the forward interregister signal, it stops sending the backward interregister signal;

— as soon as the outgoing R2 register recognizes the cessation of the acknowledging backward interregister signal it may, if necessary, start sending the appropriate next forward interregister signal.

When the duration of the forward and backward signals is not controlled by the compelling mechanism described above, it is either limited by the time-out delay for release of the register or determined by the nature of the pulse imposed on them (see Recommendation Q.442).

Figure 12/Q.440 shows a basic compelled signalling cycle.

Figure 18/Q.457 shows in detail the build-up and time sequence of a compelled signalling cycle, including the operating and release times of multifrequency signalling equipment and other internal operating times of exchange equipment.

Besides being a functional part of the compelled procedure, the acknowledging backward signals serve to convey special information concerning the required forward signals, to indicate certain conditions encountered during call set-up or to announce switchover to changed meanings of subsequent backward signals. Changeover to secondary meanings allows information concerning the state of the called subscriber’s line to be transferred (see Recommendation Q.441, § 4.2.4). Therefore a choice of acknowledging backward signals is provided.

Figure 12/Q.440 p.2

Recommendation Q.441

4.2 SIGNALLING CODE

4.2.1 *Multifrequency combinations*

Each interregister signal consists of the simultaneous sending of 2 out of a range of 6, 5 or 4 in-band frequencies (multifrequency combination). The band of the interregister signalling frequencies does not overlap with the frequency band generally used for line-signalling.

This *2-out-of-n* | ode allows erroneous signals consisting of less or more than two frequencies to be detected and identified as faulty.

To make the system suitable for application on 2-wire links, two different sets of 6 frequencies are defined for the composition of the forward and the backward signals.

Table 5/Q.441 shows all multifrequency combinations which can be derived from the maximum of 6 signalling frequencies per direction provided by the system. For reference purposes each multifrequency combination of a given direction is identified by a serial number. The numerical value of this serial number can be calculated by adding the respective index and weight allocated to the two frequencies making up the combination.

The number of multifrequency combinations depends upon the number of signalling frequencies used. When the maximum of 6 signalling frequencies are used, 15 multifrequency combinations are available.

System R2 is designed for operation on international links with 15 multifrequency combinations in each direction. However, it can be used in national networks with a reduced number of signalling frequencies and still permit international/national end-to-end working of System R2 signalling in the case of incoming international traffic (see Figure 13/Q.441).

The reduction naturally cuts the number of multifrequency combinations available but has the economic advantage of effecting savings in equipment. The resulting reduction in facilities is of less importance in automatic than semi-automatic service.

Tableau 5/Q.441 p.3

Figure 13/Q.441 p.4

4.2.2 *Allocation of interregister signals*

The signal coding consists of the association of the defined meaning of interregister telephone signals to the multifrequency combinations transmitted over the links. Certain combinations are left spare for the allocation of national or international signals. (For signalling procedures, see Recommendations Q.460 to Q.480.)

4.2.2.1 *Multiple meaning*

The meaning of both the forward and backward multifrequency combinations can change after transmission of certain backward signals. The changed meaning is specific to the signal which caused or announced the change. In certain cases a change back to the original meaning is possible. The meaning of certain forward multifrequency combinations may also vary depending on their position in the signalling sequence.

4.2.2.2 *Meanings of the forward multifrequency combinations*

There are two groups of meanings allocated to the forward multifrequency combinations. The Group I meanings are indicated in

Table 6/Q.441 and the Group II meanings in Table 7/Q.441 . The change from Group I to Group II meanings takes place when requested by the backward signals A-3 or A-5. Change back to Group I meanings is only possible when the change to Group II meanings was in response to signal A-5.

The first forward signal transmitted in international working is used for additional routing information. It enables a distinction to be made between terminal and transit calls. In the case of terminal calls it carries the language or discriminating digit whereas, for transit calls, it serves the dual purpose of providing a country code indicator and to indicate whether an echo suppressor is required or not.

The above arrangements obviate the need for two different seizing signals (line signals) to distinguish between transit and terminal traffic on links terminated in a transit exchange.

4.2.2.3 *Meanings of the backward multifrequency combinations*

There are two groups of meanings allocated to the backward multifrequency combinations. The Group A meanings are indicated in Table 8/Q.441 and the Group B meanings in Table 9/Q.441. The change to Group B meanings is announced by the backward signal A-3. No change back is possible once a change to the Group B meanings of the backward multifrequency combinations has been indicated.

4.2.2.4 *Integration of national and international signalling codes*

The utilization of Signalling System R2 in national networks is facilitated by the provision, in the specified signalling code, of signals specially assigned for national use. Under the specified code, specific national meanings are allocated to some of these signals, others are available for the allocation of national meanings at the discretion of each Administration.

National allocations must not conflict with the present specifications in order to ensure end-to-end interregister signalling i.e. the direct dialogue between the outgoing international R2 register (in the originating country) and incoming R2 registers, in the national network of the destination country.

The specified signalling code allows for a reduction of signalling frequencies in national networks (see § 4.2.1 above).

4.2.3 *Forward signals*

4.2.3.1 *Group I forward signals*

Compelled interregister signalling must always begin with a Group I forward signal. For the signal codes see Table 6/Q.441.

TABLE 6/Q.441, p.

The *signals I-1 to I-10* | re numerical signals indicating:

a) the *address* | equired for setting up the call (country code, national significant number); such address signals are sent by an outgoing R2 register or an outgoing international R2 register, either spontaneously and immediately after the seizure of the link or in response to one of the backward signals A-1, A-2, A-7 or A-8;

b) the country code (and possibly the area code as well) of the *location of the outgoing international R2 register* , in response to signals requesting the origin of the call. For national traffic, the telephone number of the calling subscriber's line (see Recommendation Q.480);

c) for automatic working the *discriminating digit* | r, in the case of semi-automatic working, the service language to be used by the operator (i.e. *language digit*).

The *signal I-11* | s a non-numerical address signal. The meaning of the signal is dependent on its position within the sequence of address signals specified in Recommendation Q.107.

a) *Country code indicator, outgoing half-echo suppressor required*

When signal I-11 is transmitted as the first forward signal it indicates that:

i) a country code will follow (international transit);

ii) the call requires echo suppressors;

iii) the outgoing half-echo suppressor has to be inserted.

The use of this signal in international working is subject to bilateral agreement and is made in conformity with Recommendation Q.479.

b) *Access to incoming operator (code 11)*

When signal I-11 is preceded by the language digit (and possibly by one further address digit) it indicates the address of the incoming operator's position and is then always followed by signal I-15 alone.

For international working this signal is to be used only in conformity with Recommendation Q.107 | fIbis . It can be used in national traffic only if the incoming R2 registers are equipped to receive all six forward frequencies. The necessary specifications are then the responsibility of the Administration concerned.

The *signal I-12* | s a non-numerical address signal. The meaning of the signal is dependent on its position in the sequence of address signals specified in Recommendation Q.107.

a) *Country code indicator, no echo suppressor required*

When signal I-12 is transmitted as the first forward signal it indicates that:

i) a country code will follow (international transit);

ii) the call may not require any echo suppressor (see Recommendation Q.479).

b) *Access to delay operator (code 12)*

When signal I-12 is preceded by the language digit (and possibly by one further address digit) it indicates that the call must be routed to the delay operator's position, either to a particular operator, or one of those operating a particular group of positions. It is then followed by further digits and the signal I-15 or by the signal I-15 alone.

In international working this signal is to be used in conformity with Recommendation Q.107 | fIbis . It can be used in national traffic only if the incoming R2 registers are equipped to receive all six forward frequencies. The necessary specifications are then the responsibility of the Administrations concerned.

c) *Request not accepted*

An outgoing international R2 register which receives a signal A-9 or A-10, the use of which is exclusively national, or which receives by signal A-13 a request to which it is unable to reply, should indicate by transmitting signal I-12 that it cannot answer the query (see Recommendation Q.480). This signal may be similarly used in national traffic to indicate that response to signal A-9 or A-10 is not possible.

The meaning of the non-numerical signal I-13 is dependent on its position in the sequence of address signals specified in Recommendation Q.107.

a) *Test call indicator*

When in international working the signal I-13 is transmitted as the first forward signal it occupies the position of the language or discriminating digit. It serves then as a test call indicator and must be followed by the complete test equipment address information as specified in b) below.

b) *Access to test equipment (code 13)*

To access automatic test equipment the second signal I-13 (the address digit) must be followed by two digits *xy* and the signal I-15.

c) *Satellite link not included*

In response to signal A-13, the meaning of the signal I-13 is that up to the outgoing R2 register no satellite link is included.

The meaning of the non-numerical *signal I-14* | s dependent on its position in the sequence of address signals specified in Recommendation Q.107.

a) *Country code indicator, outgoing half-echo suppressor inserted*

When signal I-14 is transmitted as the first forward signal it indicates that:

i) a country code will follow (international transit);

ii) the call requires echo suppressors;

iii) the outgoing half-echo suppressor has already been inserted.

This signal is to be used in international working and only in conformity with Recommendation Q.479.

b) *Incoming half-echo suppressor required*

In response to signal A-14, the meaning of the signal I-14 is that an incoming half-echo suppressor is necessary.

c) *Satellite link included*

In response to signal A-13, the meaning of the signal I-14 is that up to the outgoing R2 register a satellite link is included in the connection.

The non-numerical *signal I-15* | ndicates the end of a sequence of forward interregister signals. It is never sent as the first signal on an international link.

a) *End-of-pulsing*

In international working, signal I-15 is used to indicate that there are no more address signals to follow (see Recommendations Q.107 and Q.473).

b) *End of identification*

In national traffic, signal I-15 may be used to indicate that transmission of the sequence identifying the calling subscribers line is terminated (see Recommendation Q.480, § 5.8.2).

4.2.3.2 *Group II forward signals*

The Group II forward signals are calling party's category signals sent by outgoing R2 registers or by outgoing international R2 registers in reply to the backward signals A-3 or A-5 and give information whether national or international working applies. For the signal codes see Table 5/Q.441.

It is useful to identify calls according to type or function:

i) to indicate whether the forward transfer facility is required in international traffic;

ii) for adequate control of switching operations;

iii) to enable any additional meanings for the signals A-5 used in a national network but not internationally accepted (for example, to change the meanings of one or more following signals, forward or backward) to be made inoperative for incoming international calls;

iv) for maintenance purposes.

The meanings of the calling party’s category signals are detailed below:

a) The *signal II-1, subscriber without priority* | ndicates that the call is set up from a subscriber’s line and is non-priority.

b) The *signals II-2 and II-9, subscriber with priority*
| ndicate that the call is set up from a subscriber’s line to which priority treatment of calls has been accorded. Signal II-2 is specified for national working only since there are no Recommendations regarding priority calls in automatic international working (see Recommendation Q.480).

c) The *signal II-3, maintenance equipment* | ndicates that the call comes from maintenance equipment.

d) The *signal II-5, operator* | ndicates that the call is set up from an operator's position.

e) The *signals II-6 and II-8, data transmission* | ndicate that the call will be used for data transmission.

f) The *signal II-7, subscriber* | ndicates that the call is set up from a subscriber's line, an operator's position or from maintenance equipment and that no forward transfer signal will be used.

g) The *signal II-10, operator with forward transfer facility* | ndicates that the call is set up from an operator's position with possibility of recourse to the forward transfer facility. Its use must be subject to bilateral agreement (see Annex A to the present Specifications).

The signal II-4 and the signals II-11 to II-15 are spare. The meaning of signal II-4 will be decided later by international agreement.

TABLE 7/Q.441, p.

4.2.4 *Backward signals*

4.2.4.1 *Group A backward signals*

Group A backward signals (for signal codes see Table 8/Q.441) are required to acknowledge Group I forward signals and under certain conditions, Group II forward signals. Besides that functional part of the compelled procedure, the Group A signals convey signalling information as detailed below:

a) The *signal A-1, send next digit (n + 1)* | equests transmission of the next digit ($n + 1$) after reception of digit n . The latest address signal sent is assumed to have the rank n within the signal sequence specified in

Recommendation Q.107.

b) The *signal A-2, send last but one digit (n — 1)* | equests the transmission of digit (n — 1) after reception of digit n. The latest address signal sent is assumed to have the rank n within the signal sequence specified in Recommendation Q.107. This signal must not be used on a satellite link.

TABLE 8/Q.441, p.

c) The *signal A-3, address-complete, changeover to reception of Group B signals* | ndicates that the incoming R2 register at the incoming end needs no additional address digit and is about to go over to transmission of a Group B signal conveying information about the condition of the equipment at the incoming exchange or the condition of the called subscriber's line (see Recommendation Q.442).

d) The *signal A-4, congestion in the national network* | ndicates:

i) congestion of national links;

ii) congestion in selection stages of terminal international or national exchanges;

iii) occurrence of time-out or abnormal release of a System R2 register produced for any reason.

For exception to these rules see n) below. See also signal B-4 and Recommendation Q.442.

e) The *signal A-5, send calling party's category* | equests transmission of a Group II signal.

f) The *signal A-6, address-complete, charge — set-up speech conditions* | ndicates that the R2 register at the incoming end needs no additional digit, but will not send Group B signals. The call has to be charged on answer (see Recommendation Q.442).

g) The *signal A-7, send last but two digit (n — 2)* | equests the sending of digit (n — 2) after reception of digit n . The latest address signal sent is to have the rank n within the signal sequence specified in Recommendation Q.107. This signal must not be used on a satellite link.

h) The *signal A-8, send last but three digit (n — 3)* | equests the sending of digit (n — 3) after reception of digit n . The latest address signal sent is to have the rank n within the signal sequence specified in Recommendation Q.107. This signal must not be used on a satellite link.

i) The *signals A-9 to A-10* | re spares available for allocation of national meanings. The use of signals A-9 and A-10 in national networks can be decided by each Administration. These signals must not be used on international satellite links.

j) The *signal A-11, send country code indicator* | equests the country code indicator (transit indication) in acknowledgement of any forward signal. The signal is used in international transit calls only (see Recommendation Q.462). This signal must not be used on a satellite link.

k) The *signal A-12, send language or discriminating digit*

| equests the language digit or the discriminating digit in acknowledgement of any forward signal. This signal must not be used on a satellite link.

l) The *signal A-13, send nature of circuit* | equests information regarding the nature of the circuits involved in the connection so far, i.e. satellite link (see Recommendation Q.480). This signal should only be used on a satellite link by bilateral agreement.

m) The *signal A-14, request for information on use of echo suppressor* | is an incoming half-echo suppressor required?) indicates that an incoming international exchange acknowledges the discrimination digit or the language digit and that it is possible to insert an incoming half-echo suppressor in that incoming international exchange if required. This signal must not be used on a satellite link.

n) The *signal A-15, congestion in an international exchange or at its output* | ndicates:

i) congestion on international links;

ii) congestion in selection stages at an international transit exchange or at a terminal international exchange and/or its outgoing links;

iii) occurrence of time-out or abnormal release of a System R2 register produced for any reason (see Recommendation Q.442).

4.2.4.2 *Group B backward signals*

Any Group B backward signal (for signal codes see Table 9/Q.441) acknowledges a Group II forward signal and is always preceded by the address-complete signal A-3 which indicates that the incoming R2 register has received all the Group I forward signals it requires from the outgoing international R2 register. Besides that functional part of the compelled procedure the Group B signals convey information about the condition of switching equipment in the incoming exchange, or about the condition of the called subscriber's line, to the outgoing international R2 register which can then take the necessary action as specified in Recommendation Q.474.

TABLE 9/Q.441, p.

The following Group B signals are specified:

a) The *signal B-1 is spare* | or national use and its meaning must be compatible with that of signal B-6 (see Recommendation Q.474).

b) The *signal B-2, send special information tone* | ndicates that the special information tone should be returned to the calling party. This tone indicates that the called number cannot be reached for reasons not covered by other specific signals and that the unavailability is of a long term nature (see also Recommendation Q.35).

c) The *signal B-3, subscriber's line busy* | ndicates that the line or lines connecting the called subscriber to the exchange are engaged.

d) The *signal B-4, congestion* | ndicates that congestion condition is encountered after the changeover from Group A signals to Group B signals. The signal B-4 shall be sent in the conditions specified for signal A-4 [see § 4.2.4.1, d) and Recommendation Q.474, § 5.3.5.1].

e) The *signal B-5, unallocated number* | ndicates that the number received is not in use (e.g. an unused country code, an unused trunk code or subscriber number that has not been allocated).

f) The *signal B-6, subscriber's line free, charge*
| ndicates that the called party's line is free and that the call has to be charged on answer.

g) The *signal B-7, subscriber's line free, no charge* | ndicates that the called party's line is free but is not to be charged on answer. This signal permits non-chargeable calls without the need for transferring ''no charge'' information by line signals.

h) The *signal B-8, subscriber's line out of order*
| ndicates that the subscriber's line is out-of-service or faulty.

i) *Signals B-9 and B-10* | re spare for national use. Their meaning must not be incompatible with the sending of special information tone to the calling party (see Recommendation Q.474).

j) *Signals B-11 to B-15* | re spare for national use. Their meaning can be allocated as required. Sending of these signals into the international network must be prevented.

To deviate from this rule will result in the actions defined in Recommendation Q.474.

Recommendation Q.442

4.3 PULSE TRANSMISSION OF BACKWARD SIGNALS A-3, A-4, A-6 OR A-15

Under certain conditions it may prove necessary or desirable to send one of the *signals A-3, A-4, A-6 or A-15* without prior reception of a forward signal. This can occur when the incoming R2 register, after acknowledging a recognized forward signal, is unable to complete the call (for example during congestion) and the next forward signal does not appear on the line; or when the address-complete signal must be sent after the last forward address signal has been acknowledged. It may be desirable to deliberately suspend compelled signalling by acknowledging the last address digit, and signal I-15 if received, with signal A-1 to avoid prolonging the transmission

time of certain interregister signals. Such a course should certainly be considered when there is a possibility that a relatively long period may elapse between reception of the last digit and detection of the condition of the called subscriber's line. The average duration of such periods during the busy hour must be limited to 3 seconds in view of the load on the carrier systems in the case of international calls.

The following conditions must be observed in transmitting pulsed interregister signals (see Figure 14/Q.442):

— the minimum delay between the end of transmission of the last signal of the compelled cycle and the start of transmission of the pulse signal must be 100 ms;

— the pulse duration must be 150 ± 50 ms.

Reception of a pulse signal must cause interruption of any forward signal in course of transmission at the outgoing R2 register. It is sometimes impossible, however, to prevent a forward signal from being sent by the outgoing R2 register at the very moment when one of the backward signals A-3, A-4, A-6 or A-15 is sent in pulse form by the register at the incoming end.

To reduce the operating difficulties which may result, the incoming R2 register must be so designed that no forward multifrequency combination can be recognized during and after the transmission of signals A-4, A-6 or A-15 in pulse form or during 300 ± 100 ms from the start of transmission of the address-complete signal A-3 in pulse form (900 ± 180 ms when signal A-3 is transmitted over a satellite link) (see Figures 14/Q.442 and 15/Q.442). When the end of a pulse signal A-3 has been recognized in the outgoing R2 register, a Group II signal must be sent forward. The incoming R2 register will acknowledge this signal by a Group B signal.

On recognizing signal A-4, A-6 or A-15 no forward signal is sent by the outgoing R2 register. The end of these backward signals must cause the dismissal of the outgoing and incoming R2 registers in accordance with Recommendation Q.475.

The conditions under which pulse transmission of the backward signals A-3, A-4, A-6 or A-15 apply are specified in Section 5.

Figure 14/Q.442, p.

4.4 MULTIFREQUENCY SIGNALLING EQUIPMENT

Recommendation Q.450

4.4.1 GENERAL

Since System R2 can provide, in international working, end-to-end signalling from the outgoing international R2 register to an incoming R2 register at the called subscriber's local exchange (see Recommendation Q.440), the specifications for multifrequency signalling equipment take account of transmission conditions in both the international

and national networks. The incoming national network may include both 4-wire and 2-wire links.

However, it is assumed in the following specifications for multifrequency signalling equipment for outgoing international R2 registers and incoming R2 registers in international exchanges including the incoming international exchange that the registers are directly connected by four wires to the virtual switching points of the links. The registers thus contain a multifrequency signalling equipment with a transmitting part and a receiving part, each separately connected to the GO and RETURN path of the 4-wire circuit respectively (see Figure 16/Q.451).

When the outgoing international R2 register is situated in a national exchange preceding the outgoing international exchange, or when the incoming R2 register is situated in a national exchange following the incoming international exchange, special conditions apply (see Recommendation Q.457).

The upper and lower limits specified for the sending level and for the national extension attenuation leave a degree of freedom, thus simplifying the problem of interworking among different networks. The outgoing international R2 register relays the interregister signals by the method described in Recommendation Q.478. The present specification ensures that the system has an adequate range.

Recommendation Q.451

4.4.2 DEFINITIONS

4.4.2.1 *Multifrequency signalling equipment*

During the exchange of multifrequency combinations the link or multi-link section is terminated at both ends by equipment allowing multifrequency combinations to be sent and received under mutual, compelled control, as indicated in Recommendation Q.440. Generally speaking, the equipment involved in the signal transfer at each end of the multi-link section has the following functions:

— reception of multifrequency combinations;

— protection against disturbances (e.g. 2-out-of-*n* -check, 0-out-of-*n* -check, see Recommendation Q.458);

— transfer of signals to and from the registers or equivalent equipment;

— sending of multifrequency combinations.

This equipment as a whole can be considered as a single functional unit, henceforth called the multifrequency signalling equipment.

The functions of the multifrequency signalling equipment may be distributed among a number of sub-units, according to the design principles adopted in each particular case; these, within certain limits, are open to choice.

For the purpose of the present specification, the multifrequency signalling equipment is divided into a sending part and a receiving part.

a) *Four-wire multifrequency signalling equipment*

Multifrequency signalling equipment connected to the speech path by two pairs of wires is called 4-wire multifrequency signalling equipment (see Figure 16/Q.451). In such cases, the speech path itself is generally 4-wire too.

In Figure 16/Q.451, point B is the output of the sending part and point C the input to the receiving part of the 4-wire multifrequency signalling equipment. The latter includes the devices for protection against disturbances and the equipment for transferring signals to the register or equivalent equipment.

b) *Two-wire multifrequency signalling equipment*

Because different frequencies are used for interregister signalling in the two directions of transmission, a single pair of wires connecting the speech path to the multifrequency signalling equipment can be used for simultaneous sending and reception of multifrequency combinations.

Multifrequency signalling equipment connected to the speech path by a single pair of wires is called 2-wire multifrequency signalling equipment (see Figure 17/Q.451).

In Figure 17/Q.451, point A is the output of the sending part and, at the same time, the input to the receiving part. The latter includes the devices for protection against disturbances and for transferring signals to the register or equivalent equipment.

4.4.2.2 *Operate and release times of the receiving part of the signalling equipment*

The speed and reliability of the compelled interregister signal transfer is dependent on the operation and release times T_0, T_R, T'_0 and T'_R defined below. These times include the minimum recognition times referred to in § 4.4.5.3 below.

FIGURE 16/Q.451, p.

a) *Operation time*

If the two frequencies making up a multifrequency combination are applied simultaneously to the input of the receiving part of the multifrequency signalling equipment, the time interval between the application of both frequencies and recognition of the multifrequency combination is called operation time T_0.

If one of the two frequencies making up a multifrequency combination is applied to the input of the receiving part of the multifrequency signalling equipment somewhat after the other frequency, the time interval between the application of the second frequency and recognition of the multifrequency combination is called operation time T'_0.

b) *Release time*

If the two frequencies making up a multifrequency combination are simultaneously cut off from the input of the receiving part of the multifrequency signalling equipment, the time interval between the cut-off and recognition of the end of the multifrequency combination is called release time T_R.

If one of the two frequencies making up a multifrequency combination is cut off from the input of the receiving part of the multifrequency signalling equipment somewhat after the other frequency, the time interval between the cut-off of the second frequency and recognition of the end of the multifrequency combination is called release time T'_R.

4.4.2.3 *Internal operation time*

a) If the equipment at a switching centre has to analyse one or more of the signals received and if it has to carry out routing and switching operations before being able to determine which backward signal should be sent, it can delay completion of the compelled signalling cycle. Such delay depends on the function the centre has and on the design of the switching equipment used in it. The delay cannot therefore be specified.

The time required by an incoming R2 register to determine which backward signal to send in reply to a forward signal is denoted as $T_{int\,1}$ must therefore be kept to a minimum. Its value will be zero if the signal to be sent is already determined.

b) An outgoing R2 register sends a forward signal after interpreting the backward signal it has received. The time required to determine the appropriate signal is denoted as $T_{int\,2}$

c) At the end of a forward signal the incoming R2 register may have to perform certain functions in order to be ready to receive the next signal. The time required for these functions is denoted as $T_{int\ 3}$

4.4.3 REQUIREMENTS RELATING TO TRANSMISSION CONDITIONS

4.4.3.1 *Impedances*

The impedance Z_A measured at the terminals A (see Figure 17/Q.451) of a 2-wire multifrequency signalling equipment will have a nominal value equal to the nominal terminating impedance Z_T of the links at the exchange under consideration and will be balanced to earth. In most cases this value Z_T will be 600 ohms non-reactive. The impedance Z_A will then satisfy the conditions:

$$20 \log \left| \frac{00 + Z_A fR}{00 - Z_A fR} \right| \geq 10 \text{ dB} \qquad (1)$$

in the 300-3400 Hz band, and

$$20 \log \left| \frac{00 + Z_A fR}{00 - Z_A fR} \right| \geq 16 \text{ dB} \qquad (2)$$

in the 520-1160 Hz and 1360-2000 Hz bands.

The impedances Z_B and Z_C measured at the terminals B and C (see Figure 16/Q.451) of a 4-wire multifrequency signalling equipment will have a nominal value equal to the nominal terminating impedance Z_T at the exchange under consideration and will be balanced to earth. In most cases this value Z_T will be 600 ohms non-reactive. The impedances Z_B and Z_C will then satisfy condition (1) above in the 300-3400 Hz band and condition (2) above in the 520-1160 Hz or 1360-2000 Hz bands, according to the set of frequencies generated by the equipment concerned.

All the above requirements must be met, whether signalling frequencies are being transmitted or not.

4.4.3.2 *Echoes*

The balance return loss presented to the international link by different national networks varies considerably. Recommendation G.122 gives the desirable values based on transmission requirements and these values could hardly be improved on simply in order to facilitate signalling, especially as the balance return loss would then have to be very high.

The multifrequency signalling equipment must therefore function with an echo signal. Allowance is made for this in the test conditions (see Recommendation Q.455).

In order to eliminate disturbing and unwanted double-echo effects, outgoing international R2 registers must be provided with 4-wire signalling equipment; the 4-wire loop will then remain open at the outgoing end of the multi-link section during signalling.

For the same reason, it is recommended that 4-wire signalling equipment be provided whenever 4-wire switching equipment is used.

4.4.3.3 *Location and connection of mutifrequency signalling equipment associated with outgoing international R2 registers*

The multifrequency signalling equipment of the outgoing international R2 registers is assumed to be directly connected to the virtual switching point of the links in an international exchange. This equipment may be situated in a national switching centre of the country of origin on the

national network side of the outgoing international exchange provided that the 4-wire extension links between this centre and the outgoing international exchange have the same upper limit for the standard deviation of transmission loss variations with time (1 dB) as the international links.

Should the national extension links not have a nominal transmission loss of 0.5 dB between the national exchange and the virtual switching point in the outgoing international exchange, there must be suitable compensation of the power level of the multifrequency combinations.

Recommendation Q.454

4.4.4 THE SENDING PART OF THE MULTIFREQUENCY SIGNALLING EQUIPMENT

4.4.4.1 *Signalling frequencies*

The composition of the multifrequency combinations is specified in Recommendation Q.441.

The frequencies in the forward direction are:

f_0 = 1380, f_1 = 1500, f_2 = 1620, f_3 = 1740, f_4 = 1860, f_5 = 1980 Hz.

The frequencies in the backward direction are:

f_0 = 1140, f_1 = 1020, f_2 = 900, f_3 = 780, f_4 = 660, f_5 = 540 Hz.

The frequency variation at the sending point must not exceed ± | Hz relative to the nominal value.

4.4.4.2 *Absolute power level transmitted*

a) Four-wire multifrequency signalling equipment for outgoing international R2 and incoming R2 registers assumed to be directly connected to the virtual switching point in an international exchange:

i) The absolute power level of each non-modulated signalling frequency transmitted by the sending part of the multifrequency signalling equipment in the international exchange concerned will have a nominal value of —8 dBm0 with a tolerance ± | dB. At an analogue input of the exchange, this corresponds to —11.5 dBm ± 1 dB.

ii) The difference in level between the two signalling frequencies making up a multifrequency combination must be less than 1 dB.

The tolerances specified apply to the sending point itself, i.e. terminal B in Figure 16/Q.451.

b) Four-wire multifrequency signalling equipment for outgoing international R2 registers situated in a national exchange further down in the network of the country of origin:

i) The sending-level conditions mentioned above under a) are applicable in such national exchanges, provided that the national 4-wire extension links between the national exchange and the outgoing international exchange have the same nominal transmission loss (0.5 dB) and the same upper limit of standard deviation of transmission loss variations with time (1 dB) as the international links.

ii) If these national links do not have a nominal transmission loss of 0.5 dB, the level of interregister frequencies must be compensated as required.

c) Multifrequency signalling equipment for incoming R2 registers in national exchanges:

The nominal absolute power level N | f a single signalling frequency transmitted by the sending part of the multifrequency signalling equipment (2-wire or 4-wire) in any national exchange must be chosen within the limits: N
≥" A_b + 0,5 m + 2.3 $\sqrt{(m+k)+(m+k+1)0.04}$ — 31 dBm (1)

.sp 1 and N A_b — 11.5 dBm (2)

.sp 1 or $N A_b + 0.5\, m — 2.3 \sqrt{(m + k) + (m + k + 1)0.04}$ — 9 dBm (3)

.sp 1

whichever of (2) or (3) yields the lower value.

In order to avoid marginal operation, it is recommended that levels higher than the minimum levels given by formula (1) be specified.

In these formulae:

— m = the number of 4-wire links switched in tandem between the outgoing international R2 register and the incoming international exchange. The number m thus includes the national 4-wire extension links in the country of origin (see Recommendation Q.457) and the international links. In formula (1) m should always be given the maximum value 4. In formula (3), m should be given all its values, from minimum to maximum, and the lowest value so obtained or derived from formula (2) is to be taken as the upper limit of N .

— k = the number of national 4-wire extension links switched in tandem between the incoming international terminal exchange and the national exchange. The maximum value of k will be 4.

— A_b = the nominal transmission loss at 800 Hz in the backward direction between the output terminals of the sending part of the multifrequency signalling equipment of the incoming R2 register in the exchange under consideration and the *send* side of the virtual switching point of the backward speech path in the incoming international exchange.

Formulae (1), (2) and (3) were derived as shown in Annex A to Section 4.

The variation in level relative to the nominal value N | hosen for a given exchange must not exceed ± | dB.

However, the difference in level between the two signalling frequencies making up a multifrequency combination must not exceed 1 dB.

4.4.4.3 *Signalling frequency leak level*

The total power level of the leak current transmitted to line must be:

a) at least 50 dB below the nominal level of one signalling frequency when no multifrequency combination is being sent;

b) at least 30 dB below the level of either of the signalling frequencies when a multifrequency combination is being sent. Furthermore, any single leak current must be at least 34 dB below the level of either of the signalling frequencies when a multifrequency combination is being sent.

4.4.4.4 *Harmonic distortion and intermodulation*

The total power level of all frequencies due to harmonic distortion and intermodulation within the frequency band 300-3400 Hz must be at least 37 dB below the level of one signalling frequency.

4.4.4.5 *Time tolerance for multifrequency combinations*

The time interval between the start of sending of each of the two frequencies constituting a multifrequency combination must not exceed 1 ms.

The time interval between the cessation of sending of each of the two frequencies must not exceed 1 ms.

Recommendation Q.455

4.4.5 THE RECEIVING PART OF THE MULTIFREQUENCY EQUIPMENT

4.4.5.1 *Sensitivity range*

The power levels given below relate to the nominal impedance of the receiving part of the multifrequency signalling equipment.

The receiving part of the multifrequency signalling equipment shall have a sensitivity range of —31.5 dBm0 to —5 dBm0

For equipments already in service the sensitivity range is —35 dBm to —5 dBm.

4.4.5.2 *Operate and release time requirements*

The operating and release times of the receiving part of the multifrequency signalling equipment depend on the design and, for a given design, on:

— the time difference between the instants of reception of each of the two frequencies making up a multifrequency combination;

— the level of each of the two frequencies;

— the difference in level between the two frequencies;

— the level, spectrum and instant of onset of the noise.

The factors vary with transmission conditions. With certain types of switching equipment it may prove advisable to embody devices to counteract low-frequency disturbances in the multifrequency signalling equipment.

Time requirements have been specified for two types of *multifrequency test combinations* , A and B, applied to the input of the receiving part of the multifrequency signalling equipment in the presence of disturbing signals as specified below.

When test combinations and disturbing frequencies as specified under a) to c) below are applied to the terminals A (see Figure 17/Q.451) of 2-wire multifrequency signalling equipment or to the terminals C (see Figure 16/Q.451) of 4-wire multifrequency signalling equipment, the following time requirements must be met:

— for type A test combinations:

$$T_0 + T_R \quad 70 \text{ ms}$$

— for type B test combinations:

$$T_0 + T_R \quad 80 \text{ ms}$$

— for test combinations of types A and B:

$$(T'_0 + T'_R) \quad (T_0 + T_R) + 5 \text{ ms}$$

For definitions of T_0, T'_0, T_R, and T'_R see Recommendation Q.451.

For the third requirement, the only cases to be considered are those in which the frequency first appearing is also the first to disappear (transmission delay effect). The T'_0 and T'_R time requirements are specified to ensure proper functioning of the multifrequency signalling equipment when the received multifrequency combination is affected by group delay distortion, for example. The appropriate procedure for this test depends on the design of the equipment to be tested; in many cases it will be convenient to assume that a delay of one second or more for the second frequency constitutes the most unfavourable case.

When a multifrequency combination has caused the receiving part of the multifrequency signalling equipment to operate, the latter cannot release if the signal frequencies are interrupted for not more than 7 ms. A method of improving the system reliability in case of interrupted signals is described in Annex B of Section 4.

a) *Multifrequency test combinations type A*

— The multifrequency test combination consists of any 2-out-of-*n* combination of the *n* signalling frequencies;

— each frequency differs from the nominal frequency by not more than ± | Hz;

— the absolute power level of each of the two frequencies of the multifrequency combination lies between —5 dBm and —20 dBm;

— the difference in level between the two frequencies is not greater than 3 dB.

b) *Multifrequency test combinations type B*

— The multifrequency test combination consists of any 2-out-of-*n* combination of the *n* signalling frequencies;

— each frequency differs from the nominal frequency by not more than ± | 0 Hz;

— the absolute power level of each of the two frequencies of the multifrequency combination lies between —5 dBm and —35 dBm;

— the difference in level between the two frequencies is not greater than 5 dB for adjacent frequencies and 7 dB for non-adjacent frequencies.

c) *Disturbing frequencies*

The disturbing frequencies to be applied are:

— in all cases one or more of the *n* | requencies for which the receiving part under test is designed, with a total power level of —55 dBm or less, when no multifrequency test combination is being applied;

— when a multifrequency test combination is applied, one or more of the (*n* — 2) remaining frequencies with a total power level 20 dB below the highest test combination frequency level during application of the test combination;

— for testing the receiving part of 4-wire multifrequency signalling equipment in an outgoing international R2 register:

any multifrequency combination consisting of two frequencies out of the forward group of frequencies, each of these two frequencies having a level of 13.5 dB above the lowest test-combination frequency level in the backward direction; an upper limit of —12.5 dBm is nevertheless specified for the level of the disturbing signal.

System R2 interregister signalling may be used in the country of origin on the national links preceding the out-going international R2 register. In that case, the receiving part of 4-wire multifrequency signalling equipment connected to the forward speech path of the national 4-wire links may have to function in the presence of frequencies used in the backward direction. No general specification can be given for the level of these disturbing frequencies; it is recommended that Administrations formulate their own specifications.

— for testing the receiving part of 2-wire multifrequency signalling equipment:

any multifrequency combination at the highest level used in operational signalling (measured at point A, Figure 17/Q.451) by the sending part of the 2-wire multifrequency signalling equipment concerned.

4.4.5.3 *Non-operate and non-recognition requirements*

The receiving part of the multifrequency signalling equipment must remain in the *non-operate* state when the following disturbances, singly or together, are the only signals that are applied to the terminals A or C (see Figures 17/Q.451 and 16/Q.451):

— any single pure sine wave or any combination of two pure sine waves, each with a power level of —38.5 dBm0 within the 300-3400 Hz band;

— any single pure sine wave or any combination of two pure sine waves, each with a power level of —42 dBm within the 300-3400 Hz band;

For equipments already in service, the non-operation level is —42 dBm.

— any combination of two pure sine waves, each with a power level of —5 dBm within the 1300-3400 Hz band for the set of frequency receivers used in the backward direction; and within the 330-1150 Hz and 2130-3400 Hz bands for the set of frequency receivers used in the forward direction.

Furthermore, when signalling tones have activated the receiving part of the multifrequency signalling equipment, this must assume the *non-operate* state when the signalling tones are removed in the presence of these same disturbances, singly or together, at the above-mentioned terminals.

The receiving part of the multifrequency signalling equipment must not recognize a combination consisting of two signalling frequencies out of the set of frequencies normally used in the transmission direction considered, each having a level not exceeding —5 dBm and a duration of less than 7 ms.

The receiving part of the multifrequency signalling equipment must not recognize a combination consisting of two signalling frequencies used in the transmission direction considered, having a difference in level of 20 dB or more.

4.4.5.4 *Influence of transient disturbances* | see also Recommendation Q.458)

The recognition of faulty signals due to short-lived transient conditions can largely be avoided if a multifrequency combination is recognized only after a specified minimum time, during which two, and only two, of the individual receivers are active and if the absence of multifrequency combinations is recognized only after a minimum time, during which all individual receivers are at rest. These times are included in the operating and release times T_0 and T_R.

Typical transient disturbances, such as clicks, change of polarity, etc., generated by the switching equipment, must not change signals transferred from the receiving part of the signalling equipment to the register.

It is recommended that Administrations formulate their own specification for a test method according to the type of disturbances encountered in their switching equipment.

4.5 RANGE, SPEED AND RELIABILITY

OF INTERREGISTER SIGNALLING

Recommendation Q.457

4.5.1 RANGE OF INTERREGISTER SIGNALLING

4.5.1.1 *Number of international links*

The number of international links switched in tandem for establishing an international connection using System R2 must not exceed 4 (see Recommendation Q.440).

Assumptions for the transmission loss in 4-wire international links:

i) nominal transmission loss at 800 Hz: 0.5 dB (Recommendation G.101, § 5);

ii) standard deviation of transmission loss variations with time must not exceed 1 dB [Recommendation G.151, § 3, a)];

iii) the difference between the mean value and the nominal is assumed to be 0 [as in Recommendations G.122, § 1.2), and G.131, § 1].

4.5.1.2 *Number of national links*

a) *Outgoing international R2 register and number of national 4-wire extension links in the country of origin*

The outgoing international R2 register is always provided with 4-wire multifrequency signalling equipment and the 4-wire loop will be open during interregister signalling.

The outgoing international R2 register must be placed in an exchange from where the incoming international exchange in the country of destination is reached by not more than four 4-wire links switched in tandem (see Recommendation Q.440).

It is understood that the national 4-wire links in the country of origin shall have the same standard deviation of transmission loss variations with time (1 dB) as the international links and that, if these national links do not have the same nominal transmission loss as the international links

(0.5 dB), appropriate compensation of the multifrequency combination levels will be made in both directions of transmission.

b) *Number (k) of national 4-wire extension links in the country of destination*

Not more than four national 4-wire extension links may be used.

Forward transmission loss in the country of destination:

i) The standard deviation of transmission loss variations with time in the national 4-wire extension links in the country of destination must not exceed 1 dB.

ii) The nominal transmission loss at 800 Hz in the forward direction (A_f) between the virtual switching point in the incoming international exchange and any incoming R2 register in the country of destination must not exceed:

11.4 dB for a country using 3 national 4-wire extension links at the most

or

11.0 dB for a country using 4 national 4-wire extension links at the most,

and must never be less than:

$$A_{f\,\mathrm{min}} = 2.5 + 0.5\,m + 2.3\sqrt{(m+k)+(m+k+1)0.04}\ \mathrm{dB}.$$

The values for the minimum forward transmission loss $A_{f\,\mathrm{min}}$ resulting from this formula are shown in Table 10/Q.457 (for the definitions of *m* and *k* see Recommendation Q.454). In practice the forward transmission loss must not fall below these values.

The formula has been determined as shown in Annex C to Section 4.

When System R2 end-to-end signalling is applied in a national network, the 4-wire links involved may not conform to the characteristics specified by the CCITT for international circuits. Also, national transmission plans may be based on principles different from those of the international transmission plan. Consequently, the range over which end-to-end signalling is possible must be established using calculations, e.g. as shown in Annex C to Section 4 (see also §§ 4.5.1.3 and 4.5.1.4 below).

Table 10/Q.457, p.

4.5.1.3 *Total attenuation distortion*

It has been assumed that at all frequencies within the 530-1990 Hz band the overall attenuation distortion relative to 800 Hz between the outgoing international R2 register and any incoming R2 register will not exceed ± | dB. Attention is drawn to the fact that on some national connections these assumptions might not be fulfilled.

As type B test signals (see Recommendation Q.455) allow for a 5 dB difference in level between two adjacent signalling frequencies, and a 7 dB difference between two non-adjacent signalling frequencies, a 4 dB attenuation distortion of the multi-link section can be allowed for two adjacent frequencies and a 6 dB distortion for two non-adjacent frequencies, provided that the level of the weakest signalling frequency is not lower than —35 dBm at the terminals of the receiving part of the multifrequency signalling equipment.

The values 4 dB and 6 dB were obtained by allowing for a 1 dB difference in sending level.

4.5.1.4 *Intermodulation*

A multifrequency signalling system in conformity with the above specifications will allow satisfactory working over a multi-link section introducing intermodulation products from two signalling frequencies and falling within the 520-1160 Hz and 1360-2000 Hz bands, the level of each of such products being at least 24 dB below the highest signal frequency level.

4.5.2 *Build-up and time specification of a complete forward compelled signalling cycle*

Figure 18/Q.457 shows in detail the build-up and time sequence of a compelled signalling cycle.

Figure 18/Q.457 p.

In this figure:

$T_{P\backslash \mathrm{d}F}$ denotes the transmission delay of the slower of the two frequencies of a forward multifrequency combination;

$T_{P\backslash \mathrm{d}B}$ denotes the transmission delay of the slower of the two frequencies of a backward multifrequency combination;

T_0 and T'_0 denote the operating times as defined in Recommendation Q.451;

T_R and T'_R denote the release times as defined in Recommendation Q.451;

$T_{int\,1}$, $T_{int\,2}$ and $T_{int\,3}$ denote the internal operation times as defined in Recommendation Q.451.

If the values of $T_{int\,2}$ and $T_{int\,3}$ lie within certain limits, they do not contribute to the total duration of the compelled signalling cycle, as can be seen from Figure 18/Q.457.

T_{S1} and T_{S2} denote respectively the time required for starting and stopping the sending of a multifrequency combination (switching-on or switching-off times, exclusive of logic operations).

It thus appears that the total duration T of a complete compelled signalling cycle is given by the formula:

$$T = 2(T_{PF} + T_{PB}) + \left\{ (T'_0 + T'_R)_D + (T'_0 + T'_R)_A \right\} + T_{int\,1} + (T_{S1} + T_{S2})_D + (T_{S1} + T_{S2})_A$$

or

The subscripts D and A apply respectively to the outgoing and the incoming registers.

T_{PF} and T_{PB} depend on the propagation characteristics of the forward and backward speech paths respectively and therefore cannot be specified.

A value of 10 ms for T_{PF} and T_{PB} can be considered as typical, e.g. for average terrestrial regional connections and 320 ms for circuits including a satellite link.

The maximum value of $T_0 + T_R$ has been fixed at 70 ms. A value of 35 ms could be taken in a certain number of cases as representing the minimum duration of $T_0 + T_R$.

$T_{int\,1}$, $T_{int\,2}$ and $T_{int\,3}$ are dependent on the type of exchange and therefore cannot be specified; but their contribution to the total duration of the compelled signalling cycle must be kept as small as possible.

If the influence of $T_{int\,1}$, $T_{int\,2}$ and $T_{int\,3}$ is ignored, and if the extreme values of $T_0 + T_R$ and for $T_{S1} + T_{S2}$ are assumed to be identical for the outgoing and the incoming register, the extreme values of $T_{S1} + T_{S2}$ being taken as 5 ms $T_{S1} + T_2$ 10 ms and if the value of 10 ms indicated above as typical is adopted for T_{PF} and T_{PB}, the probable extreme values of the compelled signalling cycle T would be:

for terrestrial connections: 120 ms T 200 ms.

for circuits including a satellite link: 1080 ms T 1440 ms.

The signalling rates would be between approximately 8 and 5 signalling cycles per second for terrestrial circuits. These values are not absolute limits; the signalling cycle could, for example, be longer on a complex connection or in the presence of noise or other conditions approaching those of type B test combinations (see Recommendation Q.455).

Recommendation Q.458

4.5.3 RELIABILITY OF INTERREGISTER SIGNALLING

4.5.3.1 *General*

In signal transmission, reliability and speed are to some extent conflict requirements: the slower the signalling, the more reliable it is likely to be. System R2 combines the two essential requirements of speed and reliability, since it is a compelled system, adapting its signalling speed to the working conditions with minimum loss of reliability.

System R2 is protected against the acceptance of faulty information (multifrequency combinations consisting either of one frequency only or of more than two frequencies) by means of the *2-out-of-n* method of checking the number of frequencies received.

This protection is inoperative in the case of disturbances (noise, clicks, etc.) activating two, and only two, of the single frequency receivers; nor does it prevent the release of all the receivers (thus wrongly indicating the end of a multifrequency combination) in the event of an interruption caused by disturbances during transmission of a multifrequency combination.

Disturbances causing the operation of two single frequency receivers or the release of all the receivers are due mainly to short-lived, transient conditions. The recognition of faulty information due to such conditions can therefore largely be avoided by so designing the receiving part of the multifrequency signalling equipment that a multifrequency combination will be recognized only after a specified minimum time. During this time two, and only two, of the individual receivers are active and the absence of multifrequency combinations will be recognized only after a specified minimum time, during which all individual receivers are at rest. The degree of protection against faults due to the above-mentioned conditions is dependent on these times, which are included in the operating and release times defined for the receiving part of the multifrequency signalling equipment in Recommendation Q.451.

4.5.3.2 *Error rate for compelled working*

The test of the multifrequency signalling equipment as a whole consists in continuous, compelled transmission of multifrequency combinations.

It must be ensured that all possible combinations of the forward and backward multifrequency combinations have equal probability of occurrence during the test period.

The error rate is observed at the receiving part at both ends of the link and is defined, for each end, as the number of errors divided by the number of combinations sent by the corresponding sending parts at each end of the link.

It is for each Administration to define the sources of permanent and impulsive noise to be applied to the interface between the sending and receiving parts in the light of its experience and local conditions.

The compelled working may be tested, on the one hand, by using test combinations of Type A (see Recommendation Q.455) in the presence of noise at a power level of —40 dBm and a uniform power distribution in the 300-3400 Hz band (filtered white noise) and, on the other hand, by using Type B test combinations in the presence of noise at a power level of —45 dBm and a uniform power distribution in the 300-3400 Hz band.

The error rates in these conditions will be:

— for Type A test combinations and noise at —40 dBm: 10^{D}lF261^{5};

— for Type B test combinations and noise at —45 dBm: 10^{D}lF261^{4}.

ANNEX A
(to Section 4)

(see Recommendation Q.454)

Development of formulae for the power level of signalling frequencies

The formulae (1), (2), and (3) of Recommendation Q.454 describing the nominal absolute power level N of a transmitted single signalling frequency were derived as follows:

1. The nominal transmission loss in the backward direction between the incoming R2 register and the outgoing international R2 register is given by (see Recommendation Q.457):

$$A_b + 0.5\, m \ \text{dB.}$$

2. On the assumption that the contribution of the national 2-wire links to transmission loss variations with time is negligible and with allowance for the standard deviation of transmission loss variations with time of the international and national 4-wire circuits and in the exchanges (see CCITT Recommendation Q.45: σ = 0.2 dB), the total transmission loss variation for a 1% probability of it being exceeded is given by:

$$\pm 2.3 \sqrt{(m+k)+(m+k+1)(0.2)^2} \ \text{dB.}$$

3. Given a total attenuation distortion of ± | dB relative to 800 Hz (see Recommendation Q.457) and a tolerance of ± | dB on the nominal power level N , the lower and upper limits of the level received in the outgoing international R2 register will be:

$$N - A - b\sqrt{(m+k)+(m+k+1)0.04} - 0.5\,m - 2.3 - 3 - 1 \text{ dBm}$$

and

$$N - A - b\sqrt{(m+k)+(m+k+1)0.04} - 0.5\,m + 2.3 + 3 + 1 \text{ dBm.}$$

respectively.

4. The receiving part of the multifrequency signalling equipment has a sensitivity range between

—35 dBm and —5 dBm (see Recommendation Q.455).

The minimum value of N | s thus given by:

$$\frac{N - A}{b} - 0.5\,m + 2.3\sqrt{(m + k)+(m + k + 1)0.04} - 4 = -35 \text{ dBm}$$

hence

$$\frac{N \geq'' A}{b} + 0.5\,m + 2.3\sqrt{(m + k)+(m + k + 1)0.04} - 31 \text{ dBm}$$

(1)

The maximum value of N | s given by:

$$\frac{N - A}{b} - 0.5\,m + 2.3\sqrt{(m + k)+(m + k + 1)0.04} + 4 = -5 \text{ dBm}$$

hence

$$\frac{N \quad A}{b} + 0.5\,m - 2.3\sqrt{(m + k)+(m + k + 1)0.04} - 9 \text{ dBm}$$

(3)

5. The nominal level of the backward signals at the virtual switching point of the incoming international exchange must not be higher than —11.5 dBm; thus

$$\frac{N - A}{b} - 11.5 \text{ dBm}$$

hence

$$\frac{N \quad A}{b} - 11.5 \text{ dBm.}$$

(2)

ANNEX B
(to Section 4)

(see Recommendation Q.455)

Possible method of improving protection from interruptions

If the receivers are locked through an internal function of the registers until the times Q and S (see Figure B-1) the intervals during which there is a risk that interruptions may cause their release are reduced by PQ and RS respectively.

This method can be used on both terrestrial and satellite circuits.

To ensure that the duration of the compelled signalling cycle is not prolonged on terrestrial circuits (short transmission delay). PQ and RS must be calculated with:

$$T_{P\backslash dF} = T_{P\backslash dB} = 0 \text{ ms: } PQ \quad T_{i\backslash dn\backslash dt\backslash d1} + T_{S\backslash d1} + T_0 + T_{S\backslash d2}$$

and

$$RS \quad T_{S\backslash d2} + T_R + T_{S\backslash d2}$$

To ensure that the duration of the compelled signalling cycle is not prolonged on satellite circuits (long transmission delay) PQ and RS must be calculated with:

$$T_{P\backslash dF} + T_{P\backslash dB} = 250 \text{ ms: } PQ \quad 500 \text{ ms} + T_{i\backslash dn\backslash dt\backslash d1} + T_{S\backslash d1} + T_0 + T_{S\backslash d2}$$

and

RS 500 ms + $T_{S\backslash d2} + T_R + T_{S\backslash d2}$.bp

Figure B-1/Q.455, p.

ANNEX C
(to Section 4)

(see Recommendation Q.457)

Development of a formula for the admissible forward

transmission loss in a country of destination

The formula used in Recommendation Q.457 for the calculation of the minimum forward transmission loss $A_{f\,\min}$ a country of destination was determined as follows:

1. According to Recommendation Q.454 the lowest and highest sending levels will be, respectively,

—11.5 — 1 = —12.5 dBm

and

—11.5 + 1 = —10.5 dBm.

2. Let A_f be the nominal transmission loss at 800 Hz in the forward direction, between the virtual switching point in the incoming international exchange and the incoming R2 register concerned.

The total nominal transmission loss between the outgoing international R2 register and the incoming R2 register will then be:

$$A_f + 0.5m \text{ dB.}$$

3. On the assumption that the contribution of the national 2-wire links to transmission loss variations with time is negligible, and that the standard deviation of transmission loss variation in the exchange is 0.2 dB (see Recommendation Q.45), the total transmission loss variation, calculated for a 1% probability of it being exceeded will be:

$$\pm 2.3\sqrt{(m+k)+(m+k+1)0.2^2} \text{ dB.}$$

4. With allowance for a total attenuation distortion of ±1 dB relative to 800 Hz (see Recommendation Q.457) the lower and upper limits of the level of each frequency at the input of the incoming R2 register will be respectively:

$$-12.5 - A_f - 0.5m - 2.3\sqrt{(m+k)+(m+k+1)0.04} - 3 \text{ dBm}$$

and

$$-10.5 - A_f - 0.5m + 2.3\sqrt{(m+k)+(m+k+1)0.04} + 3 \text{ dBm.}$$

5. The receiving part of the multifrequency signalling equipment has a sensitivity range of —35 dBm to —5 dBm.

6. The maximum value of A_f is thus given by:

$$-12.5 - A_{f\,max} - 0.5m - 2.3\sqrt{(m+k)+(m+k+1)0.04} - 3 = -35 \text{ dBm}$$

hence

$$A_{f\,max} = 19.5 - 0.5\,m - 2.3\sqrt{(m+k)+(m+k+1)0.04}\ \text{dB}.$$

7. The minimum value for A_f is given by:

$$-10.5 - A_{f\,min} - 0.5\,m + 2.3\sqrt{(m+k)+(m+k+1)0.04} + 3 = -5\ \text{dB}$$

hence

$$A_{f\,min} = -2.5 - 0.5\,m + 2.3\sqrt{(m+k)+(m+k+1)0.04}\ \text{dB}.$$

According to Recommendation Q.457, the maximum number of 4-wire links with *international* characteristics is $m = 4$.

The maximum number of national 4-wire extension links is $k = 4$.

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SECTION 5

SIGNALLING PROCEDURES

A major characteristic of System R2 is the inherent flexibility in the interregister signalling procedures which allow efficient signal information transfer, adapted to the particular requirements relating to different call types, traffic conditions and switching equipments. This flexibility is primarily achieved by the principle that the interregister signalling sequence is controlled by the incoming R2 register by means of backward signals.

In this context the function of an outgoing R2 register is basically to respond with the forward signal requested by the incoming R2 register. At the incoming R2 register the determination of the backward signal to be sent, thus controlling the signalling sequence, is closely related to the analysis necessary to determine the routing and handling of the call.

In this Section the signalling procedures are specified. Although System R2 in principle allows a high degree of freedom in the combination of these procedures within the signalling sequence for call set-up, the procedures to be used for normal international calls connected via terrestrial links are described below. These procedures may vary when a satellite link is employed in a connection because the register at the incoming end of a satellite link also acts as an outgoing R2 register (see Recommendation Q.440, § 4.1.1). For national application of System R2 the signalling sequences to be applied have to be defined in accordance with the limitations of the present specifications by the Administration concerned.

Recommendation Q.460

5.1
NORMAL CALL SET-UP PROCEDURES FOR INTERNATIONAL WORKING

5.1.1 *General*

During call set-up an outgoing international R2 register is connected to an international link. This register signals to at least one incoming R2 register situated in an international exchange and possibly, depending upon the routing, to as many as 4 successive incoming R2 registers in international exchanges and 4 successive incoming R2 registers situated in national exchanges in the destination country where System R2 is employed.

The duration of the normal call set-up procedure can vary because different phases of the signalling sequence between the outgoing international R2 register and successive incoming R2 registers may be repeated.

Recommendation Q.462

5.1.2
SIGNALLING BETWEEN THE OUTGOING INTERNATIONAL R2

REGISTER AND AN INCOMING R2 REGISTER IN AN INTERNATIONAL EXCHANGE

The address signals from an operator or a subscriber must be stored in an outgoing international R2 register. When a sufficient number of digits is available an outgoing link is selected and a seizing (line) signal is sent. When the seizing signal is recognized an incoming R2 register is associated with the link.

Immediately the outgoing link is seized the outgoing international R2 register sends the first interregister signal.

5.1.2.1 *Signalling to an international transit exchange*

When the outgoing link is to an international exchange from which a transit routing is required to the destination country, the first interregister signal sent is a country code indicator. This is one of signals I-11, I-12, I-14 depending upon the requirement for echo suppressors (see Recommendation Q.479).

On recognition of a country code indicator the incoming R2 register determines that the call is to be internationally transit switched. The incoming R2 register sends signal A-1 when it requests the first digit of the country code. The outgoing international R2 register sends this address digit (a signal I-1 to I-10). The incoming R2 register may send signal A-1 to request the next digit.

The incoming R2 register examines the address digit(s) and if a further digit (or digits) is required for routing, signal A-1 is sent to request the next digit.

When sufficient digits are stored at the incoming exchange to permit the call to be routed to the next exchange, the backward signal is determined by the nature of the signalling system employed on the outgoing link.

a) If the outgoing link employs System R2, one of two backward signals is sent immediately the outgoing link is seized:

i) If the outgoing link is to another international transit exchange from which a transit routing is required to the destination country, signal A-11 is sent to request repetition of the country code indicator.

On recognition of signal A-11 the outgoing international R2 register sends a country code indicator as the first signal to be received by the incoming R2 register in the next international transit exchange. This is one of signals I-12 or I-14. If signal I-11 was sent initially, signal I-14 is sent subsequently.

On recognition of a country code indicator the incoming R2 register determines that the call is to be internationally transit switched. The signalling procedure which follows is identical to that described above.

ii) If the outgoing link is to an incoming international exchange in the destination country, signal A-12 is sent to

request a language or discriminating digit.

In both these cases after the backward signal is sent and the compelled signalling sequence is complete, the transit exchange releases the incoming R2 register and through-connects the speech-path between the outgoing exchange and the next exchange.

b) If the outgoing link employs a signalling system other than System R2, then the acting incoming R2 register is the last incoming R2 register. The exchange seizes an outgoing international link to a further international transit exchange or an incoming international exchange in the destination country. Signalling continues between the outgoing international R2 register and the last incoming R2 register and interworking takes place with the other signalling system.

If congestion is encountered signal A-15 is sent, if necessary in pulse form. After the compelled signalling sequence is complete or after the end of the pulse signal the transit exchange dismisses the register.

On recognition of signal A-15 the outgoing exchange may initiate a repeat attempt, a re-routing or cause the return of congestion information to the calling subscriber. In all cases the outgoing (multi-)link section is released.

5.1.2.2 *Signalling to an incoming international exchange in the destination country*

When the outgoing international link is a direct link to an incoming international exchange in the destination country the first interregister signal sent is a language or discriminating digit.

Alternately, if the outgoing multi-link section is routed via one, two or three international transit exchanges then on recognition of signal A-12 the outgoing international R2 register sends a language or discriminating digit as the first signal to be received by the incoming R2 register in the terminal international exchange in the destination country.

The first signal A-12 received from an international transit exchange by the outgoing international R2 register informs it that an international link terminating at an incoming international exchange has been added to the (multi-)link section.

In both cases, on recognition of a language or discriminating digit (a signal I-1 to I-10), the incoming R2 register determines that the call is to be routed to the national network, and selects the next backward signal:

i) The incoming R2 register may send signal A-14 to request information about the requirement for echo suppression.

— If an incoming half-echo suppressor is required the outgoing international R2 register sends signal I-14.

In response to signal I-14 the incoming R2 register sends signal A-1 to request the first digit of the national (significant) number. In response to signal A-1 the outgoing international R2 register sends the first digit of the national (significant) number.

— If no echo suppressor is required the outgoing international R2 register sends the first digit of the national (significant) number.

ii) Alternatively, if it is known that no echo suppressor is required to be inserted the incoming R2 register may send signal A-1 to request the first digit of the national (significant) number. In response to signal A-1 the outgoing international R2 register sends the first digit of the national (significant) number.

The incoming R2 register examines the first digit of the national (significant) number and if a further digit (or digits) is required for routing, signal A-1 is sent to request the next digit.

When sufficient digits are stored at the incoming exchange to permit the call to be routed to the next exchange the backward signal (if any) is determined by the nature of the signalling system employed on the outgoing link and the national routing principles.

a) If the outgoing national link employs System R2 and international/national end-to-end signalling is used, a backward signal may be sent after the outgoing link is seized to request the address digit required as the first signal to be received by the incoming R2 register in the following national exchange.

The appropriate signal is one of signals A-1, A-2, A-7, A-8 or A-12. These signals may be sent after any digit, and can be repeated provided they do not conflict with the logic procedure.

However, if the address digit *on-line* | s the digit required as the first signal to be received by the incoming R2 register in the next exchange, it is possible for the transit exchange to release the incoming R2 register and through-connect the speech-path after the outgoing link is seized without sending a backward signal.

Otherwise, after the appropriate backward signal is sent and the compelled signalling sequence is complete the transit exchange releases the register and through-connects the speech path.

b) If the outgoing national link employs System R2 but end-to-end international/national signalling cannot be used, the register in the incoming international exchange relays the multifrequency signals: it acts as an outgoing R2 register. It requests the remainder of the address digits by repetitive use of signal A-1. The digits received by the outgoing R2 register are retransmitted over the outgoing national link at the request of the incoming R2 register in the following national exchange(s) (see Recommendation Q.478).

c) If the outgoing link employs a signalling system other than System R2 then the acting incoming R2 register is the last incoming R2 register. The exchange seizes a national link. Signalling continues between the outgoing international R2 register and the last incoming R2 register and interworking takes place with the other signalling system.

If congestion is encountered, congestion signal A-4 or A-15 is transmitted (if necessary in pulse form) and the incoming R2 register is dismissed.

On recognition of the congestion signal A-4 the outgoing exchange releases the outgoing link or connection and causes the return of congestion information to the calling subscriber.

On recognition of the congestion signal A-15 the outgoing exchange may initiate a repeat attempt, re-routing or cause the return of congestion information to the calling subscriber. In all cases the outgoing link or connection is released.

It is desirable to use the congestion signal A-15 solely in the case of incoming international terminal traffic when repeat attempt or re-routing may be expected to be successful.

Recommendation Q.463

5.1.3 SIGNALLING BETWEEN THE OUTGOING INTERNATIONAL | R2 REGISTER AND AN INCOMING R2 REGISTER IN A | NATIONAL EXCHANGE IN THE

DESTINATION COUNTRY

5.1.3.1 *Signalling to a national transit exchange*

The outgoing international R2 register sends the requested address digit as the first signal to be received by the incoming R2 register in the national transit exchange in the destination country.

The incoming R2 register examines the digit and if a further digit (or digits) is required for routing, signal A-1 is sent to request the next digit.

When sufficient digits are stored at the incoming exchange to permit the call to be routed to the next exchange the backward signal (if any) is determined by the nature of the signalling system employed on the outgoing link and the national routing principles.

a) If the outgoing national link employs System R2 a backward signal may be sent after the outgoing link is seized to request the address digit required as the first signal to be received by the incoming R2 register in the next exchange. The signalling procedure which occurs is similar to that described in § 5.1.2.2 a) above.

b) If the outgoing link employs System R2 but end-to-end international/national signalling cannot be used, the register in the national exchange relays the interregister signals: it acts as an outgoing R2 register. The digits received by this outgoing R2 register are retransmitted over the outgoing link at the request of the incoming R2 register in the following exchange(s) (see Recommendation Q.478).

c) If the outgoing link employs a signalling system other than System R2 then the acting incoming R2 register is the last incoming R2 register. The exchange seizes an outgoing national link to the next national exchange. Signalling continues between the outgoing international R2 register and the last incoming R2 register and interworking takes place with the other signalling system.

If congestion is encountered signal A-4 is sent (if necessary in pulse form) and the incoming R2 register is released.

On recognition of congestion signal A-4 the outgoing exchange releases the outgoing multi-link section and causes the return of congestion information to the calling subscriber.

5.1.3.2 *Signalling to a national exchange to which the called subscriber is connected*

When the outgoing multi-link section is routed to the national exchange to which the called subscriber is connected the acting incoming R2

register is the last incoming R2 register: the outgoing international R2 register sends the requested address digit as the first signal to be received by the last incoming R2 register and signalling continues as described below.

Recommendation Q.464

5.1.4
SIGNALLING BETWEEN THE OUTGOING INTERNATIONAL R2

REGISTER AND THE LAST INCOMING R2 REGISTER

5.1.4.1 *General*

The usual System R2 signalling procedure is to request in succession the remainder of the address digits stored in the outgoing international R2 register by the repetitive use of signal A-1 until it is determined at the incoming end that the complete address information has been received by the incoming exchange or that the call cannot be routed.

System R2 enables transmission of information concerning a large number of different conditions of called subscriber's line or reasons why call set-up has failed. But this can only be sent if the switching systems and other signalling systems employed on the remaining links of the connection offer the possibility of differentiating several line conditions. Group B-signals are provided for this purpose.

Transition from Group A to Group B meanings is indicated by means of address-complete signal A-3. However, if the incoming exchange is unable to send any signals concerning the condition of the called subscriber's line it is unnecessary to send signal A-3 followed by a Group B signal. In such cases the address-complete signal A-6, provided for the purpose is used.

If congestion is encountered after transmission of the address-complete signal A-3 the congestion signal B-4 is sent in place of signal A-4 or A-15.

5.1.4.2 *When the last incoming R2 register is able to transmit the condition of the called subscriber's line*

When the condition of the called subscriber's line can be determined the incoming R2 register can send signals conveying this information after receipt of the address digits.

As soon as the last address digit is received the last incoming R2 register sends the address-complete signal A-3 to announce changeover to the transmission of Group B signals. In response the outgoing international R2 register sends the appropriate calling party's category signal (II-7 to II-10). The last incoming R2 register acknowledges this with the relevant Group B signal indicating the condition of the called subscriber's line.

Immediately the compelled signalling sequence is complete the incoming R2 register is released and depending upon the Group B signal sent the speech-path may be through-connected.

When the condition of the called subscriber's line is determined by an electrical signal to the last incoming R2 register and if the called subscriber's line is free the address-complete signal A-6 can be sent instead of signal A-3, possibly in pulse form. This will be the last interregister signal. After signal A-6 is sent the incoming R2 register is released, the

speech-path is through-connected and ringing tone returned to the calling subscriber. Outgoing international R2 registers must be able to interpret all Group B signals.

On recognition of the last backward signal the outgoing exchange releases the outgoing international R2 register and either through-connects the speech-path or releases the outgoing connection and causes the return of an appropriate tone or special announcement or both alternately to the calling subscriber.

5.1.4.3 *When the last incoming R2 register is not able to transmit the condition of the called subscriber's line*

In this case the last incoming R2 register sends the address-complete signal A-6, possibly in pulse form, as the last interregister signal. After this is sent, the last incoming R2 register is released and the speech-path is through-connected.

When the last incoming R2 register is in the exchange to which the called subscriber is connected, an appropriate tone is returned to the calling subscriber from this exchange.

On recognition of address-complete signal A-6, the outgoing exchange releases the outgoing international R2 register and through-connects the speech-path. The calling subscriber will then hear ringing tone, busy tone, special information tone or a recorded announcement alternately with special information tone sent by the incoming equipment.

Recommendation Q.465

5.1.5 PARTICULAR CASES

5.1.5.1 *Unallocated number*

When, after the reception of any digit, the incoming R2 register determines that the address information corresponds to an unallocated number, the address-complete signal A-3 is sent immediately without requesting all the address digits. In response the outgoing international R2 register sends the appropriate Group II signal. This is then acknowledged by signal B-5 *unallocated number* .

5.1.5.2 *Congestion in the national network*

If congestion is encountered in the national network the incoming R2 register sends congestion signal A-4, possibly in pulse form. However, if address-complete signal A-3 has already been sent, congestion signal B-4 is sent in acknowledgement of the Group II signal which commences the last compelled signalling sequence.

5.1.5.3 *Operator calls*

The procedures described in Recommendations Q.462-Q.464 are also valid for a semi-automatic call. However, in this case the address information is always terminated by the end-of-pulsing signal I-15.

For code 11 or code 12 calls only a limited number of backward signals can be employed as the last interregister signal (e.g. signal A-4, A-6 or B-6).

5.1.5.4 *Request of calling party's category*

At any time calling party's category information may be requested by the incoming R2 register interrupting the normal transmission of address information. The incoming R2 register sends signal A-5 in acknow ledgement of a Group I signal and the outgoing international R2 register sends the appropriate Group II signal (a signal II-7 to II-10) in reply. If this Group II signal is acknowledged by a signal different from address-complete signal A-3 or signal A-5 the next forward signal sent will be one of the Group I.

Recommendation Q.466

5.1.6 SUPERVISION AND RELEASE OF THE CALL

An answer signal is sent when the called subscriber's off-hook condition is detected. Each transit exchange in the connection, relays this line signal. At the outgoing international exchange, receipt of the answer signal normally causes call charging to take place and metering for international accounting purposes to start.

When the called subscriber’s on-hook condition is detected a clear-back signal is sent and relayed by each transit exchange.

When the calling subscriber’s on-hook condition is detected a clear-forward signal is relayed by the outgoing international exchange over the outgoing international link. On receipt of the clear-forward signal on an incoming link, release operations are initiated and the clear-forward signal is repeated forward on the outgoing link.

Immediately release operations at an exchange are complete (although the outgoing circuit may still be held) a release-guard sequence is initiated on the incoming link. After recognition of the end of the release-guard sequence at the outgoing exchange the link reverts to the idle state.

Supervision of a call must be in accordance with Recommendation Q.118.

Recommendation Q.468

5.2 ROUTING AND NUMBERING FOR INTERNATIONAL WORKING

(See Recommendations Q.107 and Q.107 **|** fIbis , Fascicle VI.1.)

5.3
TERMINATION OF INTERREGISTER SIGNALLING

Recommendation Q.470

5.3.1 AT AN INCOMING R2 REGISTER SITUATED IN A TRANSIT EXCHANGE

5.3.1.1 *Successful routing*

Normally, interregister signalling is terminated in one of the following ways:

a) The last forward interregister signal received by the incoming R2 register at the transit exchange is not acknowledged from that register. After an outgoing link to the next exchange is seized, the register is dismissed and the speech-path is through-connected. The forward signal remains on-line and is the first signal received by the next incoming R2 register. Provision must be made for the switching operations to be completed so as to ensure that the signal will remain on-line and be received by the succeeding register.

b) The last forward interregister signal received by the incoming R2 register at the transit exchange is acknowledged by a backward signal (A-1, A-2, A-7, A-8, A-11 or A-12) requesting transmission of a clearly specified signal as the first to be received by the next incoming R2 register. When the compelled signalling sequence is complete the register is dismissed and the speech-path is through-connected.

Because it is not possible to send signals A-2, A-7, A-8, A-11 or A-12 in pulse form, precautions are necessary to

avoid acknowledging the last address digit (on automatic calls) until the signalling system employed on the outgoing link is known. If signal A-1 is sent in acknowledgement of the last address digit and if the outgoing link employs System R2 it may not then be possible to send one of these signals and therefore end-to-end signalling to the next exchange is no longer feasible (see also Recommendation Q.474).

In international working signals A-2, A-7 and A-8 may be used to acknowledge receipt of any forward signal.

Signal A-11 must be used to request a country code indicator.

Signal A-12 must generally be used to request the language or discriminating digit. However, in the case where an incoming R2 register is equipped with only 5 backward signalling frequencies only one of the signals A-2, A-7 or A-8 can be used for this purpose. Attention is drawn to the fact that in this case the language or discriminating digit may not be sent by all outgoing international R2 registers.

Although it is not normally necessary to request a repeat of a digit *n* because it remains on the line until acknowledged (but see

Recommendation Q.476) such repetition may prove necessary after an interruption of digit transmission (e.g. to request information concerning the calling party’s category) or if the completion of switching operations referred to in method *a)* above, cannot be guaranteed with a time compatible with the time-out of the outgoing (international) R2 register (see Recommendation Q.476). The procedure is then as follows:

Signal A-2 is sent, eliciting the digit *n* -1; this is immediately acknowledged by signal A-1 to elicit the required digit *n* . When the digit *n* in question is the first digit in the store of the outgoing R2 register this procedure is not applicable.

At an international transit exchange method *b)* above, must be used and only one of the signals A-11 or A-12 applies.

When the outgoing link connects to a further international transit exchange signal A-11 must be used to request a country code indicator. On recognition of signal A-11 the outgoing international R2 register must send a country code indicator (signal I-12 or I-14, see Recommendation Q.479) as the first forward signal to be received by the next incoming R2 register.

Signal I-12 or I-14 may be requested as many times as necessary by sending signal A-11.

When the outgoing link connects to an incoming international terminal exchange signal A-12 must be used to request the language or discriminating digit. On recognition of signal A-12 the outgoing international R2 register must send the language or discriminating digit (a signal I-1 to I-10) as the first forward signal to be received by the next incoming R2 register.

On recognition of signal A-12 (sent from an international transit exchange) an outgoing international R2 register is informed that an international link connected to an incoming international terminal exchange has been added to the (multi-)link section and that call set-up is now in progress in the national destination network. This is of importance when signal A-9 or A-10 are, in the originating country, amongst those used to set-up international calls.

5.3.1.2 *Congestion*

If it is impossible to set-up the desired connection in the transit exchange the incoming R2 register terminates interregister signalling by transmission of the congestion signal A-4 or A-15. The backward signal may serve as acknowledgement of the last forward signal received by the incoming R2 register at the transit exchange or is sent in pulse form.

The two congestion signals A-4 and A-15 are provided to enable an outgoing international R2 register to determine whether congestion is occurring in the international network or in that of the destination country so that provision for repeat attempt or re-routing can be made in the former case:

— Signal A-15 is sent from an international exchange.

— Signal A-4 is sent from a national exchange or possibly from a terminal international exchange. [See also § 5.1.2.2 c).]

Because receipt of congestion signal A-15 by an outgoing international R2 register may initiate repeat attempt or re-routing it is possible to transmit congestion signal A-4 from international exchanges where repeat attempt or re-routing may be expected useless.

Recommendation Q.471

5.3.2 AT THE LAST INCOMING R2 REGISTER SITUATED IN THE EXCHANGE TO WHICH THE CALLED SUBSCRIBER IS CONNECTED

5.3.2.1 *Successful routing*

When a call has been completely set up by means of System R2 interregister signalling, the incoming R2 register terminates interregister signalling immediately on receipt of the entire number.

The following criteria are used to determine whether the number received by the incoming R2 register is complete:

a) analysis — to determine the last digit;

b) electrical conditions given by the switching equipment succeeding the incoming R2 register;

c) receipt of the end-of-pulsing signal (I-15);

d) the assumption, after a specified time has elapsed, that no further digits will be sent (see Recommendation Q.476).

When criterion *a)* (analysis) is applied:

— if the incoming R2 register is equipped to send Group B signals to provide information about the condition of the called subscriber's line the address-complete signal A-3 is transmitted on receipt of the last digit. As soon as it is known whether the connection with the subscriber's line can be established, only the appropriate Group B signal needs to be sent. The use of the Group B signals is detailed in Recommendation Q.474;

— if the incoming R2 register is not equipped to receive information about the condition of the called subscriber's line, the address-complete signal A-6 is sent immediately after

reception of the last digit and no Group B signal will be transmitted.

In both cases the time interval between the end of a signal A-6 or a Group B signal and the start of the subsequent answer signal must not be less than 75 ms.

When criterion *b)* (electrical conditions) is applied:

It is recommended that, to avoid delay in sending the answer signal, no Group B signal should be sent when the called subscriber's line is free, and that the setting-up of speech conditions be ensured by sending address-complete signal A-6 immediately the electrical conditions are recognized. The time interval between the end of signal A-6 and the start of transmission of the subsequent answer signal must be not less than 75 ms (see also Recommendations Q.412 and Q.475).

Criterion *c)* (end-of-pulsing) can be applied only if the incoming R2 register is equipped to receive the 6 forward signalling frequencies (see also Recommendation Q.473). When signal I-15 is received and recognized the last incoming R2 register can perform in the way described under criterion *a)* .

When criterion *d)* (time-out) is applied:

Address-complete signal A-6 must be sent in pulse form as soon as the specified time has elapsed. The time between the end of signal A-6 and the start of transmission of the subsequent answer signal must be, as indicated above for criterion *b)* , not less than 75 ms (see also Recommendations Q.412 and Q.472).

It may happen, however, that the called subscriber answers before the specified time has elapsed. In such exceptional circumstances the pulse signal A-6 must be sent immediately the answer signal is recognized. In this case the time between the end of signal A-6 and the start of the transmission of the subsequent answer signal must be 75 ms or more but less than 150 ms. The calling subscriber will not hear the ringing tone.

This disadvantage can be avoided by not using a received digit to set up the call until after the following digit has been received or until a certain time has elapsed. This procedure, however, may give rise to difficulties if the time-out devices provided in the switching equipment succeeding the incoming R2 register are set for too short a delay [see also Recommendation Q.120, § 1.5.5.2 b) iv)].

5.3.2.2 *Congestion*

An incoming R2 register should terminate interregister signalling immediately any conditions preventing complete setting-up of a call have been recognized.

If congestion is encountered congestion signal A-4 is sent, possibly in pulse form. However if address-complete signal A-3 has already been sent then congestion signal B-4 is sent in acknowledgement of the Group II signal which commences the last compelled signalling sequence.

Recommendation Q.472

5.3.3 AT THE LAST INCOMING R2 REGISTER SITUATED IN A TRANSIT EXCHANGE

5.3.3.1 *Successful routing*

Interregister signalling to such a register can be terminated after all the address digits are received. In order to determine that the number is complete the same criteria as described in Recommendation Q.471 are used.

When criterion *a)* (analysis) is applied:

1) if the signalling system employed on the outgoing link enables the condition of the called subscriber’s line to be sent backwards within an acceptable period compared to the time-out of the outgoing international R2 register, the last incoming R2 register can react in accordance with one of the following methods:

i) address-complete signal A-3 is sent in acknowledgement of the last address digit followed by the relevant Group B signal depending upon the condition of the called subscriber’s line;

ii) signal A-1 is sent in acknowledgement of the last address digit, and signal I-15 if received, to deliberately suspend compelled signalling and later,

— when the condition of the called subscriber's line is known, address-complete signal A-3 is sent in pulse form followed by the relevant Group B signal. This makes it possible to avoid maintaining on-line the Group II signal sent after reception of signal A-3,

— when the called subscriber's line is free, it is preferable to send the address-complete signal A-6 in pulse form,

2) if the signalling system employed on the outgoing link does not enable the condition of the called subscriber's line to be transmitted backwards or if such information is only available at the last incoming R2 register after a delay incompatible with the time-out of the outgoing international R2 register, then address-complete signal A-6 is sent in acknowledgement of the last address digit.

When criterion *b)* (electrical conditions) is applied:

Only signal A-1 can be used to acknowledge each address digit. Upon receipt of an electrical signal on the outgoing link, the last incoming R2 register acts in one of the following ways:

— if the condition of the called subscriber's line is not known or is known to be *free* , address-complete signal A-6 is sent in pulse form;

— if the condition of the called subscriber's line is known to be other than *free* , address-complete signal A-3 is sent in pulse form, followed by the relevant Group B signal.

Criterion *c)* (end-of-pulsing) is only applicable if the last incoming R2 register can receive 6 forward signalling frequencies (see also Recommendation Q.473). In this case, when end-of-pulsing signal I-15 is received and recognized, the last incoming R2 register can perform in the way described under criterion *a)* .

When criterion *d)* (time-out) is applied:

Address-complete signal A-6 is sent in pulse form after the specified time has elapsed (see Recommendation Q.476).

5.3.3.2 *Congestion*

If congestion is encountered, the procedure described in Recommendation Q.470 is followed. However, if address-complete signal A-3 has already been sent then congestion signal B-4 is sent in acknowledgement of the Group II signal which commences the last compelled signalling cycle.

Recommendation Q.473

5.3.4
USE OF END-OF-PULSING SIGNAL I-15 IN INTERNATIONAL WORKING

In international working, the end-of-pulsing signal I-15 is used in accordance with Recommendation Q.468. Signal I-15 (end-of-pulsing) is sent immediately after the last digit.

In national working, signal I-15 may be used too.

In semi-automatic operation, calls to operators’ positions are always terminated by transmission of signal I-15. This signal can only be interpreted if the incoming R2 register is equipped for reception of 6 forward frequencies. However, when an incoming R2 register is equipped for reception of only

5 forward signalling frequencies no provision can be made for recognition of signal I-15. Such an incoming R2 register will then act as though signal I-15 had not been sent. Consequently the next interregister signal is only one of the signals A-3, A-4 or A-6 sent in pulse form.

5.3.4.1 *Procedures to be followed after receipt of end-of-pulsing signal I-15 by the last incoming R2 register (situated in a transit exchange or in the exchange to which the called subscriber is connected)*

Incoming R2 registers equipped for the reception of all 6 forward signalling frequencies can acknowledge receipt of the end-of-pulsing signal I-15 by sending an appropriate backward signal to complete the compelled signalling cycle. Interregister signalling is terminated according to the procedures specified in Recommendations Q.471 or Q.472 when criterion *a)* (analysis) is applied.

In particular, if the last incoming R2 register acknowledges signal I-15 with signal A-1 the outgoing international R2 register will not send any signal and the incoming R2 register can only send one of signals A-3, A-4, A-6 or A-15 in pulse form.

Since there is no compulsion to equip incoming R2 registers in national exchanges with receivers for all 6 forward signalling frequencies, the signal I-15 sent by an outgoing international R2 register may not be recognized by the incoming R2 register. In such cases other criteria can be used to determine whether the number received by the incoming R2 register is complete.

When the incoming R2 register determines that the number received is complete using criteria other than *c)* (end-of-pulsing) it may be that the last digit of the subscriber number is acknowledged by signal A-3, A-4, A-6 or A-15. In this case interregister signalling is terminated without request for the signal I-15, in the normal way according to the procedures specified in Recommendations Q.471 or Q.472 (a compelled signalling cycle including signal I-15 is saved).

5.3.4.2 *Procedure to be followed after receipt of signal I-15 by an incoming R2 register situated in a transit exchange*

Signal A-1, A-2, A-7, A-8, A-11 or A-12 may be sent in acknowledgement of signal I-15 (end-of-pulsing). However, at a transit exchange precautions are necessary to avoid acknowledgement of signal I-15 before the signalling system employed on the outgoing link has been identified. If signal A-1 is sent in acknowledgement of signal I-15 and if the outgoing link employs System R2, it is not then possible to send backward signal A-2, A-7, A-8, A-11 or A-12 after the end of the compelled signalling cycle because these signals cannot be sent in pulse form. Therefore end-to-end signalling to the next exchange is no longer possible.

Recommendation Q.474

5.3.5
USE OF GROUP B SIGNALS

Group B signals are used to transmit information about the condition of switching equipment in the incoming exchange or the called subscriber's line, to the outgoing international R2 register, which can then take the necessary action.

The address-complete signal A-3 is sent by an incoming R2 register to announce changeover to sending Group B signals. In addition, signal A-3 indicates that the incoming R2 register has received all the Group I forward signals it requires from the outgoing international R2 register. On recognition of signal A-3 an outgoing R2 register sends a Group II signal. The incoming R2 register may interpret the Group II signal giving information about calling

party's category, in order to control the switching operations accordingly (e.g. suppression of automatic ringing for operator initiated calls or to prevent subscriber access to data transmission terminals). Finally, a Group II forward signal is acknowledged by any Group B backward signal.

In cases where outgoing R2 registers are able to interpret all Group B signals there is generally no need to provide equipment at the incoming end able to send, in addition to Group B signals, the tones and/or announcements corresponding to those signals, except in the case of ringing tone.

In general, outgoing R2 registers must be equipped with devices permitting, after reception of signal A-3:

— the exchange of an additional cycle of interregister signals before the register is released;

— changeover from Group A to Group B meanings of backward signals.

Outgoing international R2 registers, however, must be able to interpret all Group B signals.

5.3.5.1 *Procedures to be followed by an outgoing international R2 register on receipt of Group B signals*

Signal B-1 is interpreted by an outgoing international R2 register as signal B-6: the register is released and the speech-path is through-connected. A subsequent answer signal initiates call charging.

Signal B-2 send special information tone is sent by the incoming R2 register:

— when the number of the called party has been changed,

— when the three following conditions are fulfilled together:

i) the called party’s line condition does not fit with one of the meanings of the present Group B signals,

ii) it does not lead to setting up the speech path,

iii) it is not incompatible with return of special information tone to the calling party.

After recognizing signal B-2, the outgoing international R2 register clears forward and causes the transmission of only special information tone.

The subscriber’s line busy signal B-3 is sent by the incoming register when the called subscriber’s line is engaged. On recognition of this signal, the outgoing register releases the connection and causes transmission of the busy tone.

When the congestion condition is encountered following the changeover from Group A signals to Group B signals, the congestion signal B-4 shall be transmitted on the conditions specified for congestion signal A-4. In all cases recognition of the signal causes release of the call and transmission of congestion information.

After recognizing unallocated number signal B-5, the outgoing international R2 register clears the call and causes transmission of special information tone or a recorded announcement and special information tone, alternately, to the calling party.

After recognizing signal B-6, the outgoing international R2 register sets up speech conditions so that a caller may hear the ringing tone. In this case, a subsequent answer signal activates the call-charging mechanism.

After recognizing signal B-7 the outgoing international R2 register sets up speech conditions, so that a caller may hear the ringing tone. In this case, a subsequent answer signal does not activate the call-charging mechanism. However, in an outgoing international R2 register signal B-7 may be interpreted as B-6 if there is no international agreement on non-chargeable calls.

After recognizing signal B-8 subscriber’s line out of order, the outgoing international R2 register clears forward and causes the transmission of a special information tone or recorded announcement and special information tone alternately to the calling party.

Receipt of signal B-9 or B-10 by an outgoing international R2 register causes release of the outgoing connection and return of special information tone to the calling subscriber, i.e. these signals should be interpreted as signal B-2.

If an outgoing international R2 register receives one of signals B-11 to B-15 the call should be released and indication of this returned to the calling subscriber or operator, i.e. this signal should be interpreted as signal B-4.

5.3.5.2 *Special procedures for national working*

Outgoing R2 registers in national exchanges may not be able to recognize and interpret Group B signals. In such networks it is essential that the equipment at the incoming end must transmit not only the Group B signals but also the corresponding tones and/or announcements, when the incoming R2 register does not know whether the outgoing R2 register is capable of interpreting Group B signals.

In the case where the incoming R2 register is able to make only two or three distinctions of conditions of the called subscriber's line the following procedure may be adopted: When the only distinction that can be made is between subscriber's line free and subscriber's line engaged,

i) signal B-3 is sent if the line is engaged;

ii) otherwise signal B-6, or signal A-6 alone is sent so the caller can hear the ringing tone sent by the incoming equipment.

In the case where outgoing R2 registers in national exchanges are only able to interpret a limited number of Group B signals or are indeed not able to interpret any, it is essential that such equipment be able to respond to signal A-3 in the specific manner and at least to recognize the next backward signal (which is a Group B signal) as indicating the end of interregister signalling.

5.3.5.3 *Possible application of signal B-1 in national working*

Signal B-1, for example, may be used to indicate that the call must remain under the control of the incoming equipment, insofar as this is possible (e.g. for maintenance reasons, to trace malicious calls, etc.). The incoming exchange sets up speech conditions, so that the calling subscriber can hear the ringing tone. At present such a use of signal B-1 in international working is not envisaged.

Recommendation Q.475

5.4 NORMAL RELEASE OF OUTGOING AND INCOMING R2 REGISTERS

An outgoing international R2 register must be released once it has received an appropriate backward interregister signal terminating the interregister signalling, or on receipt of a clear-forward (line) signal from the preceding link.

An incoming R2 register must be released once it has accomplished the necessary switching control and terminated the interregister signalling required, or on receipt of a clear-forward (line) signal from the preceding link.

The last recognized interregister signal preceding setting up of speech conditions will normally be a backward signal: e.g. address-complete signal A-6, subscriber's line free signals B-6 or B-7.

The multifrequency combination receivers at the two ends must be disconnected before the switching equipment passes to the speech condition; this procedure eliminates any possibility of their operating or being held under the influence of speech or line signals. The following conditions regarding the duration of the various phases should be observed (see Figure 20/Q.475):

a) the multifrequency signalling equipment of the incoming R2 register must be disconnected within 30 ms after recognition of the end of transmission of the last backward signal;

b) the multifrequency signalling equipment of the outgoing R2 register must be disconnected within 30 ms after recognition of the end of the last backward signal;

c) at the outgoing exchange speech conditions must be set up between 30 and 60 ms after recognition of the end of the last backward signal. However, at the exchange where the outgoing international R2 register is situated, the setting-up of speech conditions depends upon the signalling system employed on the preceding link;

d) at the incoming exchange at least 75 ms must elapse between the end of transmission of the last backward signal and the setting up of speech conditions.

Figure 20/Q.475 p.13

Recommendation Q.476

5.5
ABNORMAL RELEASE OF OUTGOING AND INCOMING R2 REGISTERS

To limit the holding time of R2 registers, when interregister signalling is interrupted either by a fault or by any other cause, all R2 registers must be equipped with devices for continuous supervision of the time taken by the various phases of interregister signalling. The time-out delay of these devices must be as short as possible, but long enough not to interrupt normal operation.

5.5.1 *Time-out of outgoing international R2 register*

In an outgoing international R2 register, the intervals during which a forward multifrequency combination is transmitted and the intervals

during which no such combination is transmitted are supervised separately.

5.5.1.1 *Supervision during sending of forward multifrequency combinations*

The lower limit of the time-out delay is a function of the time required for the switching procedures in a transit exchange.

On this basis, the time-out delay is specified as 15 ± 3 seconds.

The supervision device will start functioning at the beginning of the transmission of a forward multifrequency combination and be reset with the deactivation of the senders involved. It will start again at the beginning of the transmission of the next forward multifrequency combination.

5.5.1.2 *Supervision during intervals when no forward multifrequency combination is being sent*

The lower limit of the time-out delay is a function of:

a) the maximum permissible time interval between dialling of two successive digits by the subscriber;

b) the time-out delay specified for incoming R2 registers (see § 5.5.2 below).

On this basis, the time-out delay is specified to be longer than 24 seconds (a longer delay and an upper limit may be specified by each Administration).

If this specification is observed an incoming R2 register, which has acknowledged the last received digit with the signal A-1, is bound to be released before the supervision device of the outgoing international R2 register initiates the alarm condition.

5.5.1.3 *Procedure to be followed if time-out occurs*

If time-out occurs, the time supervision devices mentioned in §§ 5.5.1.1 and 5.5.1.2 above will bring about operations producing:

— return of an appropriate signal and/or audible tone to inform the calling party,

— release of the outgoing international R2 register and of the connection as far as the latter is not necessary for the above-mentioned operation.

Fault recording equipment may start functioning and/or a delayed alarm may alert the technical staff.

5.5.1.4 *Time-out of outgoing R2 register*

It is recommended that the same principles outlined in §§ 5.5.1.1 to 5.5.1.3 above be applied by analogy to outgoing R2 registers.

5.5.2 *Time-out of incoming R2 register*

The time-out device shall supervise the interval elapsing between seizure of the register and recognition of the first forward multifrequency combination as well as the interval elapsing between the recognition of two successive multifrequency combinations in the forward direction.

5.5.2.1 *Time-out delay*

The lower limit of the time-out delay is a function of:

a) the maximum permissible time interval between the recognition of 2 successive forward multifrequency combinations; this time interval may in certain cases be influenced by the maximum permissible time interval between dialling of 2 successive digits by the subscriber;

b) the maximum time required for setting-up the call under conditions which slow down the interregister signalling.

In view of the desirability expressed in § 5.5.1.2 above that the incoming R2 register be released before expiry of the time-out delay specified for the outgoing international R2 register, an upper limit should be fixed as well.

On this basis the time-out delay should be specified within the range of 8-24 seconds. A minimum delay of 15 seconds corresponding to the time-out delays in other CCITT standardized signalling systems is to be preferred.

For incoming R2 registers using the criterion *d)* (time-out) indicated in Recommendation Q.471 to determine completion of the number, the time referred to there as the *specified time* may exceptionally be shorter than 8 seconds, but never less than 4 seconds.

5.5.2.2 *Procedure to be followed if time-out occurs*

If time-out occurs, the time supervision device will bring about operations producing:

— sending of a congestion signal (A-4 or A-15) in pulse form;

— release of the incoming R2 register and other equipment in the incoming exchange;

— on time-out of the initial digit:

i) line signalling, analogue version: establishment of the blocked state on the incoming circuit until recognition of the clear-forward signal (see Recommendation Q.412, abnormal conditions);

ii) line signalling, digital version: no further action required.

Fault recording equipment may start functioning and/or a delayed alarm may alert the technical staff.

Recommendation Q.478

5.6
RELAY AND REGENERATION OF R2 INTERREGISTER SIGNALS
BY AN OUTGOING R2 REGISTER IN A TRANSIT EXCHANGE

When the overall multi-link connection is divided into end-to-end signalling sections, regeneration of R2 interregister signals is required by either an outgoing international R2 register or an outgoing R2 register (see Recommendation Q.440).

There are three possible procedures for relaying interregister signals by an outgoing R2 register:

a) the outgoing R2 register acknowledges each signal received over the incoming link by transmitting the appropriate backward signal; this operation is independent of the operations entailed in retransmitting on the outgoing link;

b) the forward address signal with rank $n + 1$ is acknowledged on the incoming link as soon as the forward address signal with rank n is acknowledged on the outgoing link;

c) as soon as a forward signal is received on the incoming link, a signal is sent on the outgoing link; the acknowledgement signal is sent on the incoming link only when such a signal has been received on the outgoing link.

Methods *a)* and *b)* provide the most rapid transfer of information and are therefore the preferable methods of relaying the information necessary for setting up the call. It is essential, however, that the outgoing R2 register be provided with adequate storage capacity in the case of method *a)* .

Method *b)* can only be applied after method *a)* .

Method *c)* should be used for relaying information relating to the procedures for the termination of interregister signalling.

The changeover from method *a)* or *b)* to method *c)* may require transmission of an address-complete signal A-3 in pulse form as indicated in Recommendation Q.442 (see Figure 21/Q.478).

The procedure for disconnecting the multifrequency combination receivers and setting-up speech conditions for each link, incoming and outgoing, is given in Recommendation Q.475.

When method *a)* or *b)* is used, the time-outs of the R2 registers associated with the first signalling section may expire if the signalling on the second signalling section is too slow. Relatively long time-outs are recommended (see Recommendation Q.476).

Note — The use of signal A-3 on circuits with very long transmission delay, e.g. satellite circuits, for relaying such information (method c) may result in premature release in certain incoming local exchanges with very short time guard. The problem may be avoided if the outgoing R2 register immediately following the satellite link uses signal A-5 to obtain the calling party's category information previously to the receipt of signal A-3 from those incoming local exchanges.

Figure 21/Q.478 p.14

Recommendation Q.479

5.7
ECHO-SUPPRESSOR CONTROL — SIGNALLING REQUIREMENTS

5.7.1 *Introduction*

Recommendations Q.42 and Q.115 give fundamental requirements with which the employment of echo suppressors must comply.

There are two methods of connecting echo suppressors to a circuit. One method is by use of permanently connected echo suppressors and the other is by the insertion of echo suppressors from a pool, when required.

In System R2 (see Recommendation Q.441) two forward signals (I-12 and I-14) and one backward signal (A-14) are provided to indicate whether or not an incoming half-echo suppressor (IHES) is required.

A third forward signal (I-11) is also available for use by bilateral agreement to indicate that an outgoing half-echo suppressor (OHES) must be employed.

The following principles must be taken into account.

5.7.2 *Principles of echo-suppressor control*

5.7.2.1 The outgoing international exchange may be able to determine the need for echo suppressors in the connection by analysing the received country code.

5.7.2.2 In direct traffic between 2 countries the use of echo suppressors generally takes place according to fixed rules. Echo-suppressor control signalling is not, therefore, necessary in these cases unless it is applied for the sake of uniformity.

5.7.2.3 In international transit traffic the outgoing half-echo suppressor (OHES) will normally be employed at the outgoing international exchange, and the incoming half-echo suppressor (IHES) at the incoming international exchange, unless other arrangements are agreed upon with the Administration of the international transit exchange(s) (see § 5.7.2.5 below).

However, in cases where an outgoing satellite link is selected by a transit exchange without the knowledge of the outgoing international exchange, the signal I-12 may be sent over the satellite link. In such cases half-echo suppressors are required and will normally be permanently fitted at each end of the satellite link.

5.7.2.4 An incoming international exchange, equipped for the connection of IHES, must ask the outgoing international exchange whether or not an IHES must be employed unless this is known from other criteria (e.g. line classification). It will do this by sending the backward signal A-14 as an acknowledgement of the discriminating or language digit (Z-digit).

When a satellite link is used in the connection the exchange situated at the incoming end of the satellite link responds to the A-14 signal instead of the outgoing international exchange (see Recommendation Q.7).

5.7.2.5 It may be agreed upon bilaterally that in international transit traffic the OHES (IHES) will not be employed in the outgoing (incoming) international exchange, but in the international transit exchange, e.g. in the case where most of the traffic on the circuit group between the outgoing exchange and the transit exchange (between the transit exchange and the incoming exchange) needs no echo-suppressor.

a) When echo suppressors are needed and the OHES must be employed at the international transit exchange the outgoing international exchange sends the signal I-11 as a country code indicator.

If an international connection is routed via two or more transit exchanges, signal I-11 must not be sent beyond the first transit exchange. Therefore the outgoing exchange, after having sent the signal I-11 once, must send the signal I-14 if the country code indicator is requested again (signal A-11).

b) When echo suppressors are needed and the IHES must be employed at the international transit exchange this is known by the international transit exchange. In this case the incoming international exchange will not send signal A-14.

5.7.2.6 When echo suppressors are employed they will remain disabled until the answer signal is received. This condition is necessary in order to permit compelled interregister signalling to (e.g. national) exchanges further on in the connection.

Alternatively, when the ability exists to detect that interregister signalling has been completed, the echo-suppressor may be enabled at that time without awaiting the answer signal.

5.7.3 *Examples of echo-suppressor control signalling*

The following situations may arise:

5.7.3.1 *Direct interregister signalling between two countries A and B.*

a) No echo-suppressor control signalling is applied.

This may be for one of two reasons. Either the connection does not normally require echo suppressors or echo suppressors are required and are permanently connected to the circuit.

The signalling procedure is indicated in Table 11/Q.479, column a. If echo suppressors are necessary, the OHES is employed at A and the IHES is employed at B.

b) Echo-suppressor control signalling is applied.

There are two cases:

i) No echo suppressors are required (see column b of Table 11/Q.479).

ii) Echo suppressors are required (see column c of Table 11/Q.479). The OHES is employed at A and the IHES is employed at B.

5.7.3.2 *Traffic between two countries A and D via two international transit exchanges B and C*

There are two cases:

5.7.3.2.1 The connection is via terrestrial circuits only.

a) No echo suppressors are required (see column a of Table 12/Q.479).

b) Echo suppressors are required (see columns b, c, d, e of Table 12/Q.479).

The following examples may be mentioned:

— OHES in A: IHES in D (column b);

— OHES in B: IHES in D (column c).

The country code indicator I-11 is used by bilateral agreement and indicates that B must employ the OHES. When the country code indicator is to be sent to C, B asks A to do this by sending signal A-11. A, now sends signal I-14 instead of signal I-11, because B has employed the OHES. The signal A-14, which is sent from D as an acknowledgement of the Z-digit will, of course, also be answered by signal I-14.

— OHES in A: IHES in C (column d).

In accordance with § 5.7.2.5 b) above, C knows that D cannot employ an IHES and C itself will therefore make the connection. D will naturally not send signal A-14.

— OHES in B: IHES in C (column e).

5.7.3.2.2 The connection includes a satellite link.

The following examples are given as typical situations that may arise:

a) The first link in the connection is via satellite.

In Table 13/Q.479, P and Q both know that echo suppressors are required.

If Q has a permanently connected IHES then:

— OHES in P; IHES in Q (column a).

When R or S is able to employ an IHES then:

— OHES in P; IHES in R (column c);

— OHES in P; IHES in S (column b).

b) A later link in the connection is via satellite.

In Table 14/Q.479:

When P knows that Q-R is via satellite:

— OHES in P; IHES in R or S (column b or d).

When P does not know that Q-R is via satellite:

— OHES in Q; IHES in R or S (column a or c).

Tableau 11/Q.479 p.15

Tableau 12/Q.479 p.16

Tableau 13/Q.479 (disposition à l'italienne c | te-`a-c | te avec Tableau 14: page pleine), p.17

Tableau 14/Q.479 (̀a l'italienne avec tableau 13), p.18

5.8 MISCELLANEOUS PROCEDURES

5.8.1 *Nature of circuit procedure for international working*

An incoming R2 register in an international transit exchange or in the country of destination can elicit the nature of the circuit as soon as at least one forward signal has been received from an outgoing register.

The incoming R2 register requests nature of circuit by sending the backward signal A-13. The outgoing R2 register, if capable, sends the nature of the circuit indicator signal I-13 or I-14 in reply.

Signal A-13 can be sent after any forward signal (Groups I and II) and particularly after any address digit, but it can only be sent prior to any transmission of signal A-3.

If the outgoing R2 register does not have the capability of providing the nature of circuit, signal I-12 (request not accepted) is sent in reply to signal A-13. The incoming R2 register will then ask for the following address digit by sending signal A-1, for example. If the outgoing R2 register receives signal A-13 again it will send signal I-12 again.

For existing equipment if the outgoing international R2 register does not have the capability of providing the nature of the circuit, but is capable of sending identification information as defined in the *Yellow Book* , the procedure starts with the first digit of the country code.

5.8.2 *Identification procedure for national working*

System R2 makes provision for the signalling necessary to identify the calling subscriber's line: for example, by repetition of signal A-5 or by using one of signals A-9 or A-10. For the time being this procedure is restricted to national working only; outgoing international R2 registers prevent its use over international links (see § 5.8.4). The outgoing R2 register at the incoming end of an international satellite link must similarly prevent its use via that link.

5.8.3 *Processing of Group II signals reserved for national use*

The Group II signals reserved for national use must be converted in the outgoing international R2 register to Group II signals used for international working.

The conversion must be carried out as follows:

II-1 must be converted to II-7

II-2 must be converted to II-7 or II-9

II-3 must be converted to II-7

II-4 must be converted to II-7

II-5 must be converted to II-7 or II-10

II-6 must be converted to II-8

II-11 to II-15 must be converted to II-7.

Since there are no Recommendations yet regarding handling of priority calls in automatic international working, conversion of signal II-2 to signal II-9 must be the subject of bilateral agreement.

If an incoming R2 register is situated in a national exchange and because signals II-7 to II-10 are not used for national working, then analysis of Group II signals enables a distinction to be made between nationally and internationally originated calls.

If an incoming R2 register knows a call is of international origin and if a Group II signal reserved for national use is received, signal A-4 or B-4 (congestion on the national network) should be sent in acknowledgement. This procedure cannot be applied if an incoming R2 register in the destination country is employed for national and international working and is not able to detect the origin of the call.

5.8.4 *Procedures to be followed by outgoing international R2 registers on receipt of particular backward signals*

An outgoing international R2 register must send the appropriate calling party's category signal (II-7 to II-10) in reply to signals A-3 and A-5.

On recognition of one of the signals A-9 or A-10 an outgoing international R2 register sends signal I-12 (request not accepted) in response. Therefore, national incoming R2 registers using these signals should be equipped to receive signal I-12.

The incoming national R2 register receiving I-12 has to determine the appropriate international standardized signal to be sent in response to signal I-12 and which substitutes for signals A-9 or A-10.

In reply to signal A-14 an outgoing international R2 register sends:

— signal I-14 when an incoming half-echo supressor is required;

— the next address digit (a signal I-1 to I-10) when no incoming half-echo suppressor is required.

If an outgoing international R2 register receives a backward signal requesting an impossibility in the logical procedure (e.g. receipt of signal A-8 after sending the country code indicator), the call shall be released.

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