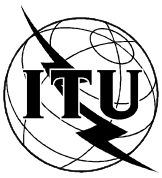


INTERNATIONAL TELECOMMUNICATION UNION

CCITT

THE INTERNATIONAL
TELEGRAPH AND TELEPHONE
CONSULTATIVE COMMITTEE

Z.100 Annex E

(11/1988)

SERIES Z: LANGUAGES AND GENERAL SOFTWARE ASPECTS FOR TELECOMMUNICATION SYSTEMS

Functional specification and description language (SDL)
Criteria for using formal description techniques (FDTs)

STATE-ORIENTED REPRESENTATION AND PICTORIAL ELEMENTS

Reedition of CCITT Recommendation Z.100 Annex E published in the Blue Book, Fascicle X.1 (1988)

NOTES

1 CCITT Recommendation Z.100 Annex E was published in Fascicle X.1 of the *Blue Book*. This file is an extract from the *Blue Book*. While the presentation and layout of the text might be slightly different from the *Blue Book* version, the contents of the file are identical to the *Blue Book* version and copyright conditions remain unchanged (see below).

2 In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

ANNEX E

(to Recommendation Z.100)

State-oriented representation and pictorial elements

E.1 *Introduction*

SDL is based on an "extended" Finite State Machine (FSM) model. That is, an FSM is extended with objects, such as variables, resources, etc. A machine stays in some state. On receiving a signal, a machine executes a transition, in which relevant actions (e.g. resource allocation and/or deallocation, resource control, signal sending, decision, etc.) are taken. Therefore, the dynamic behaviour of an extended FSM can be explained by describing action sequences on objects for each transition of the FSM in a procedural way.

As a consequence of the state transition, the machine arrives in a new state. The state of an extended FSM can be characterized by objects associated with the state, additional object information (e.g. the value of variables, states of resources, relations between the resources), and signals which can be received in that state. For example, the "await-first-digit state" in telephone call processing is characterized as follows:

Caller:	handset-off
Dial tone-sender:	dialtone sending
Digit receiver:	ready for receiving
Timer:	supervising permanent-signal timing
Path:	Caller is connected to dial tone-sender and digit receiver, etc.

As can be seen, each state can be defined statically by objects and additional information (qualifying text) associated with that state.

The SDL/GR is extended with **pictorial elements** to define objects associated with each state. The state definitions in terms of pictorial elements are called **state pictures.** The SDL/GR state symbol may include a state picture. This is an optional part of SDL/GR. Figure E-1 shows a state definition example of the "await-first-digit state".

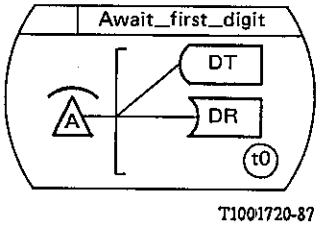


FIGURE E-1

State definition example in terms of pictorial elements

In many cases, actions on each object, which are required in the transition, can be derived from the difference between state definitions before and after the transition. For example, if some resource appears only after transition, it means that resource allocation action is necessary in the transition. Therefore, if detailed state definitions are given, total actions in the extended FSM transition can usually be derived from the difference between pre-and post-state definitions. However, the sequence of actions in the transition may not be derived from the state definition difference. Therefore, in SDL diagrams, when the sequence of actions is less important, those transition actions which can be derived from the state definition need not be described explicitly. Otherwise, it is desirable to describe action sequences explicitly.

An SDL diagram, in which transitions are described exclusively by explicit action symbols, is called a **transition-oriented version of SDL/GR.**

An SDL/GR diagram, in which states are described using state pictures and transition actions are minimized, is called the **state-oriented version of SDL/GR** or **state-oriented SDL with pictorial elements (SDL/PE).** State pictures can be used advantageously when applied to certain system definitions, resulting in more compact, declarative and less verbal process diagrams.

A combined version is also possible. Thus, these are 3 SDL/GR versions:

a) Transition-oriented version
   - Transition sequences are described exclusively by explicit action symbols.
   - This is, as it were, a procedural explanation of the extended FSM.
   - This version is suitable when the sequence of actions is important and detailed state descriptions are not important.

b) State-oriented version
   - The state is described uniquely using pictorial elements. This picture is called a state picture.
   - The transition action sequence is implied by the difference between pre-and post-state definitions.
   - This is, as it were, a declarative specification of the extended FSM.
   - This vesion is suitable when the sequence of actions within each transition is of low importance, when pictorial explanation is desirable, or when a compact representation is desirable.

c) Combined version
   - The combined version is suitable when both the sequence of actions within each transition and the detailed state descriptions are under consideration.

Examples of these three versions are given in Figure E-2, E-3 and E-4.

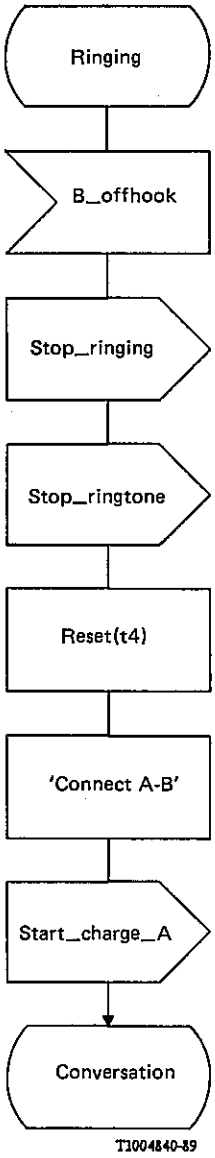


FIGURE E-2

Transition-oriented version

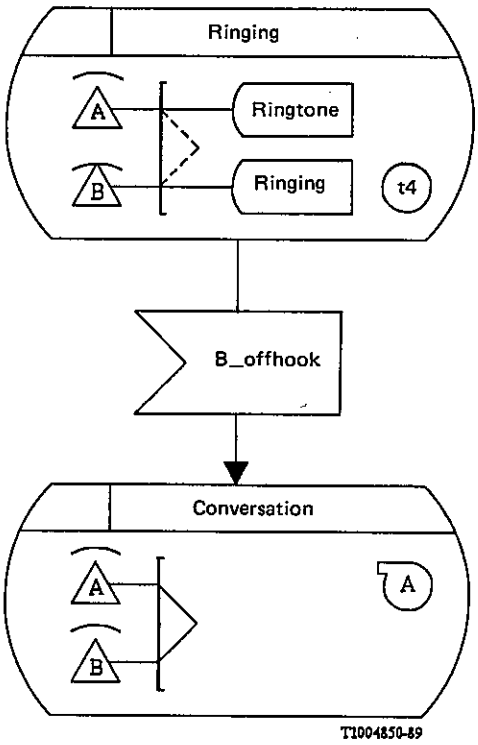


FIGURE E-3

State-oriented version

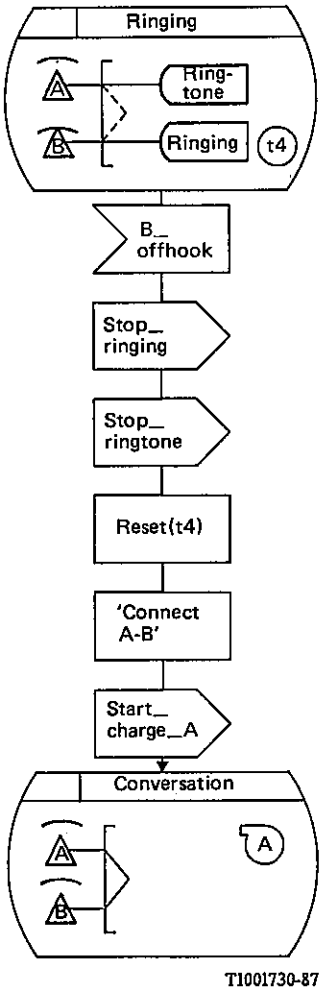


FIGURE E-4

Combined version

E.2 *Pictorial elements in SDL/GR*

The syntax and semantics defined in Recommendation Z.100 SDL applies to pictorial elements. However, these semantics and syntax are extended as follows:

Pictorial elements represent various objects. The repertoire of pictorial elements is in principle unlimited because new pictorial elements can be invented to suit any new application of the SDL. However, in applications to telecommunications switching and signalling functions, the following repertoire of pictorial elements has been found to have considerable versatility:

- functional block boundary (left or right),
- terminal equipment (various),
- signalling receiver,
- signalling sender,
- combined signalling sender and receiver,
- supervising timer,
- switching path (connected, reserved),
- switching modules,
- charging in progress,
- control elements,
- uncertainty symbol.

Standard symbols for these pictorial elements are recommended in section E.2.2.

E.2.1 *Rules of interpretation*

1) A state symbol may include a **state picture**. A state picture defines de state using pictorial elements and qualifying text.

2) Each pictorial element in a state picture represents an object associated with the state, such as:
   - resources,
   - variables,
   - internal and external boundaries,
   - the relations between objects,
   - signals which can be received in that state,
   - etc.

3) Each pictorial element may have accompanying **qualifying text**. Qualifying text can be used to explain:
   - detailed resource name,
   - the resource state,
   - value for a variable,
   - signals relevant to the object,
   - etc.

4) Function block boundary:
   a) A **function block boundary** is used to express whether a pictorial element is "internal" or "external" to the process. An internal pictorial element represents objects which are owned by the process. An external pictorial element represents objects which are owned by another process under consideration.
   b) Rule a) also applies to the distinction between internal and external qualifying text, by substituting the term "qualifying text" for pictorial elements in the rule.

5) Transition interpretation rule:

   The total processing involved when a process goes from one state to the following state is the combination of:
   - The processing to effect changes to all relevant objects which are derived from the state definition difference.
   - The processing explicitly described in the transition, e.g. outputs or tasks.

Thus:

a) The absence from one state if a pictorial element which represents a resource with its presence in the next state implies the allocation of the resource in all transitions joining the two states. This can be equivalently represented by a task(s) showing allocation of the resource in transition(s).

b) If "presence" and "absence" are interchanged in rule a), then "allocation" is replaced by "deallocation".

c) In rule a) if "pictorial element" is replaced by "external pictorial element" then the task should be replaced by an output signal requesting the process which owns the resource to allocate it or simply an input signal from that process saying that it has been allocated.

d) If in rule a) "presence" and "absence" are interchanged and also "pictorial element" is replaced by "external pictorial element" then follow rule c) with "allocate" replaced with "deallocate".

e) Rules a), b), c) and d) also apply to the appearance or disappearance in the state picture of qualifying text, by substituting the term "qualifying text" for pictorial elements in those rules.

6) For a given process diagram, particular pictorial elements (or a particular combination of pictorial elements and qualifying text) should always be placed in the same position within the state picture whenever they appear, so that the presence or absence of this pictorial element (or combination) in a state symbol can be quickly determined by comparing the state picture with other state pictures in the process diagram.

7) When a signal sender appears in a state picture, its qualifying text identifies a signal which is sent during the following transitions.

8) When a sender of a permanent signal (e.g. a ringtone) appears in a state picture, its qualifying text identifies a signal which has been started to be sent during the following transition and in this state.

9) Such transition actions that cannot be derived from the difference of pre- and post-state definitions should be explicitly described in the transition. For example, if a resource with an exported variable does not appear in the pre- and post-states, the necessary actions are better to be described in the transition.

E.2.2 *Recommended symbols for pictorial elements*

When using pictorial elements, each state is represented by a state symbol containing a state picture with the format shown in Figure E-5:

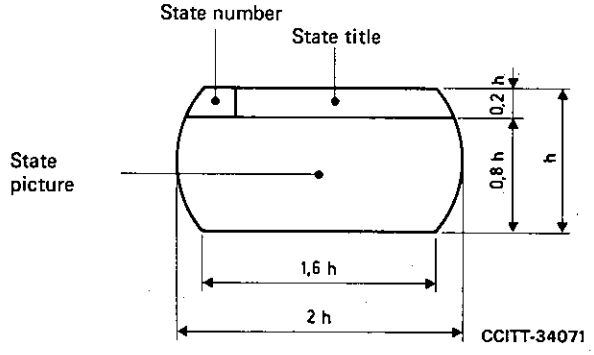


FIGURE E-5

Recommended format for a state symbol with a state picture

A basic set of pictorial elements is recommended for use in SDL/GR with application to the system description of telecommunications call handling processes, including signalling protocols, network services and signalling interworking processes. Many of these pictorial elements are capable of being applied in applications of SDL/GR to other than call handling processes.

The recommended symbols for the basic set of pictorial elements is shown in Figure E-6, and the recommended proprotions for pictorial element symbols are shown in Figure E-7.

Examples of the use of the basic set of pictorial elements are shown in Figure E-8.

E.2.3 *Special conventions and interpretations used in the state oriented extension of SDL/GR*

A number of special conventions and interpretations have been defined in this section with regard to the state-oriented version of SDL/GR. These includes:

- The special interpretation required for process diagrams according to the so-called TRANSITION INTERPRETATION RULE (see § E.2.1, rule 5).
- The unique position of pictorial elements (or pictorial elements and qualifying text) within a state picture that is required when using pictorial elements (see § E.2.1, rule 6).
- The special interpretation required for the variables represented by external pictorial elements and external qualifying text, as proxy variables associated with other processes.

E.3 *Selection criteria for pictorial elements*

The choice of symbols for pictorial elements has been based upon the following considerations and general selection criteria. These should be consulted before developing additional pictorial element symbols for wider applications of the SDL.

1) Ease of reproduction

   In order to permit convenient reproduction of SDL diagrams using the dye-line or blue-print methods of reproduction as well as photocopying and photo-printing, pictorial element symbols should consist of clear lines without shading or coloration.

2) Ease of comprehension

   a) Appropriateness – The shape of each symbol should be appropriate to the concept that the symbol represents.

   b) Distinctiveness – When choosing a basic set of symbols, care should be taken to permit each symbol to be readily distinguishable from others in the set.

   c) Affinity – The shapes of pictorial elements representing different but related functions, e.g. receivers and senders, should be related in some obvious way.

   d) Association of abbreviated qualifying text with symbols – In some cases it is expected that abbreviated text will be associated with a pictorial element in order to indicate the class of pictorial element; e.g. the letters MFC associated with a receiver symbol to indicate that multi-frequency coded signals are to be received. In these cases, the pictorial elements should incorporate enclosed space to permit the use of a very small number of alphanumerical characters.

   e) Limited set – The total number of symbols should be kept to a minimum in order to permit easy learning of the pictorial method.

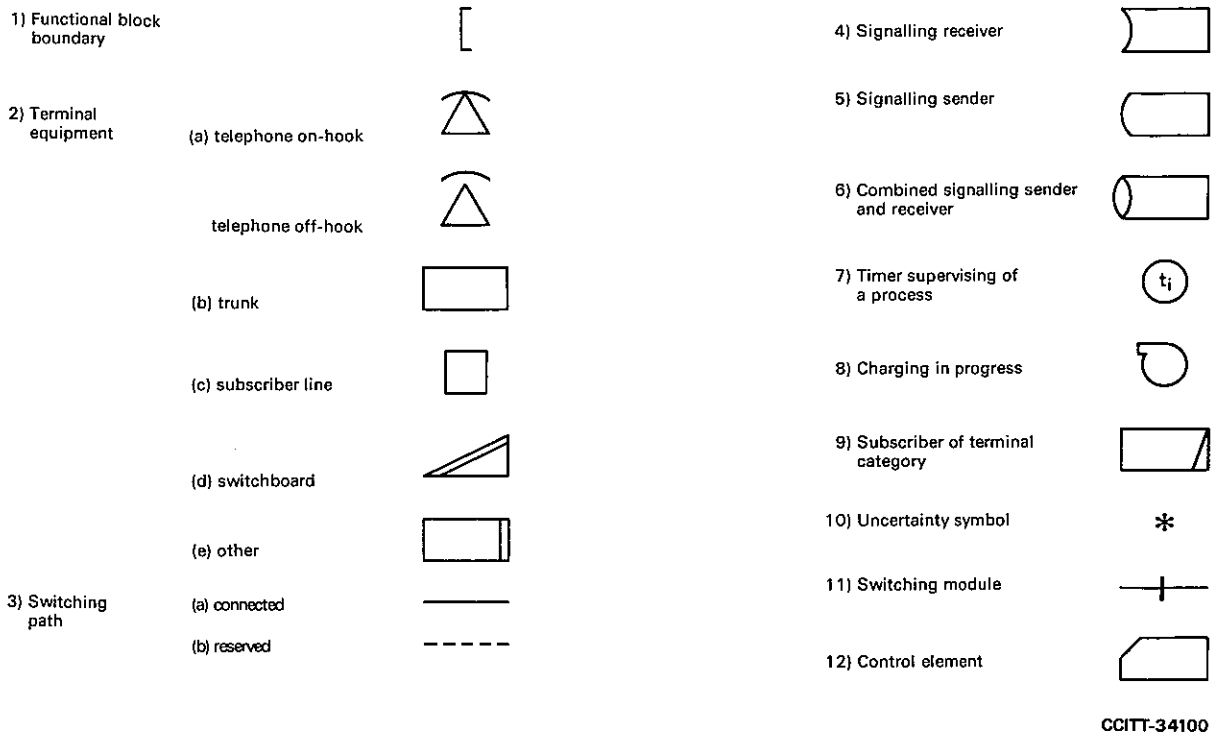


FIGURE E-6

Recommended symbols for the basic set of pictorial concepts

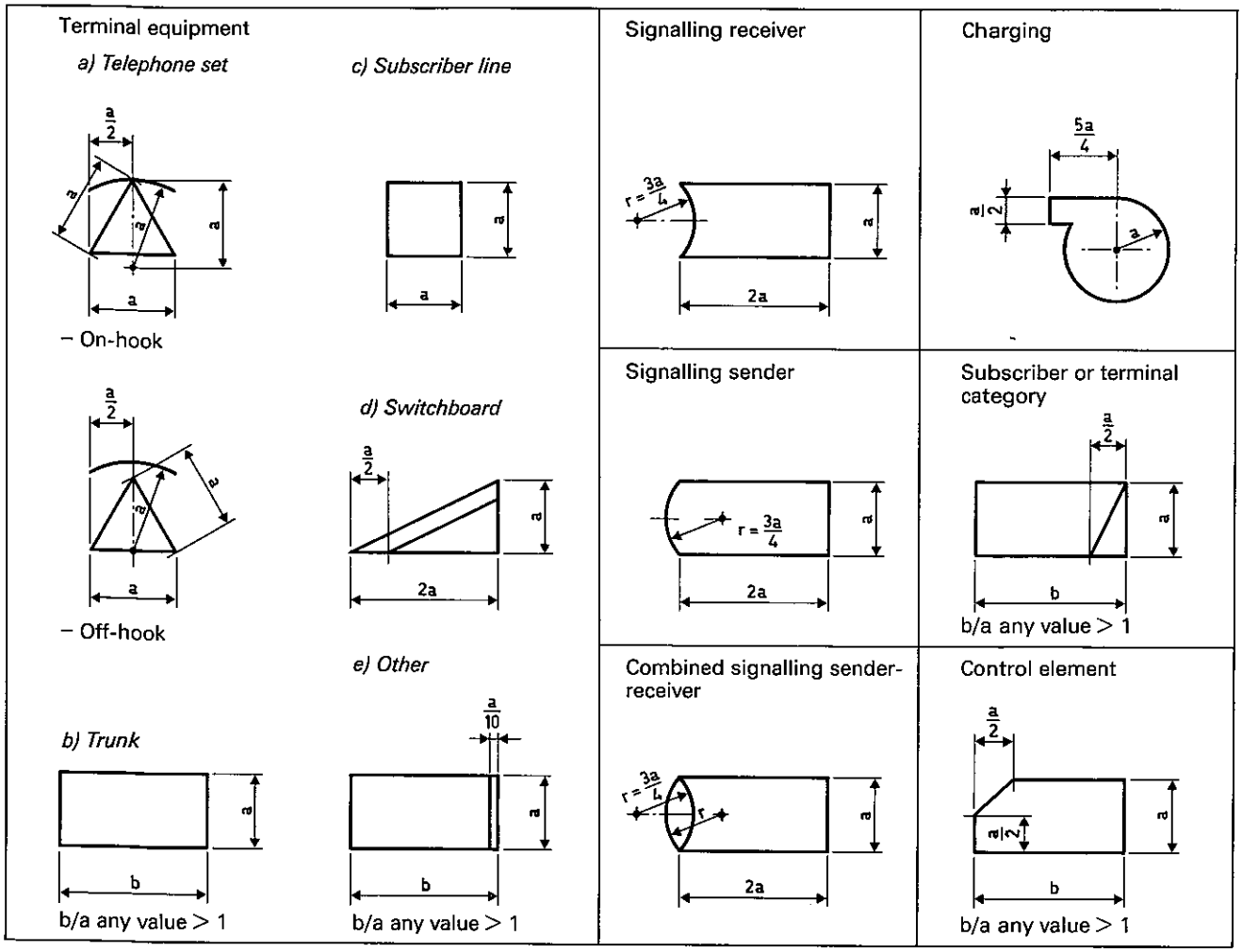


FIGURE E-7

Recommended proportions for the basic sets of pictorial elements

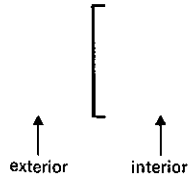
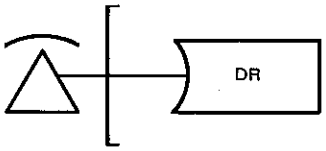
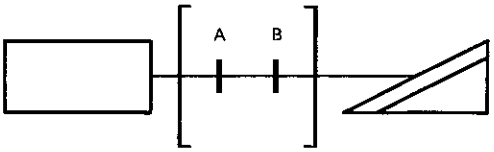
No.	Pictorial element	Comment	Examples
1.	*Functional block* (FB) *boundary* 	To distinguish between objects inside and outside the FB boundary. Only the states of objects within the boundary can be changed directly by this process.	1.1 A digit receiver inside the FB boundary connected to a handset outside the boundary.  1.2 A trunk outside the FB boundary connected via a two-stage switching unit to a switchboard outside the boundary 
2.	*Terminal equipment* a) Telephone set on-hook off-hook b) Trunk c) Subscriber line [except a)] d) Switchboard e) Other	It can be useful to show terminal equipment (e.g. telephone set and switchboard equipment) outside the FB boundary, to improve understanding of the processing work.	2.1 A on-hook 2.2 B off-hook 2.3 Incoming trunk junctor (from a space division switching exchange) Incoming 2.4 Outgoing subscriber line to party line Outgoing party line 2.5 PBX switchboard PBX 2.6 Modem Modem

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FIGURE E-8

Examples of the use of the basic set of pictorial elements

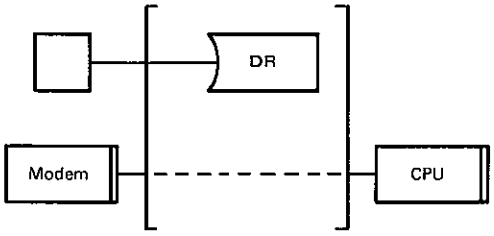
No.	Pictorial element	Comment	Examples
3.	*Switching path* a) connected ——— b) reserved - - - - - -	To show connectivity between terminal equipment and/or signalling devices involved in the process.	3.1 Subscriber line connected to a digit receiver and a modem with a reserved path to a central processing unit (CPU) 
4.	*Signalling receiver* 	To indicate the nature of the signals received, especially those crossing the functional block boundary.	4.1 Multi-frequency code signalling receiver 
5.	*Signalling sender* 	To specify a signal sending process, and to indicate the nature of the signals sent, especially those required to cross the functional block boundary.	5.1 Ringtone sender 
6.	*Combined signalling sender and receiver* 	This conveniently combines the functions of a signalling sender and signalling receiver.	6.1 MFC sender-receiver 
7.	*Process supervising timer* 	This shows the timer to be running in the state.	7.1 Timer t_3 is running  7.2 Generic timer t_s is running  where s = 1, 2, ... n define different service tones.

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FIGURE E-8 (*cont.*)

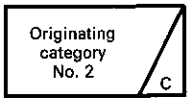
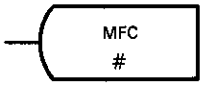
No.	Pictorial element	Comment	Examples
8.	Charging in progress 	The qualifying text in the element indicates which customer is being charged.	8.1 Subscriber A is currently being charged 
9.	*Subscriber or terminal category (and identity information)* 	This element is convenient to show the changes in the subscriber or terminal category, for each party in a multi-party call.	9.1 The C party has originating category No. 2 
10.	*Uncertainty symbol* 	This substitutes for deliberately undefined information that is shown unambiguously in other state pictures. In certain cases, two or more states may be safely merged into one, with a net gain in the intelligibility of the diagram, by using the uncertainty symbol.	10.1 Handset either on-hook or off-hook  10.2 An undefined MFC signal is being sent in this state 

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FIGURE E-8 (*cont.*)

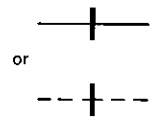
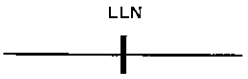
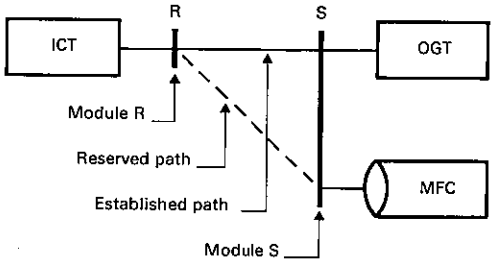
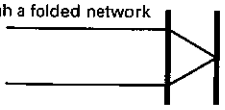
No.	Pictorial element	Comment	Examples
11.	*Switching module*  or	To show what switching modules are involved in the process. *Note* – The horizontal line is the pictorial element for a switching path, which may be connected or reserved. The vertical line can be used to represent either a complete switching module (when the internal structure of the module is not required) or else one of the switching stages within a switching module.	11.1 A path connected through one switching module LLN (Line link network) LLN = Line link network  11.2 Paths connected and reserved through two switching modules  ICT – Incoming trunk OGT – Outgoing trunk MFC – Multi-frequency code *Note* – In this example, ICT is connected to OGT, but ICT is not connected to the MFC sender/receiver. 11.3 A path connected through a three-stage switching module RSN  11.4 A path reserved through a three-stage switching module ABC  11.5 A path connected through a folded network 
12.	*Control element (assigned to a process)* 	To show what control equipment is involved in the process (especially modules that must be dimensioned). This symbol can be used to indicate that particular software elements have been assigned to the process.	12.1 Call register buffer 

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FIGURE E-8 (*end*)

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