1. General

1.1 Scope. This practice describes the mechanism for the transfer of control messages between tributaries used within a general-purpose communications channel of an interface system which transports data and digital control signals between equipment utilized in the production, post-production, and/or transmission of visual and aural information.

It is intended that the mechanism described in this practice be utilized when transferring control messages between tributaries used as a part of an overall system. The tributaries may be located either within a local network or on separate local networks which are interconnected by means of gateways and an interconnection bus.

It is further intended that this mechanism, when used as part of an overall system, shall allow the interconnection of programmable and non-programmable equipment as required to configure an operational system with defined function, and will allow rapid re-configuration of a system to provide more than one defined function utilizing a given group of equipment.

1.1.1 The message transfer mechanism makes use of virtual circuits, linkage directories, and system service messages (defined below).

1.1.2 The primary intent of this practice is to define the mechanism enabling the transfer of messages between tributaries for the purpose of controlling equipment by external means.

1.2 Definitions. For the purposes of this practice the following definitions shall apply:

Virtual Machine: a logical device consisting of a single device or a combination of devices that respond in essence or effect as a generic type of equipment, e.g., VTR, video switcher, telecine, etc.

Virtual Circuit: A transparent, unidirectional, logical communications connection between virtual machines. The communications path, in reality, passes through other levels and is propagated over a physical medium.

2. Interconnection within a Local Network

2.1 Message Transfer. The mechanism for message transfer between tributaries is based broadly on the principles of communications layering and makes use of virtual circuits. This allows for the establishing of, and breaking down of, multiple links between the tributaries. System service messages perform this function.

A 'linkage directory' is established within the bus controller for each working session. The directory is considered to be a system service feature and provides for the establishment of multiple virtual circuits through the network.

2.2 Linkage Directory. The linkage directory shall establish a relationship between virtual machines, i.e., a virtual circuit. Establishment of the linkage directory shall be completed as the initial task in each working session. The linkage directory resident within the system service level of the bus controller binds message 'sources' and 'destinations.'

Linkage information may originate in any application level, and shall effect directory construction within the system service level of the bus controller. Linkage messages are reserved messages within the system service sub-set of all message dialects; they establish and disconnect virtual circuits within the network.

The bus controller, on receipt of a transmission request from the supervisory level of any tributary, will identify the destination tributary by reference to the linkage directory; acting as an intermediary it will forward the message as directed.

2.3 Multiplexing within Tributaries. Tributaries, in general, have a single supervisory level address, and a single physical connection end point to the bus. Alternative multiplexing mechanisms, as described below, enable multiple virtual circuits to pass through any single connection end point.

2.3.1 Multiple, logically independent virtual machines, each with a unique supervisory level address, may be attached to the communications channel through a common connection end

point. Multiplexing is then performed by multiple polling of the addressing entity residing within the supervisory level (Fig. 1).

(It may be noted that any individual tributary address may achieve a higher priority — and hence an improved response time at the expense of that of the remaining tributaries — by being allocated more than one poll within each poll sequence.)

2.3.2 Alternatively, a single supervisory level address may be multiplexed to multiple logically independent virtual machines, with selection being performed by a logical switch residing within the entity of the destination tributary system service level. (See Fig. 2.)

The required virtual machine is selected from those associated with the single supervisory level address, by means of a system service 'virtual-machine-select' message. (See 3.4 below.) This is transmitted from the bus controller under the direction of the linkage directory held within its system service level, to the destination tributary system service level, immediately prior to the transmission of any control message, or sequence of control messages, destined for that specific virtual machine.

The selected routing will remain in existence until receipt, by the system service level, of a new virtual-machine-select message thereby minimizing the message traffic on the communications channel.

2.3.2.1 The reverse route of each virtual circuit, when required, will be selected similarly by the logical switch resident within the entity of the system service level of the multiplexed tributary. This selection is performed on receipt of a control or response message from any one of the virtual machines attached to the system service level of the tributary. The system service level will then instruct its supervisory level to transmit the appropriate 'virtual-machine-select' message to the supervisory, and hence the system service, level of the bus controller.

2.3.2.2 System service level group 'Assign' and 'De-assign' commands shall be used to assemble/disassemble groups of virtual machines within the system service level, from those associated with a single supervisory level address, for simultaneous control purposes.

Virtual circuits employing virtual group identifiers shall be recorded as additional entries within the bus controller linkage table.
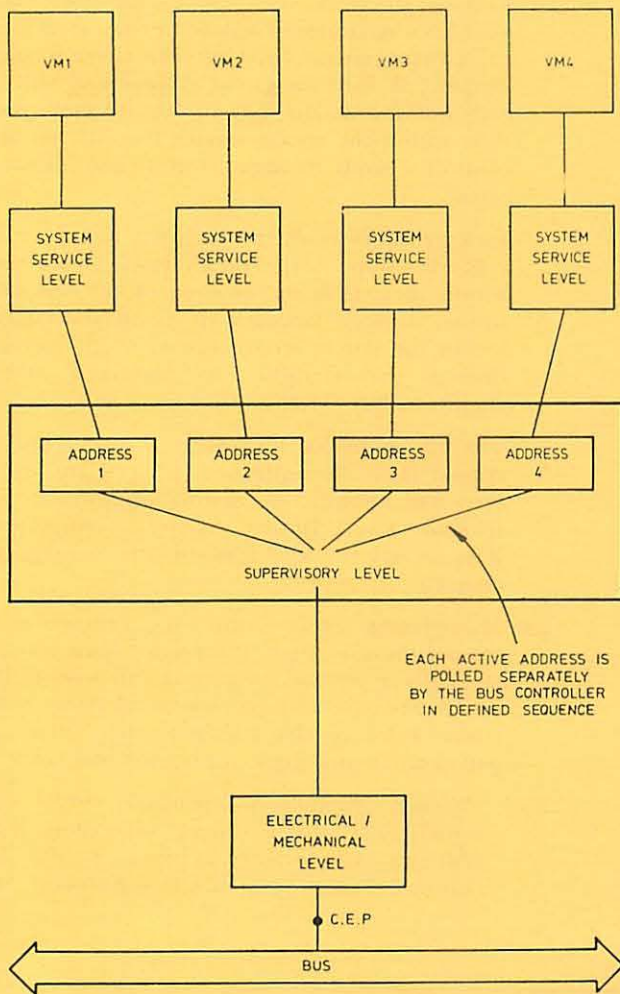

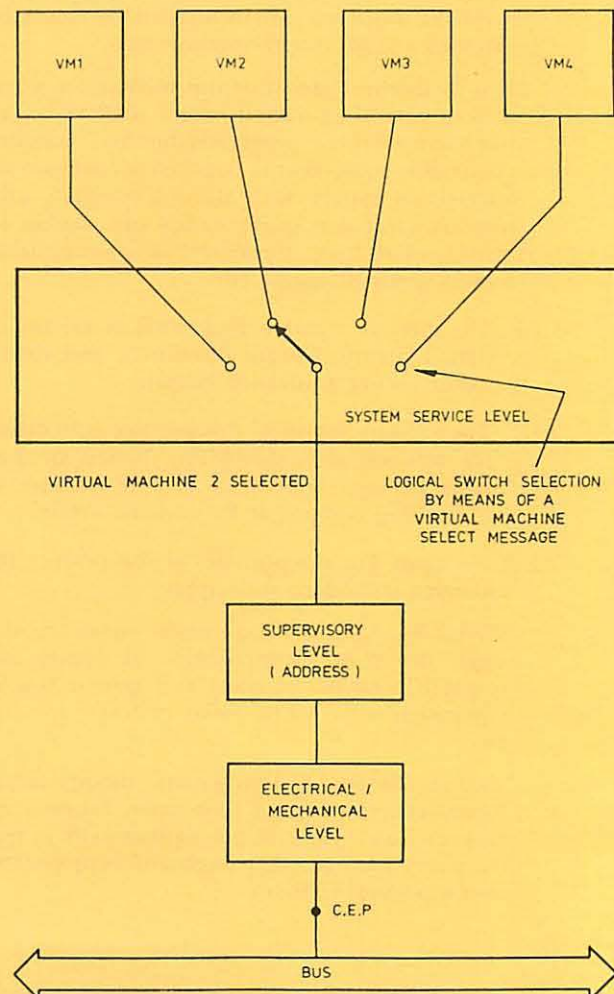**Fig. 1**
Multiplexing within Supervisory Level

Fig. 2
Multiplexing within System Service Level

2.3.3 It should be noted that a bus overhead exists in each method of virtual circuit multiplexing. Where the multiplex is to take place within the supervisory level (2.3.1), the overhead will take the form of additional polls in each cycle.

System service level multiplexing (2.3.2) introduces an additional control message (the virtual-machine-select message) prior to each virtual machine message, or series of virtual machine messages, destined for an alternative virtual machine.

The choice of multiplexing mechanism, where used, rests with the system designer in recognition of specific design considerations.

2.4 Forbidden Configurations. Some virtual circuit configurations may be forbidden due to the function of the particular tributary, i.e., the functions of the tributaries are incompatible. Checking mechanisms should be employed to ensure that illegal virtual circuits cannot be established. Most of the checking would be performed in the system service level according to predefined rules within the particular network. Some rules could be readily derived from the type of tributary (built in) while others may be imposed by the user or system designer.

3. *System Service Messages*

System service messages are messages contained in the system service sub-set of all message dialects and shall be used to command the performance of system functions. These functions include, but are not limited to:

3.1 Segmentation and Re-assembly. These processes enable the transfer of messages which exceed the maximum supervisory level message block length (see Fig. 3a). The parsing mechanism for segmentation and blocking is described by the state diagram given in Fig. 4.

3.1.1 A data segment shall take the following form (see Fig. 3b):

1st Byte:	Keyword SEGMENT
2nd Byte:	Number of segments remaining; last segment is 0; segment count shall be sent in sequentially descending order.
Remaining Bytes:	Segment data. No further message shall follow a data segment message within a single supervisory level block.

3.2 Blocking and De-blocking. These processes enable the concatenation of messages within a single supervisory level message block.

3.2.1 A Data Block shall take the following form (see Fig. 3c):

1st Byte:	Keyword BLOCK.
2nd Byte:	Byte count (N), where N is the number of bytes in the block data.
Remaining Bytes:	Block data.

3.2.2 The supervisory level shall transfer the byte count to the system service level.

3.3 Establishment of Virtual Circuits. This process is effected through the management of the linkage directory contained within the bus controller.

3.4 Selection of a Virtual Machine. This process enables the selection of a virtual machine from those previously assigned to a tributary.

3.5 Tributary reset. This command returns the tributary to its power-up default state.

3.6 Group Assign/De-assign. These commands establish/break down system service level groups of virtual machines for joint control purposes.

3.7 Virtual Group Assign/Deassign. These commands establish/break down supervisory level groups of tributaries for joint control purposes.

4. *Interconnection of Local Networks*

4.1 Interconnection Bus. Interconnection of individual local networks shall be by means of an interconnection bus (see Fig. 5). Linking of the local network to the interconnection bus shall be by means of a GATEWAY.

ISO 3309 and 4335 (HDLC), in accordance with CCITT Recommendation X.25 — LAPB, shall be used for the data link layer protocol between the gateway and the interconnection bus coupler; the physical link layer shall be as specified in CCITT Recommendation X.21.

4.2 Gateway. The gateway is a logical device whose task is to transfer messages between a local network and an external interconnection bus coupler. The gateway provides for the interchange of messages between multiple local networks.

The gateway will maintain a linkage directory in its system service level. The linkage table will allow the gateway to be seen by the bus controller as a set of 'virtual' tributaries linked by virtual circuits.
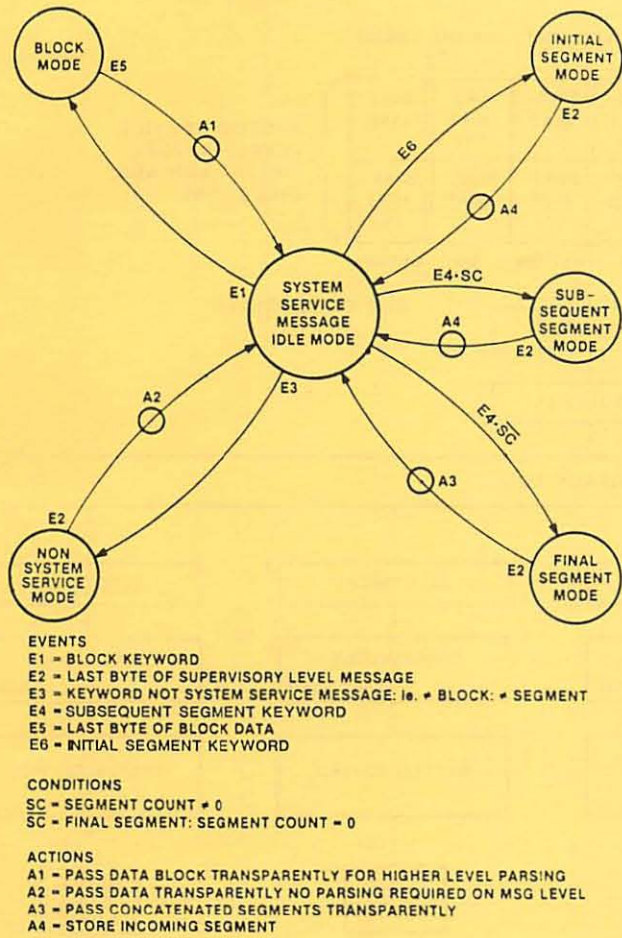
The gateway will provide for all protocol conversions required to convert from the interface bus supervisory and electrical/mechanical level standards as specified in SMPTE Recommended Practice on Supervisory Protocol for Digital Control Interface, RP 113-1983, and American National Standard for Television — Digital Control Interface — Electrical and Mechanical Characteristics, ANSI/SMPTE 207M-1984, respectively, to the HDLC data link and X.21 physical link layers.
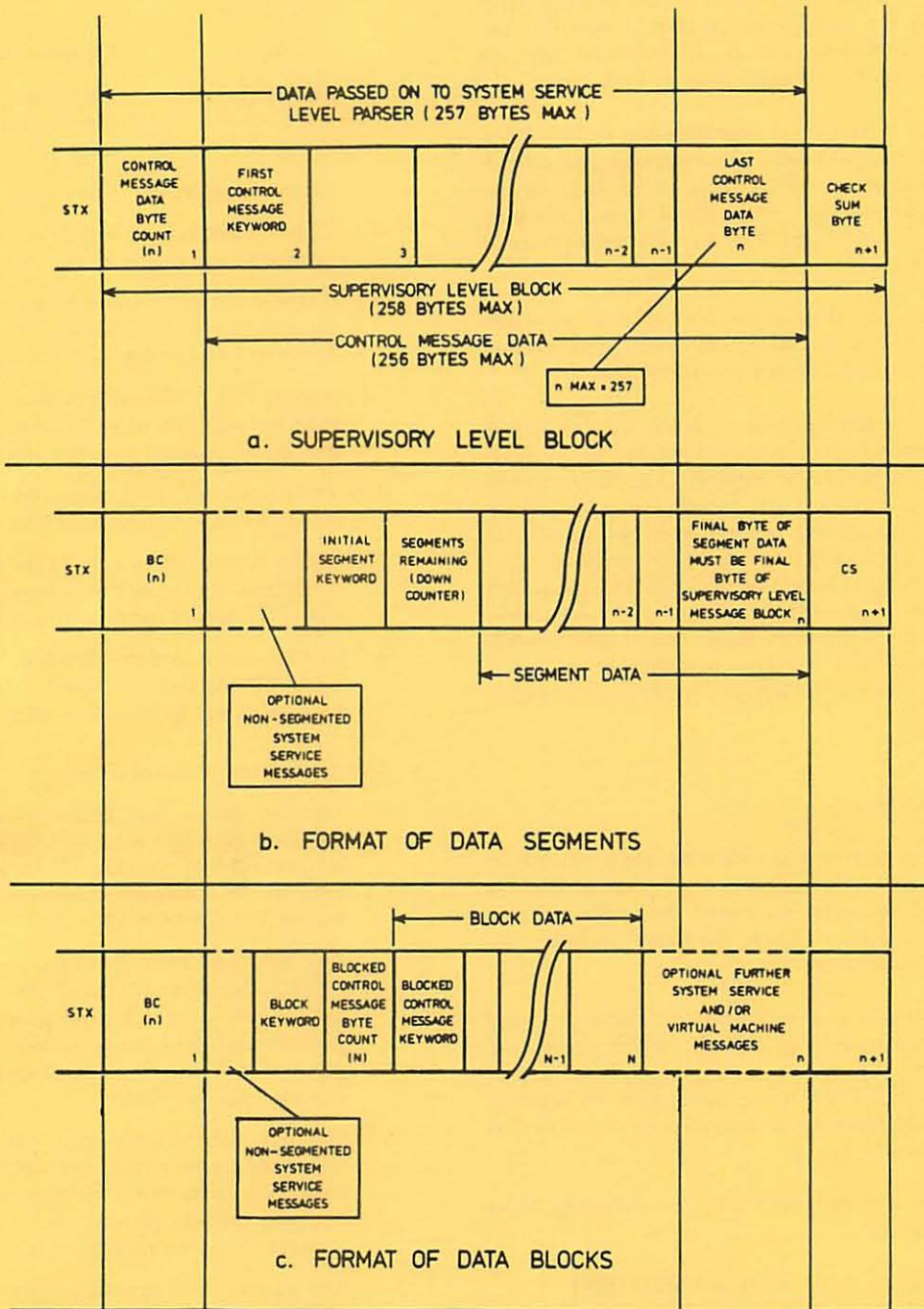
Fig. 3
Data Segments and Blocks

The gateway will provide decoding of group addresses provided for in the supervisory level (SMPTE RP 113-1983) and will forward messages addressed to these groups over the interconnection bus as discrete individual select addresses. Where more than one 'external' tributary is addressed by a group message, the individual messages to all such tributaries shall be dispatched sequentially as individual messages from the gateway. Translation takes place in the system service level of the gateway. The functional structure of the gateway is shown in Fig. 6.

Fig. 4
Segmentation/Blocking State Diagram

EVENTS
E1 = BLOCK KEYWORD
E2 = LAST BYTE OF SUPERVISORY LEVEL MESSAGE
E3 = KEYWORD NOT SYSTEM SERVICE MESSAGE: ie. ≠ BLOCK: ≠ SEGMENT
E4 = SUBSEQUENT SEGMENT KEYWORD
E5 = LAST BYTE OF BLOCK DATA
E6 = INITIAL SEGMENT KEYWORD

CONDITIONS
SC = SEGMENT COUNT ≠ 0
SC = FINAL SEGMENT: SEGMENT COUNT = 0

ACTIONS
A1 = PASS DATA BLOCK TRANSPARENTLY FOR HIGHER LEVEL PARSING
A2 = PASS DATA TRANSPARENTLY NO PARSING REQUIRED ON MSG LEVEL
A3 = PASS CONCATENATED SEGMENTS TRANSPARENTLY
A4 = STORE INCOMING SEGMENT

5. Guidelines

This section gives a typical example of virtual machine selection when using the multiplexing technique detailed in 2.3.2. It encompasses operations in both the system service and supervisory levels and thus includes features described in SMPTE RP 113-1983.

In 5.1, the procedure is described in broad outline; in 5.2, the same example is dealt with in more rigorous detail.

5.1 In this broad outline, the form of the messages is not defined precisely but is given only as an illustration of the function to be performed.

(A) Assume that three control panels are linked to the local network through a single tributary address and connection end point as shown in Fig. 7.

During the assignment process, the control panels CP1, CP2, and CP3 have been associated with VTR, telecine and still store, respectively, via virtual circuits (1), (2) and (3).

(B) Assume further that a VTR command has just been issued by CP1 and a telecine PLAY command is now required.
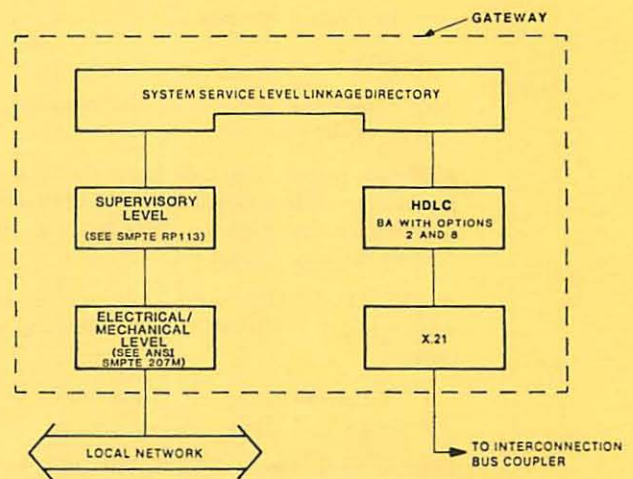
(C) The following linkage message must be issued by the system service level of the control panel tributary:

[Virtual-machine-select] [2]

This changes the virtual machine selection from virtual machine [1], (VTR), to virtual machine [2], (telecine).
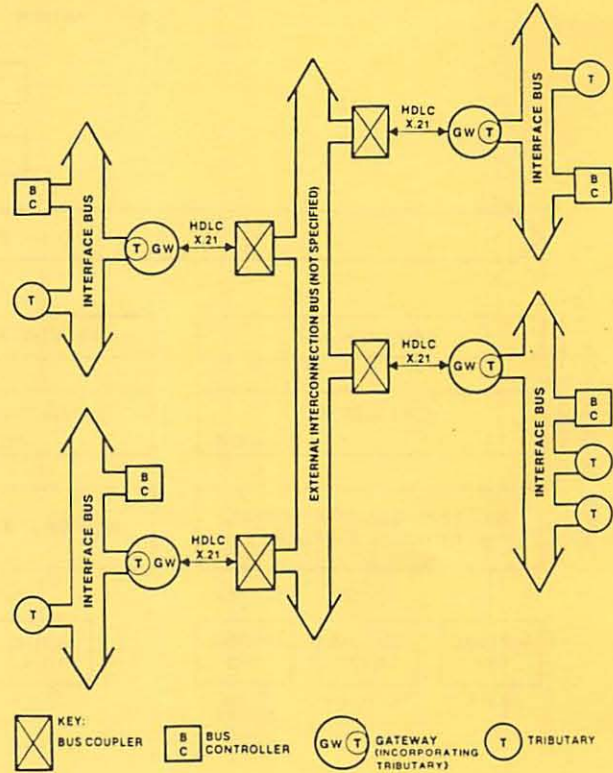
Fig. 5
Local Network Interconnection

NOTE:
THE HDLC/X.21 DEFINITION SHALL BE IN ACCORDANCE WITH THE CCITT X.25-LAPB
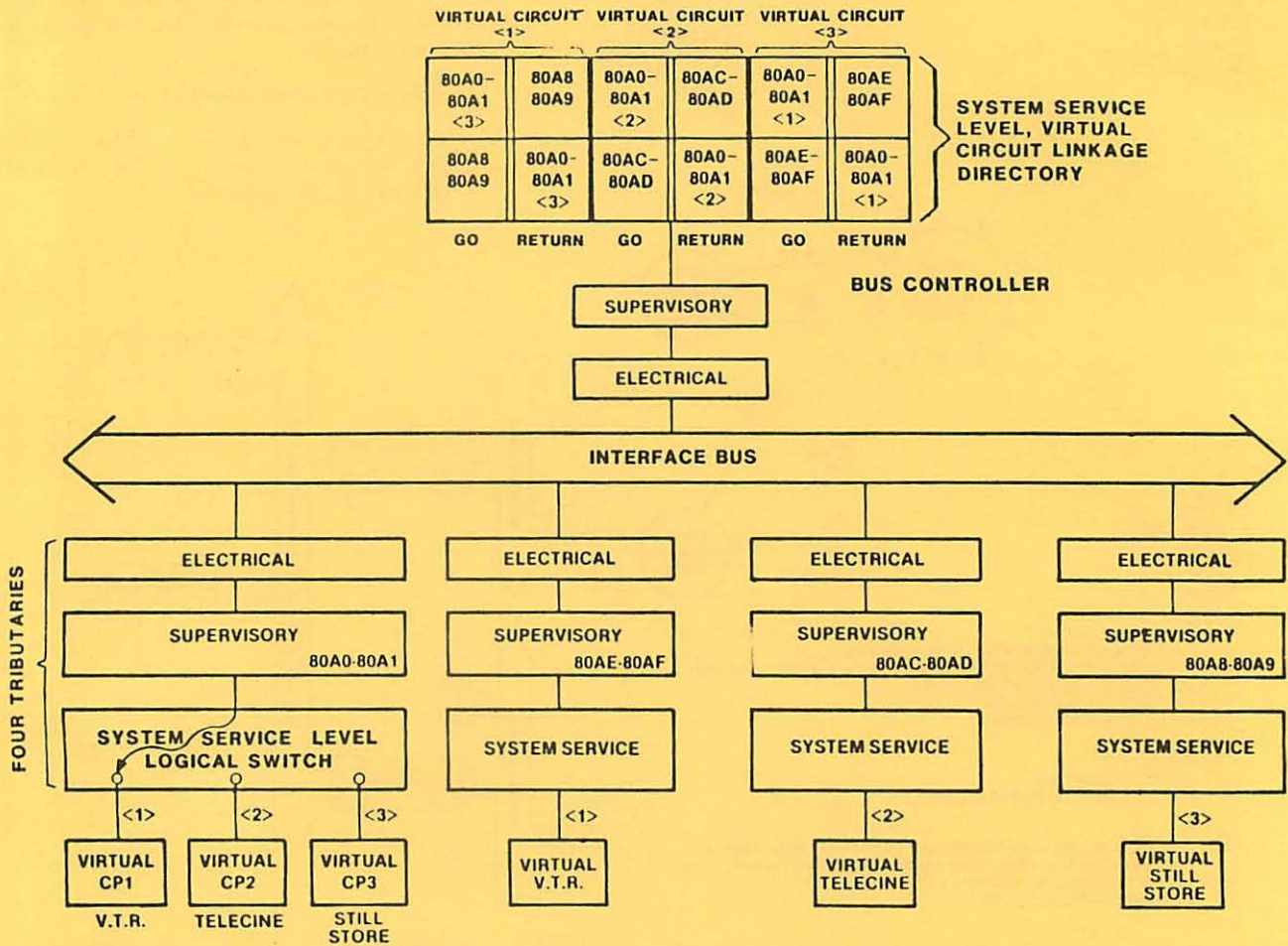
Fig. 6
Gateway Functional Structure

Fig. 7
Example of Virtual Circuit Select Mechanism

(D) The control panel virtual machine then issues the control message:

[PLAY]

This causes the telecine virtual machine to change to the play state.

Any subsequent messages from the control panel to the telecine will be transferred without any further linkage messages, e.g., the control message [STOP].

A [NEXT SLIDE] command for the still store virtual machine would, however, require:

1. [Virtual-machine-select] [3] and
2. [NEXT SLIDE]

in order to re-select the virtual machine CP3.

5.2 In this more rigorous treatment of the example given in 5.1, it is assumed that the three control panel virtual machines, CP1, CP2, and CP3, are linked to the interface bus through the single tributary address [80A0/80A1] and connection end point.

5.2.1 A [START] command from the telecine control panel virtual machine CP2 attached to tributary 80A0/80A1 is to be sent by virtual circuit [2] to the telecine virtual machine connected to tributary 80AC/80AD. A possible message exchange might be:

(A) Telecine control panel virtual machine, (CP2), passes [START] command to system service level of tributary 80A0/80A1.

(B) 80A0/80A1 system service level instructs supervisory level to raise the service request flag (SVC).

(C) The bus controller, as part of its normal poll sequence, polls 80A1; and receives [SVC].

(D) The bus controller issues select address 80A0: it then sends [TEN] to 80A0/80A1 supervisory level.

(E) 80A0/80A1 supervisory level sends:

[STX] [byte count (BC)] [virtual-machine-select] [2] [block check (B.CK)]

to the bus controller (see Note 1).

(F) The bus controller responds with [ACK] and a further [TEN]. (Since the last message was a 'virtual-machine-select' message, a further virtual machine control message is expected by the bus controller (see Note 1).

(G) The supervisory level of the tributary 80A0/80A1 sends:

[STX] [BC] [START] [B.CK]

to the bus controller (see Note 1).

(H) The bus controller system service level identifies the destination of [80A0/80A1 — virtual-machine 2] from its linkage directory. The address is found to be 80AC/80AD.

(I) The bus controller issues [BREAK] followed by the select address 80AC.

(J) 80AC/80AD tributary supervisory level responds with [ACK].

(K) The bus controller then sends:

[STX] [BC] [START] [B.CK]

to tributary 80AC/80AD.

(L) The supervisory level of tributary 80AC/80AD responds with [ACK] and passes the control message to the system service level parser.

(M) The system service level parser passes the [START] command to the telecine virtual machine.

Note 1: The messages in (E) and (G) might be concatenated into the single 'hybrid' command:

[STX] [BC] [virtual-machine-select] [2] [START] [B.CK]

in order to limit protocol overhead. In this case the message contained in (F) would not be necessary.

5.2.2 A tally response [STARTED] from the telecine virtual machine tributary 80AC/80AD is to be sent to telecine control panel virtual machine CP2 attached to the interface bus through tributary 80A0/80A1.

(A) The telecine virtual machine passes the [STARTED] tally to the system service level of tributary 80AC/80AD.

(B) The system service level instructs the supervisory level of 80AC/80AD to raise the service request flag (SVC).

(C) The bus controller, as part of its normal poll sequence, polls 80AD and receives [SVC].

(D) The bus controller issues the select address 80AC, followed by [TEN] to the supervisory level of 80AC/80AD.

(E) The bus controller receives the tally:

[STX] [BC] [STARTED] [B.CK]

from 80AC/80AD.

(F) The bus controller system service level determines the destination (80A0/80A1 — virtual machine 2) from its system service level linkage directory.

(G) The bus controller issues [BREAK] and the select address 80A0.

(H) 80A0/80A1 supervisory level responds with [ACK].

(I) The bus controller sends:

[STX] [BC] [virtual-machine-select] [2] [B.CK]

to tributary 80A0/80A1 (see Note 2).

(J) The tributary 80A0/80A1 responds with [ACK], and sets the logical switch in its system service level to select telecine control panel virtual machine CP2.

(K) The bus controller sends tally:

[STX] [BC] [STARTED] [B.CK]

to tributary 80A0/80A1 supervisory level (see Note 2).

(L) The supervisory level of tributary 80A0/80A1 responds with [ACK] and passes the control message to the system service level parser.

(M) The system service level parser passes [STARTED] tally to the telecine control panel virtual machine CP2.

Note 2: The messages in (I) and (K) might be concatenated into a single hybrid command thus:

[STX] [BC] [virtual-machine-select] [2] [STARTED] [B.CK]

in order to limit protocol overhead.

5.2.3 It should be noted that further commands to the same virtual machine, and which follow immediately on the sequences detailed in 5.2.1 will omit steps (E) and (F) since no further changes are needed in the virtual machine selection.

Similarly, 5.2.2 steps (I) and (J) will be omitted under the same circumstances.