FIG. 12

- TU-0 STATUS

- TU-1 STATUS

- TU-2 STATUS

- TU-3 STATUS

- TU-4 STATUS

- TU-5 STATUS

- TU-6 STATUS

- TU-7 STATUS

FIG. 22

TAPE UNIT GROUP COMBINATIONS

<table>
<thead>
<tr>
<th>TUS #1-L.O.</th>
<th>TUS #2-H.O.</th>
</tr>
</thead>
<tbody>
<tr>
<td>GR-1</td>
<td>GR-2</td>
</tr>
<tr>
<td>0 1 2 3 4</td>
<td>4 5 6 7 0</td>
</tr>
<tr>
<td>4 5 6 7 0</td>
<td>1 2 3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>TUS #1-H.O.</th>
<th>TUS #2-L.O.</th>
</tr>
</thead>
<tbody>
<tr>
<td>GR-1</td>
<td>GR-2</td>
</tr>
<tr>
<td>8 9 10 11 12</td>
<td>13 14 15 8</td>
</tr>
<tr>
<td>12 13 14 15</td>
<td>8 9 10 11</td>
</tr>
</tbody>
</table>
FIG. 23
INPUT/OUTPUT UNIT SWITCH

Filed Apr. 27, 1964, Ser. No. 362,710
21 Claims. (Cl. 340—172.5)

ABSTRACT OF THE DISCLOSURE

An input/output (I/O) unit switch operated by a plurality of control units, permitting them to independently select and use any available I/O unit from a plurality of I/O units. No additional computer instruction is needed to recognize the status of the I/O unit switch, which is a passive device that responds to standard I/O unit instructions without the I/O switch. Coordinating selection circuitry prevents improper selection of any I/O unit. A modular configuration with nodes having slow speed (asynchronous) bus switching circuits and high speed (semi-conductor) control switches permits full performance in switching and controlling magnetic tape units. The control units may be connected to the same or different computer systems.

This invention relates generally to a switching system for selectively connecting any input/output (I/O) unit of a plurality of I/O units to any control unit of a plurality of control units. All control units can simultaneously operate with different I/O units. Furthermore, any I/O unit can be permanently made not available to any control unit on a selective basis.

The component means of selecting an I/O unit from a group of units via a direct connection between a control unit and each of a plurality of I/O units. In this sense, a control unit is designed to accommodate up to a specific maximum number of I/O units.

Tape units are a form of I/O unit and hereafter are used to represent I/O units generally. Frequently, it is desired to increase the capacity of a magnetic tape unit installation without the use of special apparatus through the use of additional tape controls. In this case, each tape control selects among only its own bank of tape units, and it cannot operate tape units connected to other tape controls.

Example, an overall computer installation may have two tape controls and 16 tape units, in which 8 of the tape units are connected to one control unit while the remaining 8 tape units are connected to the remaining control unit. One tape control can operate only with one of its 8 tape units and cannot operate with the 8 tape units connected to the other control unit. In this event, the addition of a tape control and its tape units does not increase the flexibility of either the tape controls or the individual tape units, although it increases the I/O capacity of the system due to the addition of more units. It is, therefore, desirable to be able to find a convenient means of increasing the flexibility of an installation so that any of several tape controls can operate with any tape unit among all tape units at an installation. A method of accomplishing this end is a tape unit switch (TUS). The tape unit switch connects between a plurality of the tape controls and a plurality of tape units so that any of the plurality of tape units is selectable by any of a plurality of tape controls.

Various tape unit switches have been suggested, some of which are directly address programmable and require special instructions by the computing system in order to connect a given tape unit to a given tape control. Other tape unit switches are manually controlled to connect a particular tape unit to a particular tape control. The manual switch offers the flexibility of changing a semi-permanent tape unit connection, but it cannot provide tape switching between data block transfers by a computer system without first stopping the system, which is highly undesirable.

It is an object of the invention to provide switching means to allow any of a plurality of control units to be connected selectively to any of a plurality of I/O units. In some cases, the total number of available I/O units can exceed the maximum number that can normally be attached to a control unit.

It is another object of the invention to provide an I/O switch which can operate without the necessity of any special computer instruction or any other special program intervention by a computing system, and yet can operate under complete computer control.

It is a further object of this invention to provide an I/O unit switch having the general physical configuration of a two-dimensional matrix.

It is another object of this invention to provide a switch that can operate all input-output lines between a control and its selected I/O unit.

It is a further object of this invention to provide switching circuitry that allows an overlapped operation between a high speed tape control unit and a relatively slow I/O unit by overlapping data bus switching with read or write delays of an I/O unit.

It is another object of this invention to provide means for locking out the availability of a particular I/O unit to any one or more control units.

It is another object of this invention to provide an I/O switch capable of modular expansion for future increase in the number of I/O units and/or controls in a computer installation.

It is an object of this invention to provide an I/O switch between plural I/O units and plural controls, where the controls can be connected to different channels of the same computer system, or to channels of different computer systems, or to channels of a computer system and to off-line devices.

It is another object of this invention to prevent another control from interfering with the operation of an I/O unit once the I/O unit has been selected by any control.

It is an object of this invention to permit any control to sample the status or type of any I/O unit connected to an I/O switch, even though the I/O unit is being operated by another control.

It is another object of this invention to permit an I/O select instruction from a computer to any of its tape controls to select among any available tape unit in the computer installation.

It is a further object of this invention to provide a "plurality control-plural tape unit" switch capable of switching among its tape units between normal data block transfers to or from a computer with no loss of time in system operation due to switching, compared to the time required to switch between tape units on a single tape control not having a tape unit switch.

The foregoing and other objects, features and advantages of the invention will be apparent from the follow-
ing more particular description of the preferred embodiment of the invention, as illustrated in the accompanying drawings.

In the drawings:

FIGURE 1 represents an arrangement of tape unit switch input and output lines.

FIGURES 2 A-G show different modular combinations for tape unit switches using this invention.

FIGURE 3 illustrates a double tape unit switch arrangement.

FIGURE 4 represents generalized low and high order control gate switching.

FIGURE 5 is a single tape unit switch matrix layout.

FIGURE 6 shows a select line switching circuit.

FIGURE 7 represents a group swapping circuit arrangement.

FIGURE 8 shows a portion of a tape control having a tape unit selection register and a decode circuit.

FIGURE 9 illustrates low order tape unit switch control gate circuits.

FIGURE 10 shows tape unit availability-lockout circuits.

FIGURE 11 illustrates high order tape unit switch control gates.

FIGURE 12 represents entrance connectors for tape unit status line from eight different tape units.

FIGURE 13 is a circuit arrangement for tape unit status line switches.

FIGURES 14 and 15 provide switching circuits for tape unit sense lines.

FIGURES 16, 17 and 18 show switching circuits for control lines from one of plural tape control units.

FIGURE 19 is a write bus switching circuit.

FIGURES 20 A and B show a schematic diagram and a legend symbol, respectively, for a reed relay coil contacts used to switch read or write buses within the tape unit switch.

FIGURES 21 A and B show a schematic diagram and a legend symbol, respectively, for a multiposition switch, which can be manually set.

FIGURE 22 is a table showing tape unit group switching combinations.

FIGURE 23 is a read bus switching circuit.

In the preferred embodiment of the invention shown in the attached drawings, standard logic symbols have been used to represent types of circuits presently available in the art, such as AND, OR, circuits, which can use the same physical circuit but with differently defined input and output states to obtain the designated, or equivalent, logic function. The symbol A represents an AND circuit, O an OR circuit, N an inverter circuit, SW an electrical switch, TC a tape control, TUS a tape unit switch, TU a tape unit, F a flip-flop, trigger or latch, RLY a relay, and AR an amplifier.

Also a wedge (\( p \)) symbol with an input or output of an A, O, or N circuit block represents a negative (or less positive) voltage level when the circuit block is active.

The following disclosure which references the drawings describes a preferred detailed embodiment of the invention.

A Tape Unit Switch (TUS) contains the necessary circuitry to functionally connect a plurality of magnetic tape units to a plurality of magnetic tape control units. The functional connections accommodate all lines required for the transfer of data and control information between a tape control unit (TCU) and a selected tape unit (TU). In providing such connections the TUS is a passive device in that it cannot generate or terminate data or control lines with the exception of a high order line which is used to control multiple TUS's in a multiple switch arrangement. FIGURE 1 is a diagrammatic representation of the lines extending between a tape control unit and a tape unit through a TUS. All lines, whether generated by the tape control unit or the tape unit, with the exception of the high order line, are transferred through the switch logically unchanged. All lines are shown grouped according to the general function performed. Groupings include the write and read lines for the transfer and control of data. Control lines are generated by the control unit and provide all control functions for a selected tape unit. The control lines include all operational sequences such as write, read, and motion control to effect forward or backward motion of the tape. Select lines are the particular means whereby a control unit selects a tape unit. Sense lines are generated by a tape unit and provide significant information to a control unit regarding the current condition of a tape unit. The number associated with each line title represents the number of lines in the bundle. Since the TUS is a passive device and cannot logically change the definition of a line, all definitions are applicable whether a line begins with the control unit or with the tape unit.

Accordingly, line definitions are as follows:

**Write Bus.**—The write bus is a set of 9 lines, comprising one line for each data track. All data bytes to be recorded on tape are transferred to the tape unit via the write bus. In the present embodiment, the write bus comprises eight data lines numbered 0 through 7 plus one parity line designated P. In the tape unit the write bus lines terminate at the magnetic write head drivers. For a seven-track configuration, only seven of the nine bus lines are used.

**Write Pulse.**—Write pulse is a sync pulse controlling the actual recording of a data byte on the write bus. The rise of write pulse provides gating for write bus lines to activate the write drivers. In an NRZI encoding format, a write driver is switched whenever a one bit is on the corresponding write bus line.

**Read Bus.**—The read bus is a set of 9 lines comprising one line for each data track. All bytes of data read from tape are transferred to the control unit via the read bus. The input to the read bus is the magnetic read head preamplifier. Its output, in the control unit, is a read register. For a seven-track configuration only seven of the nine bus lines are used.

**Write Echo.**—Write echo signals the tape control whenever a bit is recorded on tape in any track. Generally, data encoding is such that the bytes of data will always include at least one 1-bit. The write echo substantiates a write check.

**Go.**—Go is a motion control interlock. All tape motion with the exception of rewind and rewind unloading is dependent upon activation of the Go line.

**Backward.**—Backward establishes backward status in the tape unit. Whenever backward status is established, activation of the go line will initiate the backward movement of the tape. Activation of the go line with an inactive backward effects forward tape motion. The backward line also sets read status and turns off the tape indicator in any tape unit to which it is directed.

**Set Write Status.**—Whenever set write status is initiated to a tape unit, the write circuits therein are conditioned to allow the tape unit to record bytes of data appearing on the write bus. Set write status resets the backward status. After initiation of set write status, the tape unit will remain in write status until either set read status or backward are activated.

**Set Read Status.**—Activation of set read status establishes read status to allow a tape unit to read data from tape for transfer, via the read bus, to a control unit. Set read status resets the write status and backward. Read status is reset whenever a set write status is activated.

**Write Pulse Control.**—The write pulse control is a line to determine whether a byte of data or a check character is to be written. Whenever write pulse control is active, the write pulse will effect the recording of data. Whenever the write pulse control is inactive, the write pulse will effect the recording of a check character. The check character may, for instance, be the longitudinal redundancy check character wherein each bit is the modulo 2 sum.

3,372,378
Rewind.—A tape unit receiving rewind will, independent of the state of the go line, rewind until the beginning of tape is indicated. Rewind resets the tape indicator.

Rewind Unlock.—Rewind unlock initiates a rewind operation in which the tape does not stop at beginning of tape but continues to rewind until the tape buffering loops are removed from the tape unit vacuum columns. This is preparatory to removal of the rewind reel of tape from the tape unit. Rewind unlock resets the tape indicator.

Naming Out.—This line allows a usage meter for timing made usage to be turned on.

Select TU.—Each control unit initiates a set of select TU lines comprising one select TU line for each attached tape unit. Activation of a select TU line initiates the selection process whereby the TUS effects operational connection between a control unit and a tape unit.

High Order.—High order is a select line in addition to the select TU lines to control the selection of any of 16 attached tape units. The 16 tape unit configuration requires two tape unit switches, each switching eight tape units. One switch is designated the low order switch, the other is designated the high order switch. The tape units attached to each of the switches are numbered 0 through 7. Tape unit selection occurs through the activation of one of the eight select TU lines in combination with activation or deactivation of the high order line to designate that the tape unit is attached to a high or low order switch.

Mod 1, Mod 2 or Mod 3.—Mod lines indicate the model of an attached tape unit. The particular difference between model numbers necessitating different mod lines is data rate (tape speed). The speed of a unit ordinarily has a direct affect on the data rate. This requires that a control unit make such changes as are necessary to operate tape units having different mod numbers. Only one mod line from a tape unit is active at a time. Activation of the mod line is also an indication that the tape unit is on-line. In combination with the TU status line it is an indication that the tape unit is either presently performing an operation or is capable of operating with a control unit attempting to select it. Activation of the mod line is a prerequisite to recognition of read or write status by a control unit.

7-Track.—Whenever 7-track is activated, it indicates to the tape control that a seven track tape unit is attached and all data operations will involve seven-bit bytes of data.

Read Status.—Read status indicates that a selected tape unit is in read status, meaning that it is conditionally to read. Write status is indicated whenever read status is inactive.

At Load Point.—At load point is initiated by a physical mark on the tape to indicate that the tape is positioned at the load point.

Backward Memory.—Backward memory is active whenever the tape unit is in a backward status.

Tape Indicator (TI) Off.—The tape indicator is activated whenever forward motion of the tape causes the end of tape indicator to be detected. Backward status or backward motion of the tape will turn off the tape indicator, thereby activating TI Off.

Not File Protected.—Each tape reel is provided with a plastic ring that is physically inserted in a groove in the back of the reel. Presence of the ring in the reel contacts a plunger protruding from the front of the tape unit and opens a switch electrically enabling the write circuits to allow the tape unit to be placed in write status. The absence of the ring in the groove removes the surface upon which the switch plays its sides. This keeps the switch closed and disables the write circuits to protect the information recorded on the tape from being written over.

TU Status.—Each tape unit initiates a TU status line that is returned to the tape control. The purpose of this line is to indicate that the tape unit is either rewinding, has been connected to another tape control (switched), or that the tape unit is not ready. An analysis of the TU status line in combination with a mod 1, 2 or 3 line provides detailed information as to the status of the tape unit. The possible combinations and the indications therefrom are included in Table 2 which follows.

<table>
<thead>
<tr>
<th>TU Status</th>
<th>Mod 1</th>
<th>Mod 2</th>
<th>Mod 3</th>
<th>Status of TU</th>
<th>TO Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>Non-Existent Tape Unit</td>
<td>UNIT CHECK (Interview required), Unit Free Indication Follows.</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>Not Ready</td>
<td>Busy</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>Ready</td>
<td>Busy</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>Rewinding or Switched</td>
<td>Busy</td>
</tr>
</tbody>
</table>

In Table 2 the term "unit freed" pertains to the temporary disconnection of a tape unit during the period that it is rewinding. In this case, the tape unit will rewind, and upon completion of rewind control an indication thereof by the deactivation of the TU status line. In the control unit, a unit freed scanning circuit such as that described in co-pending application S.N. 357,370 to P. J. Brown, filed April 6, 1964 and partially represented in FIGURE 8, continuously scans the tape unit status lines of all attached tape units. Upon detecting deactivation of the status line of a previously selected tape unit, scanning stops and the binary address of the tape unit which deactivated the TU status line is indicated by the scanning circuit register, TC 431 of FIGURE 8. If in a subsequent sequence, the tape unit providing the unit freed indication is selected, the control unit will have re-established connection with the tape unit. This reactivates the mod line which in combination with the inactive status line, indicates ready in accordance with Table 2.

All magnetic tape operations are functionally classified as either write, read, control or sense. Each such operation employing the previously defined lines is controlled by a tape control unit such as that described in co-pending application S.N. 357,370 to P. J. Brown, filed April 6, 1964. Ordinarily the control unit controls the transfer of data and command information between a tape unit and a computer channel such as that described in co-pending application S.N. 357,369 to L. King et al, filed April 6, 1964, for the ultimate transfer of such data or command information to or from the computing system. In a write operation the computing system generates bytes of data for magnetic tape storage. Each byte is placed on a data bus and transferred to a previously selected tape control unit where it is entered in a read-write register for subsequent recording on the selected tape unit. In a read operation, bytes of data read from a selected tape unit are transferred from the tape unit to the read-write register of the control unit where such operations as error detection and correction may be performed before the bytes are transferred via the computer channel to the computing system memory. In a control operation, the control unit provides such functions as are necessary to control a selected tape unit. Such control may involve instructing the tape unit to set read or write status preparatory to the execution of a read or write operation. It may involve instructing the tape unit to rewind and to indicate when it has arrived at load point. It may also instruct the tape unit to rewind and, upon arriving at the beginning of tape, unload the tape from the vacuum buffering columns preparatory to operator intervention for changing the tape reel. During a sense operation a tape control unit provides the necessary control logic to select a selected tape unit to transmit bytes of sense information which define the current condition of the tape unit to the computer channel. Sense information is a prerequisite to the use of a tape unit by the computing system as for instance, the indication that a tape unit is at load point before the issuance of an operational read or write command.
Ordinarily the number of tape units that can be connected to a single tape control unit is a design limitation. For example, a tape control unit may be designed to operate with up to eight tape units. In a computer installation where several such control units are employed, each to the maximum capacity of eight tape units, the flexibility of the system continues to be limited by the maximum designed number of tape units that can be attached to the control units. Flexibility is decidedly improved when any of the sixteen tape units present is available to either of the control units. An expeditious means of providing the desired flexibility results from the use of a TUS. The TUS provides a measure of flexibility itself, since it can be designed to provide variable amounts of switching for optimum numbers of tape control units and tape units. Accordingly, the most flexible TUS configuration is modularity expandable. FIGURE 2 shows a variety of TUS modular combinations. The basic optimum module in FIGURE 2A comprises switching circuitry for selectively connecting four tape units to control units, TA–C and TC–B and is referred to as a 2 x 4 module. A further modular expansion of a single TUS configuration is provided by increasing the number of tape units to eight (2 x 8), FIGURE 2B, followed by the addition first of TC–C (3 x 8), FIGURE 2C, and then TC–D (4 x 8), FIGURE 2D, and tape unit switches can be expanded through the use of a second TUS module. In FIGURE 2C, addition of a second 2 x 8 module adds eight more tape units. In FIGURES 2E and 2G the double TUS configuration is further extended first to a 3 x 16 module and then to a 4 x 16 module through the additions of TC–C and TC–D respectively. FIGURE 3 is a slightly more detailed representation of the 4 x 16 module of FIGURE 2G. In FIGURE 3, each TUS has eight tape units numbered 0 through 7 connected to it. Each TUS is furthermore designated by an address (L.O.) or by a group (H.O.) which, as previously described, allows selection of any of the total of 16 tape units by a control unit to the exclusion of the remaining control units. Whenever a control unit selects a tape unit 75

Specifically, it is assumed that TU–0, L.O. is to be selected. In this case, the high order line, –H.O., is positive or in the inactive state, thereby indicating low order. Through switch 129 – H.O., TU 0 switches to condition one input to AND circuit 100. Upon the rise of TU select line 0 from TC–A through switch 120, AND circuit 100 is fully conditioned to effect selection of TU–0, L.O. If TC–A had activated the high order line, +H.O., TU 0–3 from inverter 110 conditions one input to AND circuit 200. The TU select line 0 at the output of switch 120 fully conditions AND circuit 200 to effect selection of consecutively numbered tape unit 8 which in accordance with the foregoing table is TU–0 H.O. By way of further example, if –H.O. is inactive, switch 130 initiates –H.O., TU 4–7 to condition one input to AND circuit 107. Positive activation of TU select line 7 via switch 127 fully conditions AND circuit 107 to effect selection of TU–7 L.O. Similarly, if –H.O. is activated, +H.O., TU 4–7 via switch 130 and inverter 111 conditions one input to AND circuit 207. Activation of the tape unit select line 7 via switch 127 fully conditions AND circuit 207 to effect consecutively numbered tape unit 15 which is, in accordance with Table 1, tape unit 7, H.O. If it is desired to change the number designation within an ordered group, switches 120 through 127 are reversed whereupon the group comprising tape units 0 through 3 becomes tape units 4 through 7. Similarly, the group comprising tape units 4 through 7 becomes tape units 0 through 3. Furthermore, the high and low orders are interchangeable by switching switches 129 and 130 oppositely to that shown. Accordingly, the possible combinations of TU number, designations are shown in FIGURE 2G.

The TUS, henceforth to be described, provides functional connection of a tape unit to one of a plurality of control units to the exclusion of the remaining control units. The preferred, generalized, TUS configuration through which such exclusive switching is provided is in the form of a two-dimensional matrix. In FIGURE 3 a 4 x 8 TUS is shown in generalized matrix configuration comprising switching nodes for control units A through D and tape units 0 through 7. The circuitry primarily responsible for connecting any tape unit to any control unit is generally contained in the switching matrix. For example, the circuit necessary to connect TC–A to TU–0 is contained in node A0. The circuitry necessary to connect TC–A to TU–1 is contained in node A1. The circuitry necessary to connect TC–B to TU–0 is contained in node B0, etc. Whenever applicable, the sequence logic block will be included in addition to the block reference number a node designation such as A0 or B9, whenever the block is exclusively contained within a node. In the overall matrix configuration, there is no interrelationship between nodes of a row other than the provision for passage of lines coming from the other nodes. With the exception of TU select and TU status lines, all lines are connected in a parallel fashion to all nodes of a matrix row. Accordingly, if TU–5 is selected for a read operation by TC–A, bytes of data from TU–5 read bus lines are transferred in node A5 via appropriate relay switching circuitry to the TC–A read bus lines. Similarly, if TU–5 is selected for a write operation, bytes of data on the TC–A write bus are transferred via appropriate relay switching in node A5 to the tape unit write bus. Further, all sense and control lines are gated by switching circuitry contained in a selected node. In general, therefore, data and sense lines and control information are transferred via the nodes directly or from the control units without interference from any of the other nodes in the corresponding row. Columns of nodes, on the other hand, have a definite nodal interrelationship. In particular, each node contains a control gate for controlling the selection and operation of a tape unit by a control unit to the exclusion of the remaining control units. Whenever a control unit selects a tape unit,
the control gate in the corresponding node is activated. The active output of the control gate is then returned to the remaining three nodes corresponding to the remaining control units to decondition and render their respective control gates ineffective in selecting the selected tape unit. In this manner, selection of the selected tape unit by the selecting control unit is maintained until selection is relinquished by deactivation of the TU select line. A control gate, therefore, isolates a selected tape unit from the remaining control units.

All tape operations involving the functional connection of a tape unit to a tape control unit via the switching circuitry of an appropriate TUS node begins with the activation of the control gate of the selected TU from the control unit. In FIGURE 6, select TU lines from the control unit are applied to inverters 131 through 135 to initiate +select TU lines to the TUS. Each of these lines is supplied to at least two of switches 120 through 127. The switches may be any suitable signal switching device, electronic or mechanical. It is the purpose of these switches to interchange the order of tape units 0 through 7 in groups of four. FIGURE 7 is a generalized set of switches shown providing a group swapping for TUS nodes exclusive, it being understood that the group swapping circuits for TUS nodes are exactly similar. Select lines 0 through 3 or 4 through 7 from a control unit are shown switched in groups of four to either of the swapping circuit output select lines. In FIGURE 6, +select TU-0 is applied to the X-hub of switch 120 and the Y-hub of switch 124, +select TU-4 is applied to the X-hub of switch 124 and the Y-hub of switch 120. If switches 120 and 124 are switched to connect the X-hubs to the switch outputs, the output of switch 120 will be +select TU-0 and the output of switch 124 will be +select TU-4. If the switches are reversed connecting the switch outputs to the Y-hubs, the output of switch 120 will be +select TU-4 and the output of switch 124 will be +select TU-0. Each of the remaining select TU lines from the inverter circuits are similarly applied to switches. These switches are ganged so as to be switched in groups of four. Thus switches 120, 121, 122 and 123 are simultaneously switched to either the X or Y-hubs. Switches 124, 125, 126 and 127 are further grouped simultaneously switching to the X or Y-hubs. With all the switches in the X position, the output from switch 120 will be +select TU-0 through 3 and the output of switches 124 through 127 will be +select TU-4 through 7. If the switches are switched to the Y position, the output of switches 120 through 123 will be +select TU-4 through 7 and the output of switches 124 through 127 will be +select TU-0 through 3. For this description, it is assumed that the tape numbers designations at the outputs are as shown in FIGURE 6. Also included in FIGURE 6 is the high order line from the control unit. Since the active condition of a line is indicated by the signal present on the line title, a positive condition on +select HI is applied to inverters 120 and to the Y and X-hubs of switches 129 and 130 respectively.

The direct output of switch 129, +TC-A select HI, TU-0/3 controls selection of low order tape units 0 to 3 upon selection of one of these tape units by TC-A. The direct output of switch 130, +TC-A select HI, TU-4/7 controls selection of low order tape units 4 to 7 upon selection of one of these tape units by TC-A. The outputs of switches 129 and 130 are inverted via inverters 110 and 111 respectively. The output of inverter 110 is +TC-A select HI, TU-0 through 3 and controls selection of high order tape units 0 through 3 upon selection of one of these tape units by TC-A. The output of inverter 111 is +TC-A select HI, TU-4/7 and controls selection of high order tape units 4 to 7 upon selection of one of these tape units by TC-A. In the following discussion the selection and subsequent operation of a tape unit with a control unit is assumed to involve a low ordered tape unit unless otherwise indicated. In this case the direct outputs of switches 129 and 130 are positive, indicating low order.

All nodes of a TUS contain similar circuitry. Description of nodal switching circuitry is therefore expeditied by limiting description to a single node. It is, therefore, assumed hereinafter that TC-A will select and perform various tape operations with TU-0. Initial selection of a tape unit begins as described in copending application S.N. 357,370 to P. J. Brown, filed Apr. 6, 1964, where the computer channel addresses the tape control unit and a particular tape unit by placing their respective addresses on designated bus-out lines. In the tape control unit and in reference to FIGURE 8, the bus-out lines containing the control unit address are decoded in address decode circuit TC 321. Bus-out lines 4 to 7 provide binary addressing for a maximum of sixteen tape units. Successful decoding of the control unit address conditions tape unit address gates, TC 431, to gate the address on bus-out lines 4 through 7 to the address register TC 431. The TU address register has a dual function. Whenever it is not being used as the TU address register it becomes part of scanning circuitry to scan the bus-out lines as previously described to indicate that a tape unit has completed a read operation. This is referred to as a unit freed indication. However, when a TU selection is occurring, the TU select flip-flop TC 432, AG-AM is set, thereby blocking the unit freed scanning gates TC 421-428. This establishes the four-position tape select switch as a TU select register. The binary address in positions 5, 6 and 7 of the TU select register are decoded by decode circuit TC 322 to initiate the select TU-0 through 7 lines. Position 4 depending upon the presence or absence of a 1 bit in the binary 8 position of the tape unit address on the bus-out lines initiates +select high order. Ordinarily, after the transfer of a byte of data or command information, the TU select line is deactivated. This allows other control units to operate with the computer channel. If the channel requires continuous operation with a particular tape unit, it will activate the chain signal. As long as this signal is maintained, the TU select flip-flop TC 432, AG-AM is held in a set condition by the set output of the chain flip-flop TC 337, AS-AW. This has the effect of maintaining the TU select line to the node control gate thereby holding selection of the corresponding tape unit.

Returning now to FIGURE 6, selection of TU-0 begins when TC-A activates +select TU-0 to inverter circuit 311. Select TU-0 from inverter circuit 311 via the X-hub of switch 120 initiates +select HI, TU-0. This is the primary select line from TC-A to TU-0. In FIGURE 9, +select TC-A, TU-0 is applied to one input of AND circuit 301. AND circuit 301 is one of the previously mentioned control gates. All AND control gates will, hereinafter, be referred to simply as control gates. Three other inputs to control gate 301 are -B0, -L0, -C0, L0 and -D0, L0. These lines are from the remaining control gates in the 0 column of the matrix, control gates 309, 317 and 325. Whenever a control gate is active, its output is in a negative state allowing it to decondition any other control gate to which it is applied. It is assumed that TU-0 has not previously been selected, in which case the outputs of control gates 309, 317 and 325 are inactive or in a positive state, thereby further conditioning control gate 301. A further input to control gate 301 is +TU-0 available, TC-A. This line is generated on FIGURE 10 from a set of switches. With reference to FIGURE 10, the availability of TU-0 to any of the control units A through D is determined by a set of switches 350, 351, 352 and 353 and in particular by the voltage conditioned at the output of the normally closed (NC) point of the switches. Ordinarily, if TU-0 is available, switches TC-B, TC-C and TC-D, the common side of switches 350, 351, 352 and 353 will be connected to the normally open (NO) points of those switches. Since the out-
put line, TU available, is taken from the junction of the normally closed point and a resistor that is returned to a positive voltage, the output line is positive whenever the normally closed point is not connected to the common line of the switch. If it is desired to make a particular tape unit unavailable to one of the control units, the appropriate switch position is selected to connect the common line to the normally closed point. Ground is thereby returned through the remaining normally open points to the switched normally closed point and is applied to the output line. If the normally closed point of switch 350 were connected to ground via the common line, the resulting down line on +TU-0 available, TC-A on FIGURE 10 can be closed to make the corresponding tape unit unavailable to a plurality of the attached tape control units. Returning to FIGURE 9, the final line conditioning control gate 301 is —TC-A select H.O., TU-0-3. This line is in a positive state whenever high order is not indicated, thereby fully conditioning control gate 301 to initiate —A0, L.O. The active output of control gate 301 is the principal controlling line in the selection of TU-0 by TC-A. With reference to FIGURE 6, if TC-A had initiated +select TC-A, TU-0 via inverter circuit 131 and switch 170 accompanied by a negative or active condition on the high order line, inverter circuits 110 and 111 would have initiated +TC-A select H.O., TU-0-3 and —TC-A select H.O., TU-0-3, respectively. On FIGURE 11, +TC-A select H.O., TU-0-3 conditions one input to control gate 501. Assuming the conditioning inputs to be at gate level —A0, H.O. is initiated to effect connection of TU-0 in high order group to TC-A. TU-0 of the low order group is not selected since —TC-A select H.O., TU-0-3 is in a negative state and deconditions control gate 301 on FIGURE 9.

The active condition of a control gate not only controls selection of a tape unit, but furthermore generates status information to the effect that a tape unit has been previously selected by one of the remaining control units. As previously described, TU status is initiated whenever a tape unit is rewinding, is not ready, or when it has been previously selected (switched). With reference to FIGURE 12, a tape unit in either a rewind or a not ready status will enter the TUS via entry switch 175, after which it is directed to the OR circuit 250 on FIGURE 13. The output of OR circuit 250 via inverter 150 and the X-hub of switch 140 initiates —TU-0 status L.O. to a tape control unit. Other inputs to OR circuit gate 250 are —D0, L.O., —A0, L.O. to fully condition AND circuit and —D0, L.O., —A0, L.O., —D0, L.O. These are the outputs of the control gates in nodes 180, 181, 182, and 183 of the low order switch, respectively. An active condition on any of these lines via OR circuit 250 and inverter 150 through the X-hub of switch 140 will initiate —TU-0 status L.O. The effect, therefore, of a status indication to the tape control unit resulting from the active condition of a control gate other than the control gate in node A0 indicates that TU-0 has been previously selected by either TC-B, TC-C, or TC-D. Similarly status is initiated for TU-1 via circuit 251, inverter 151 and the X-hub of switch 141 to initiate —TU-1 status L.O. Status for TU-2 is initiated via OR circuit 252, inverter 152 and the X-hub of switch 142 to initiate —TU-2 status L.O. Status for TU-3 is initiated via OR circuit 253, inverter 153 and the X-hub of switch 143 to initiate —TU-3 status L.O. In similar circuits, not shown, status for TU-4 through TU-7 is initiated and via the Y-hubs of switches 144 through 147 initiates low order status lines for TU-4 through 7. Status line switching is necessary to maintain the continuity of status lines between tape units and a control unit since a unique status line exists for each attached tape unit. As has been previously described, it may be necessary to reverse the order of the tape unit number designations 0 through 7 in groups of four via the switches on FIGURE 6.

In this event, it is, therefore, necessary that the same reversal be effected insofar as the status lines are concerned. If the order of tape units 0 through 3 are to be changed to 4 through 7, switches 144, 145, 146 and 147 are reversed so that the output is connected to the X-hub. It can be seen, therefore, that a status indication from the unit previously designated TU-0 via inverter 150 and switch 144 indicates status for TU-4. Changes in the status lines for tape units 1 through 3 are similarly effected through their appropriate switches. The switches, 149 through 153, are preferably contained in a single switchable unit 147, as shown in the form of a printed circuit card that can be inserted in a terminal board in the TUS. Then in the event that the order of a double TU5 configuration is to be reversed such that the low order TUs becomes the high order TUs and vice versa, the printed circuit card can readily be removed from the low order terminal and inserted in the high order terminal as indicated by the alternate switch matrix position 161. Such a change is necessarily accompanied by a change in high order select switches 129 and 130 on FIGURE 6. The overall result is that the outputs of alternate switch matrix position 161 become status information from the high order tape units, as indicated in FIGURE 13.

It is now assumed that in the initial selection sequence, as described in the preceding application, S.N. 397,370, to P.J. Brown, filed April 6, 1964, the operational sequence issued by the computer via the computer channels decoded by the control unit command decode circuits indicated a sense operation. In a sense operation the tape control unit transmits five bytes of sense information to the computer channel. One of these bytes includes the sense information taken from the sense lines provided by the addressed tape unit and indicates to the computing system significant information relating to the status of the tape unit. The significance of the sense line has been previously described in the section on line definitions. Accordingly, if TU-0 had been placed in a read status through the expedient of set read status card readily be removed from the low order terminal and inserted in the high order terminal as indicated by the alternate switch matrix position 161. Such a change is necessarily accompanied by a change in high order select switches 129 and 130 on FIGURE 6. The overall result is that the outputs of alternate switch matrix position 161 become status information from the high order tape units, as indicated in FIGURE 13.

It is now assumed that in the initial selection sequence, as described in the preceding application, S.N. 397,370, to P.J. Brown, filed April 6, 1964, the operational sequence issued by the computer via the computer channels decoded by the control unit command decode circuits indicated a sense operation. In a sense operation the tape control unit transmits five bytes of sense information to the computer channel. One of these bytes includes the sense information taken from the sense lines provided by the addressed tape unit and indicates to the computing system significant information relating to the status of the tape unit. The significance of the sense line has been previously described in the section on line definitions. Accordingly, if TU-0 had been placed in a read status through the expedient of set read status card readily be removed from the low order terminal and inserted in the high order terminal as indicated by the alternate switch matrix position 161. Such a change is necessarily accompanied by a change in high order select switches 129 and 130 on FIGURE 6. The overall result is that the outputs of alternate switch matrix position 161 become status information from the high order tape units, as indicated in FIGURE 13.
3,372,378

3 lines from each tape unit are available at all times to the attached control whenever a control unit activates the appropriate TU select line. One exception is that the particular tape unit is unavailable to the control unit via the tape unit availability switches on FIGURE 10. Thus, on FIGURE 15, one input to AND circuit 400 is +mod 3, TU-0 which is a line activated by "+TU-0" if TU-0 is a model 3 tape unit. Further conditioning inputs are +TU available TC-A, the TU availability line, and -TC-A select H.O. TU-0-3, the high order line, which is in an active state whenever the control unit is not indicating high order. The remaining conditioning line for AND circuit 400 is +select TC-A, -TU-0 from the select switches on FIGURE 6. Upon activation of TC-A, -TU-0, -mod 3 TC-A is initiated via inverting OR circuit 451 to TC-A. If TU-0 is a model 2 tape unit, similar information will be provided via AND circuit 402 and inverting OR circuit 452 to initiate -mod 2 TC-A. If TU-0 is a model 1 tape unit, +TC-A is initiated through AND circuit 404 and inverting OR circuit 453. In addition to the mod lines on FIGURE 15, a further sense line is the +7-track TU indication. If TU-0 is a 7-track, -TU-0 select 7-track conditions one input to AND circuit 406. Activation of the control gate in node A0 fully conditions AND circuit 406 which, when inverting OR circuit 454 initiates -7-track TC-A. Whenever a 7-track tape unit is activated in the same position in a multi-track, the positive -TU-0 will be in a negative state and AND circuit 406 will be conditioned. The resulting positive condition at the output of inverting OR circuit 454 indicates to the control unit that TU-0 is a 7-track tape unit.

A further operation initiated by the control unit is a control output which is generally defined by the control lines shown in FIGURE 1. These lines are activated by the control unit in response to a control command from the computing system. The various control lines are shown in FIGURES 16, 17, and 18. These figures contain circuits that are correspondingly similar for each of the attached tape units. Accordingly, each one of the control lines exiting FIGURES 16, 17, and 18 are directed to a single tape unit, in this case TU-0. Specifically, +rewind-unload TC-A on FIGURE 18 from TC-A is placed under control of the control gate in node A6 via AND circuit 443 which, via OR circuit 472 and inverting OR circuit 485, initiates +rewind-unload TC-A, any TC. Similarly, +rewind-unload TC-B from TC-B is placed under control of the control gate in node B0 via AND circuit 444 which, via OR circuit 472 and inverting OR circuit 485 again initiates +rewind-unload TC-A, any TC. Similarly, the +rewind-unload control lines from TC-C and TC-D, via AND circuits 445 and 446 respectively, OR circuit 473 and inverting OR circuit 485 initiate +rewind-unload TC-D, any TC. Each of the remaining control lines on FIGURES 16, 17, and 18 are received and placed under control of the appropriate control gate output in a correspondingly similar manner, excluding the select and metering lines. Metering lines are applied via inverting OR circuit 457. Also, on FIGURE 18, +select TC-A, TU-0 is controlled by -TC-A Sel. H.O., TU-0-3 via AND circuit 447 which, via OR circuit 476 and inverting OR circuit 486, initiates -select TC-A, -TU-0, any TC. On FIGURE 16 +go TC-A is placed under control of the control gate in node A0 via AND circuit 419, which through OR circuit 416 and inverting OR circuit 479, initiates +go TU-0, any TC. +Backward, TC-A and +set write status, TC-A are similarly node controlled via AND circuits 423 and 427 respectively, to initiate backward TU-0, any TC and -set write status TU-0, any TC. On FIGURE 17 +set read status TC-A is placed under control of the control gate in node A0 via AND circuit 451 which, through OR circuit 466 and inverting OR circuit 482 initiates -set read status TU-0, any TC. Further, +write pulse control

TC-A and +rewind TC-A are similarly controlled by the control gate in node A0 via AND circuits 435 and 439, respectively to initiate +write pulse control TU-0, any TC and -rewind TC-A, -TU-0, any TC respectively.

It is now assumed that during the initial selection sequence by the computing system a write command was issued to affect the recording of data on a selected tape unit. All tape write operations begin when a byte of data is placed on the bus-out lines to the tape control. After a slight delay the tape control is signaled of the existence of the byte of data on the bus-out lines whereupon it is entered into a read-write register. Thereafter, in synchronism with control unit timing, the read-write register is gated onto the control unit write bus. In the TUS, as shown in FIGURE 19, the write bus lines are terminated in a set of reed relays. In the TUS there is a set of relays for each attached tape unit. Each set is connected in parallel to the control unit write bus. Reed relays are magnetically actuated devices and are diagrammatically represented in FIGURES 20A and B. Activation of a set of write bus relays is under control of the control gates. In FIGURE 19, +A0, L.O. from the control gate in node A0 is amplified via amplifier 550 to excite the actuating coil for the reed relays in blocks 552 and 553.

Thus activated the relays provide continuity for the write bus lines 7 and P to TC-A. In particular, write bus 0, TC-A is applied to one terminal of an activated relay initiates write bus 0, TU-0 to TU-0. If a data bit is on write bus 0, it is applied to the track 0 write head driver located in TU-0. The resulting turn on of the write driver supplies current to the write head coil to change the flux field at the gap of the write head corresponding to track 0 thereby recording a one bit of information on the magnetic tape. In an exactly similar manner one bit on any of the remaining write bus lines are recorded on magnetic tape. In addition to the write bus relays for TU-0, FIGURE 19 includes the write bus relays for TU-7. It can be seen that the actuating coils for the reed relays in blocks 566 and 567 are actuated from amplifier 551 by the active condition of the control gate in node A7 initiating +A7 L.O. In addition to the write bus lines, FIGURE 19 includes read relay switching for the write pulse line as previously described in the section on line definitions.

A read operation begins when the computing system via the computer channel initiates a read command during the initial sequence. In response, the addressed tape unit is placed in a read status. Subsequent activation of the go line initiates tape motion to effect reading. If a byte of data is placed on the read bus and, under control of the appropriate control gates, is switched to the read bus to the control unit. In the control unit the byte of data from the read bus is entered into the read-write register for subsequent transmission to the computing system via the computer channel. Referring to FIGURE 23, the read bus lines from the various tape units are switched to a control unit in the same manner as were the write bus lines. In particular, if TU-0 is transmitting a byte of data over the read bus to the control unit, the active condition of the control gate in node A8 initiates +A0, L.O. which, via amplifier 570, activates reed relays contained in blocks 572 and 573. Thus connected, a bit of information read from tape on any of the entering bus lines, as for instance read bus 0, TC-A via corresponding reed relay initiates read bus 0, TU-0 to TU-0. FIGURE 23 also shows reed relays in blocks 586 and 587 providing switching continuity for read bus lines from TU-7. Similarly, activation of these relays is controlled by the active condition of the control gate in node A7 which initiates +A7, L.O. to activate the reed relay in blocks 576, 577. FIGURE 23 furthermore includes relay switching for write echo TC-A to initiate write echo TU-0 and TU-7.

This line, as previously described in the section on line definitions, indicates that a bit has been recorded during a write operation. It is incidental that the write echo line
is contained in the read bus switching section for which no logical connotation should be attached.

Consider now the matrix configuration of FIGURE 5, and in particular the reliable electric operation of the control units, the tape units, and the Tape Unit Switch (TUS). In any similar multiple modular arrangement, fusing is a necessary consideration to adequately protect the device in case of a short-circuit anywhere therein. With only a single fuse or circuit breaker for the entire Tape Unit Switch, a failure in any circuit could stop the operation of all tape units and all tape controls and could result in stopping an entire computer system until the failure is determined and corrected, which may take hours or possibly days.

Ideally, each nodal circuit set and each module may be separately fused, so that a failure in a single nodal circuit would only stop operation of the combination of a single tape unit and single tape control. However, due to the interrelation between the modules in the Tape Unit Switch provided by the nodal circuitry and parallel connecting line terminators from the Tape Units and controls, separate fusing would be quite complicated to implement due to the fact that each of the line terminators, nodal circuits and special modules would require separate fusing. Although such an arrangement would provide the ultimate in reliability, it is obtainable only at the price of over-complexity, and in such case, duplicate circuitry would also be provided. A more expedient arrangement is fusing between a particular group of elements and circuits, such that failure of one element or circuit would remove only those items which normally would be inter-fered with anyway by a circuit failure in the group. Specifically, one such arrangement connects with a single fuse the line terminators in the Tape Unit Switch for one control and two of the available tape units, such as for TC-A, and TU-0 and -1. In such case, line terminators for TC-B, and TU-2 and -3 are powered through a single fuse, and with this arrangement, line terminators for TC-C and TC-D are each separately fused. The nodal circuits and line terminators associated with the four tape units TU-0 through -3 are commonly fused to the power bus. Similarly, the nodal circuits and line terminators associated with TU-4 through -7 are commonly fused.

With this arrangement, a short circuit in the line terminator for TU-0 has the effect of removing TU-0 and TU-1 from operable communication with all of the control units; also TC-A is removed from operable communication with TU-0 through -7.

Similarly, if a short circuit occurs within a line terminator for TC-B, it is removed from operable commu-nication with TU-0 through -7. Since line terminators for TU-2 and TU-3 are also fused with terminators for TC-B, they are removed from operable communication with all control units.

Furthermore, if a fuse failure occurs in the powering of the nodal circuit section associated with TU-0 through -3, communica-tion is disrupted between any of TU-0 through -3 and any of the control units TC-A through -D. However, since the nodal circuits associated with TU-4 through -7 are independently fused along with line terminators for TU-4 through -7, these tape units remain available to any of the four control units.

On the other hand, if a short-circuit occurs within the nodal circuit section or any line terminator associated with TU-4 through -7, they are effectively removed from operable communication with any of the control units. However, in the case of the separate fusing described for the TUS circuits associated with TU-0 through -3, they remain available for operable communication with the control units. Since TUS line terminators for TC-C and TC-D are each separately fused, failure in either of these control units removes only one from communication with TU-0 through -7.

While the invention has been particularly shown and described with reference to a preferred embodiment thereof,
same controlled unit one of said blocking inputs being activated when the same controlled unit is selected by another controlling unit, and each control AND circuit also receiving as an input a select line from one controlling unit for selecting one controlled unit.

7. A controlled unit switch as defined in claim 6 in which, each nodal circuit includes a plurality of bus switches, each bus switch being controlled by an output of the control AND circuit of the nodal circuit.

8. A controlled unit switch as defined in claim 7 in which, tape units comprise said controlled units, said bus switches are comprised of relay circuits with a switching time less than a read or write acceleration delay of any of said tape units, and each of said control AND circuits is comprised of non-mechanically actutable circuits with a switching speed more than one hundred times faster than said bus switches.

9. A controlled unit switch as defined in claim 7 in which, said relay circuits are reed relays, and said control AND circuits include semi-conductor amplifier elements.

10. A controlled unit switch as defined in claim 9 in which, tape units comprise said controlled units, and tape controls comprise said controlled units, said reed switching relays have a switching time less than a read acceleration delay of its connected tape unit, and said non-mechanical actutable circuit have a switching time less than a bit period during normal operation of any of said tape control.

11. A controlled unit switch as defined in claim 6 in which, at least one control line is provided from each controlling unit to connect in parallel to nodal circuits associated with the same controlling unit, another AND circuit being provided in each nodal circuit.

said another AND circuit receiving inputs from said control line from said controlling unit and from the control AND circuit of said nodal circuit, OR circuit means connected to the outputs of said another AND circuit in the nodal circuits associated with the same controlling unit, the output of said OR circuit being provided as a control line to said same controlled unit.

12. A controlled unit switch as defined in claim 11 in which, said controlled unit is a tape unit, said control line being at least one of a tape move line, a tape direction line, a write control line, a read control line, and a rewind line.

13. A controlled unit switch as defined in claim 6 in which, at least one sense line is provided from each controlled unit, another AND circuit being provided with each nodal circuit associated with said controlled unit, said another AND circuit receiving inputs from said sense line and from the control AND circuit of its nodal circuit.

OR circuit means receiving inputs from said another AND circuits of nodal circuits associated with the same controlled unit, and the output of said OR circuit providing a status line to said same controlling unit.

14. A controlled unit switch as defined in claim 13 in which, at least one of said controlled units is a tape unit.

15. A controlled unit switch as defined in claim 14 in which, at least one additional sense line is provided from each tape unit, and additional AND circuit is provided for each utilized nodal circuit to receive as an input the additional sense line.

OR circuit means receiving the outputs of each of said additional AND circuits in nodal circuits associated with the same controlling unit, the output of said OR circuit means providing a sense line to the same controlling unit corresponding to the additional sense line from said tape unit.

16. A controlled unit switch as defined in claim 15 in which, said additional sense line indicates a type of controlled unit connected to said controlled unit switch.

17. A controlled unit switch as defined in claim 6 in which, a status line is provided from each controlled unit to provide a signal indicating the immediately usable or nonusable status of said controlled unit, OR circuit means in each nodal circuit receiving said status line as an input, said OR circuit means also receiving outputs of other control gates of other nodal circuits associated with the same controlling unit, an output of said OR circuit being provided as a status line of said controlled unit to all of said controlling units connected to said controlled unit switch to indicate a nonusable state for said controlled unit if any input is activated to said other circuit means.

18. A controlled unit switch as defined in claim 17 in which, switching means is provided for changing the controlled unit logical address for an output status line to a controlling unit comprising, a switch having an output providing a status line to all of said controlling units for representing a logical address for a controlled unit, said switch having inputs from the status lines of at least two controlled units.

19. A controlled unit switch as defined in claim 18 in which, a plurality of switches being provided with outputs respectively representing a logical address for each of said controlled units, each switch receiving as inputs the signals from the select lines for at least two different controlled units, the settings of the switches receiving signals from said select lines being coordinated with the settings of the switches receiving the status signals from said controlled unit.

20. A controlled unit switch as defined in claim 6 for preventing the selection-availability of a particular controlled unit by a particular controlling unit comprising, a plurality of switches, each switch associated with a particular nodal circuit, a voltage source adjustable by said switch to an input of the control AND circuit associated with the same nodal circuit, one setting of said switch activating said control AND circuit, a second setting of said switch blocking said control AND circuit to make its controlled unit not available to its controlling unit.

21. A controlled unit switch as defined in claim 17 in which,
a plurality of select lines are provided from each controlling unit for selecting a controlled unit, means for combining the select lines from all controlling units to provide a select output to a single controlled unit, whereby a status line from a controlled unit can be sensed by any controlling unit whether or not the controlled unit is busy with another controlling unit.