

Technical Field

This invention relates to lifts and, more particularly, to lift training simulators.

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Background Art

In the lift industry, it is important to always try to increase the technical competence of the service force. A major problem, however, is that in order to conduct on-the-job training, it is often necessary to "borrow" a lift car from a customer and thereby cause him inconvenience due to service degradation.

Some of our co-workers have simulated a certain relay-based lift system with logic and software which interfaces with corresponding pushbuttons; simulative of actual hall landing pushbuttons and lanterns, a simulated in-car passenger operating panel, and other simulated indicators. Thus, in European Patent Application No. 89 303 545.1 (which claims priority from U.K. Patent Application No. 88 08 446.2) a lift training device is disclosed which provides a microprocessor-based simulator of a relay-based lift system in a portable case which may be carried home by a student in conjunction with a home study program sponsored by his employer. Such a microprocessor-based simulator provides the opportunity for student inputs in the nature of hall calls, car calls, inspection modes and various other conditions simulative of conditions in a relay-based lift system. In response to the student's inputs, the simulator provides outputs which the student is required to interpret in order to successfully "troubleshoot" a simulated "problem" which may be entered by an instructor or by the student himself selecting switch settings in accordance with instructions in a training manual.

Development of such a simulator, of a relay-based lift system, involves a degree of engineering and programming which is of relatively manageable proportions. When faced

with the task of producing a similar simulator of a microprocessor-based lift system on the other hand, using the same approach, the engineering and programming requirements become so substantial that the costs become prohibitive. The reason for this is that such modern controls have such a high degree of complexity and increased functional capability over the prior art relay-based systems that to write a simple, software-based simulation thereof would require an investment comparable to that made for the actual control itself.

One way to solve the problem would be to construct a full-scale microprocessor-based lift system in a training facility. Or, to reduce costs associated with a full-scale hoistway, one could equip the training facility with a simulated miniature hoistway with miniature sensors for sensing the movement of a miniature car and counterweight driven by a small motor and gearbox. The simulated hoistway could be interfaced by means of simulated signals with an actual, full-scale, microprocessor-based lift controller. The students would then be enabled, under the guidance of an instructor, to troubleshoot faults introduced by him. The students, however, would all have to come to the same training facility.

A similar simulator could be made to train servicemen on a full-scale microprocessor-based lift controller mounted on wheels. Such would be portable between training facilities. It is, of course, quite expensive to produce any significant number of full-scale simulators, as above described, mounted on wheels for use in various training facilities throughout a country or region. Although such a full-scale training simulator would provide the opportunity for the instructor to hook up an actual software service tool to the actual lift controller for demonstration purposes, such a tool would ordinarily be used only in his hands and would not be generally accessible to all the students who might merely watch the instructor's actions and each might not follow completely the materials presented, due to the

pace of instruction conceivably being too fast for some. Moreover, it would be quite burdensome to assemble the simulator at each site and to transport it, due to its weight and bulk. Nonetheless, this type of simulator would be particularly effective because it would enable the instructor to push actual pushbuttons and demonstrate actual lift movement and sensing with the resulting control actions with tell-tale displays, all before the eyes of the students.

Or, training instructors could use an actual microprocessor-based lift controller, the heart of which is typically mounted on a printed circuit board, to attempt to teach how to use a service tool without anything more than the printed circuit board itself powered by a stepped down AC voltage from a wall outlet. In such a case, the instructor could focus a video camera onto a service tool connected to the PC board and have a large video display presented to the class of student servicemen for demonstrating the various modes of accessing the software stored on the printed circuit board. Although the various input/output signals ordinarily used by an installed system in real time to interface with such a circuit board would not be present, this method would still be useful in showing the accessing of various memory locations. It would lack, however, the functional capabilities as well as the kind of "hands-on" feeling that would be offered by a full-scale simulator, such as previously described, but at substantial cost.

To carry the foregoing one step further, a special power supply could be designed to be capable of powering numerous such printed circuit boards in order to teach several students at once how to use a service tool with each having a service tool in his hands so that he could enjoy the actual "hands-on" feeling, although the combination still would not have the capability of demonstrating sensing, resulting control actions, and tell-tale displays before the eyes of the students.

Disclosure of Invention

The object of the present invention is to provide a training device simulative of a microprocessor-based lift system.

5 According to the present invention, a lift training device is provided by utilizing a portion of an actual microprocessor-based lift controller in conjunction with input/output devices and software, logic, or both, simulative of operative lift signaling devices.

10 In further accord with the present invention, the microprocessor-based lift controller may comprise a printed circuit board for an actual controller having a microprocessor and memory mounted thereon.

15 In still further accord with the present invention, the microprocessor-based lift controller, e.g., a microprocessor on a printed circuit board, the simulator software or logic, or both, and input/output devices may be packaged in a case which provides portability.

20 In accordance still further with the present invention, the microprocessor-based lift controller may be of the type that contains software which may ordinarily be accessed by a special service tool which is used as an aid in making various changes to the lift system (in the software) and for diagnosing various
25 problems which may arise in a lift system. In such a case, the tool may be plugged into the controller and the student may thus be trained to use the tool on the simulator.

30 In still further accord with the present invention, the simulator may include means for selecting simulated faults in order to provide means for training in fault finding techniques. The means for selecting faults may be provided in a manner that is invisible to the student for use only by the instructor or may be provided for use
35 by the student in connection with self-study materials. Or, both techniques may be used. The simulator software or logic, simulative of lift controls and hoistway

signaling devices, may be designed to decode the selected fault and provide a signal manifestation simulative of the effect of the selected fault on a real system.

5 In further accord with the present invention, the input/output devices may comprise a plurality of actuatable (or "actuatable") up-down pushbuttons simulative of hall call buttons, a plurality of car call buttons simulative of an in-car operating panel, a floor indicating device indicative of which floor the car is at
10 and a control panel which may include various switches and indicators simulative of various lift conditions and a display which may simulate lift and car door position and motion.

By utilizing an actual microprocessor-based lift
15 controller in conjunction with logic simulative of hoistway signaling devices and a human interface in the form of I/O devices, the task of producing a simulator for a microprocessor-based lift system is reduced to manageable proportions. Further, by incorporating the
20 microprocessor controller, simulator logic and I/O devices in a portable case, a student can actually be loaned the case to take home and study at his own convenience. This takes away the need to spend large amounts of time in the classroom with other students and
25 an instructor and allows the student to go at his own pace, at his convenience, using instructional materials provided by the employer. Whenever such complex lift systems are installed, it is usually difficult to obtain access from a busy building without interrupting the
30 level of service provided to the occupants. Thus, the present invention helps to avoid much of the on-the-job training which would otherwise be required for accessing and troubleshooting today's modern microprocessor-based lift systems.

35 Great flexibility is provided by the disclosed combination of simulated fault conditions with student I/O devices or even an actual service tool (which may be

plugged into the simulator) in simulating typically encountered faults.

Thus, the present invention provides the lift industry with a tremendous training advantage over prior practices and will result in an increased level of sophistication in the service force as well as reduced cost in training and interruption of service.

These and other objects, features and advantages of the present invention will become more apparent in light of the following detailed description of an embodiment thereof, given by way of example only, as illustrated in the accompanying drawings.

Brief Description of the Drawings

Fig. 1 is a schematic illustration of a lift simulator, according to the present invention;

Fig. 1A is an illustration of a prior art service tool;

Fig. 1B is an illustration of a lift control interfaced with various other devices in a lift system, which may be simulated, according to the present invention;

Fig. 2 is a schematic illustration of a lift simulator designed to fit inside a case, according to the present invention;

Fig. 3 is a perspective illustration of a lift simulator such as is disclosed schematically in Fig. 2;

Fig. 4 is a detailed illustration of a face plate shown in Fig. 3;

Fig. 5 is a detailed illustration of a control panel shown in Fig. 3;

Fig. 6 is an illustration of the manner in which Figs. 6A and 6B fit together to form Fig. 6, illustrating the hookup of the components of the face plate of Figs. 3 and 4;

Fig. 7 is an illustration of the manner in which Figs. 7A and 7B fit together to form Fig. 7, which

represents components and internal wiring of the display logic board of Fig. 2;

Fig. 8 is an illustration of the manner in which Figs. 8A and 8B fit together to show components and interconnections which may form the simulator logic board of Fig. 2; and

Fig. 9 is a graphic presentation of simulated faults identified by numerals 1-11 each of which may be selected by several different combinations of a pair of fault switches described in connection with Figs. 5 and 8.

Fig. 1 illustrates a simulator 10, according to the teachings of the present invention, wherein an actual microprocessor-based lift control 12 is utilized in conjunction with simulator software, equivalent logic, or both, 14, and student input/output devices 16. The lift microprocessor-based lift control 12 may be of the type that is accessible by a service tool 18 which may be included as part of a simulator package or which may be provided separately. An illustration of a service tool is shown in Fig. 1A.

Although the present invention need not be embodied in a portable device as described hereinafter, the preferred embodiment is in fact a portable simulator in which the components are mounted inside a case which a student may carry from place to place and which he may even bring home for pursuing a program of self study provided by his employer.

Fig. 1B is representative of a typical microprocessor-based lift control 12a, such as a Limited Car Board (A9693A) of the Otis Lift Company, shown interfacing with a plurality of relay circuits 19a, a motion control 19b, and a plurality of remote stations 19c, 19d, 19e, all communicating over a serial communications link L1, L2. The various remote stations 19d may be associated, for example, with car and car

operating panel fixtures, while the remote station modules 19e may be associated with hall and hoistway fixtures.

5 The signal processor for control 12a contains the
central processing unit for the lift system. In this
case, an 8088 microprocessor controls the flow of data
and performs all of the calculations needed to control
the lift operations. The control 12a receives inputs
10 from the relay circuits 19a on a plurality of signal
lines 19f, from the motion control on a plurality of
signal lines 19g, and from the various remote stations
19c, 19d, 19e. It performs logical operations on this
information and provides output signals on signal lines
19h, 19j, and on the serial link L1, L2. The relay
15 circuits 19a are responsive to a plurality of signals on
a line 19k indicative of the actuation of an up leveling
(UL) relay, a down leveling (DL) relay, or a door zone
(DZ) relay. In general, information provided on line 19f
from the relay circuits to the control 12a is
20 representative of information relating to conditions of
safety limits and the position of the car in the shaft.
For example, these may include an emergency stop (NOT ES)
signal, a door fully closed (DFC) signal, an inspection
(NOT INS) signal, and up (UIB) and down (DIB) inspection
25 buttons. The signals sent back to the relay circuits on
line 19h by the control may include, for example, start
commands NOT U and NOT D, a door close (NOT DC) command
signal, and a door open (NOT DO) command signal. In the
particular case of the Otis LCB Board used in the best
30 mode embodiment for the lift control 12a, the signals on
lines 19f, 19h are 110 VAC.

Although the simulator 10 of Fig. 1 may be designed
for use with any manufacturer's microprocessor-based lift
control 12, the best mode embodiment will describe
35 simulator software and logic 14 and student I/O 16
designed to interface with an Otis microprocessor-based
lift control 12a based on an Otis LCB. Thus, referring

back to Fig. 1B, the simulator 14 of Fig. 1 may be thought of, for the best mode embodiment, as encompassing a simulation of the relay circuits 19a and motion control 19b as shown by dashed lines 14a and the student I/O 16 may be thought of as encompassing the remote stations 19c, 19d, 19e with their accompanying pushbuttons, indicating lamps, etc., as shown by dashed lines 16a.

A problem in simulating any hoistway is in simulating the signals DZ 1LS, 2LS on line 19f or their equivalents, which are indicative, respectively, of signals DZ, UL, and DL on line 19k. These are from sensors in the hoistway which are activated as the car moves up and down therein. This simulation problem is handled in the simulator logic board 26 and display logic board 24 as described in more detail hereinafter in connection with Figs. 8A & 8B and 7A & 7B, respectively.

Fig. 2 represents the simulator 10 of Fig. 1 in more schematic detail as implemented for the LCB 12a of Fig. 1B in a portable case. Thus, the signals shown in Fig. 1B are shown implemented in the simulator 10b, and reference is made to Figures describing the major components in detail. Fig. 3 illustrates a portable case with several of the various devices of Fig. 2 shown in perspective. Referring to Figs. 2 and 3, the student input/output devices 16b are shown in Fig. 3 as comprising a face plate 20 illustrated in still more detail in Figs. 4 and 6, and a simulator control panel 22 illustrated in more detail in Fig. 5. The simulator 14 of Fig. 1 is shown in that Figure as comprising display software or logic, or both, which may comprise a board 24, illustrated in detail in Fig. 7, and simulator software or logic or both which may be incorporated in a board 26, illustrated in detail in Fig. 8.

Referring now to the face plate interconnection diagram of Fig. 6, a series of remote stations 30, 32, 34, 36 are shown from the rear of the face plate 20. These may be of the type RS3A (9693C3), RS2 (9693C1), RS2

(9693C1), and RS3A (9693C3), respectively, of the Otis Lift Company. The same remote stations 30, 32, 34, 36 are shown in Fig. 4 from the front on the face plate. Thus, it will be understood that the various components on the faceplate are shown in Fig. 6 from the rear with the interconnecting wiring shown in detail. The remote stations may be of the type described in detail in U.S. Patent 4,497,391 in which a modular operational lift control system is disclosed and claimed with remote stations communicating with a controller using a time-division, half-duplex multiplexing protocol. Each of the remote stations includes an industrial control unit (ICU) disclosed in detail in U.S. Patent 4,622,551. The remote stations are interconnected, as shown in Fig. 6, by four signal lines 38, 40, 42, 44 which together comprise a serial data bus described in detail in the above mentioned U.S. patents, terminated by a line terminator 46. A jack 48 connects the serial line to a mating plug on the simulator logic board 26 where it is connected to other remote stations and devices before being hooked up to the microprocessor-based lift control 12 which may be a printed circuit board with a microprocessor mounted therein for controlling a lift, such as an Otis Lift Limited Car Board (Otis Part No. A9693A1). It should be understood that a typical microprocessor controller for installation in a lift machine room will normally comprise a rather bulky steel cabinet containing a large number of electrical and electronic components including a number of printed circuit boards, one of which will typically contain the "brains" of the lift controller. It is this board which may most advantageously be used as the control 12 in the simulator 10 disclosed herein.

Other devices on the faceplate unit 20 include a position indicator 50 (9693R2), RS4 (9693C4) remote station 52, overload jewel (7069AG7) 54, RS3 (9693C2) remote station 56, RS3 (9693C2) remote station 58 and RS4

(9693C4) remote station 60, among others, to be described in detail below.

5 A line terminator (9693J1) 62 is used to terminate another branch of the serial line. A jack 64 brings lines 38a, 40a, 42a, 44a into the simulator board 26 for ultimate mating with lines 38, 40, 42, 44.

10 The remote stations 56 and 58 are associated, respectively, with pushbuttons 56a, 56b, and 58a, 58b which simulate pushbuttons that would be on a floor or landing (basement, lobby, 1 and 2) in a building. Remote station 52 provides position signals to the position indicator 50 and is connected also to a fireman's service jewel 66, a load weighing overload (LWO) switch 68 and the overload jewel 54.

15 Remote station 56 is hooked-up to an indicator driver 70 via connections E4, E3 which are outputs of the remote station. Thirty volt DC is provided to the indicator driver 70 via a 30VDC connection E13 and a return E16. Connection E12 is a 30 volt DC output provided from the controller board.

20 RS3 remote station 58 may be the same as remote station 56, as indicated previously. An independent service key switch 80 is connected to a 30 volt DC source at E12 of remote station 58 and provides that voltage to an input E7 upon actuating the key switch. A buzzer 82 is connected to 30 volt DC at connection point E13 by means of an output at connection point E4. An LNS switch 84 is connected to 30 VDC at connection point E12 and provides that 30 VDC voltage to input point E8 and also into jack 99 which is mated to another jack on the simulator board 26.

30 The RS4 remote station 52 provides position indication signals on lines 86, 88, 90, 92 which are provided, respectively from a position indicator return point E11, a position indicator data point E10, a position indicator return point E11 and a position indication clock point E9.

The remote station 52 is also hooked up to the fireman's service jewel 66 at output E2 and 30 VDC at point E15 which together cause a legend to be illuminated on a display shown from the front in Fig. 4. This occurs in response to a fireman's service switch EFK 98 being actuated by the student. The fireman's switch 98 is in turn connected to 30 volt DC at connection point E12 on remote station 34 and provides an input at connection point E7 thereon which becomes transmitted on signal lines 38, 40, 42, 44 at the appropriate time in order that the microprocessor control 12 may send a signal back to the faceplate through the simulator board to illuminate the fireman's service jewel 66.

The overload jewel 54 becomes illuminated upon receiving 30 VDC from connection point E13 upon being actuated by output point E1. Thirty volt DC is provided to the position indicator 50 from points E14 and E16.

A door-open button 100 receives 30 volt DC power at a connection point E13 of RS3 remote station 56 which is for the purpose of providing a 30 volt input to the lift microprocessor control 12 through the simulator board 14 when the student actuates the door open button 100 so that appropriate responses may be made on a display 102 shown in Fig. 5. The door open command information is transmitted on a signal line 104 through a jack (J4) 105 to the microprocessor control 12 through the simulator.

An alarm button 108 is hooked up to a buzzer 110 and to 30 volt DC at point E16 and E12 of RS3A remote station 36. A plurality of switches, Hall Call Cutoff Switch (CHCS) 120, Car Call to Top Landing Switch (CCTL) 122, Car Call to Bottom Landing Switch (CCBL) 124 are connected to remote station 60 inputs E5, E6, E7, respectively, and when actuated, apply 30 VDC from terminals E14, E13, E12, respectively, to their respective inputs E5, E6, E7. This information is in turn provided to the microprocessor control 12 through the simulator 14 for an appropriate response.

The CHCS switch may be a single pole, single throw, with latching action type switch. When activated, the car is parked with doors open and will not accept hall calls. It will accept car calls as normal. The CCPL switch may also be a single pole, single throw, switch, but with momentary action. It is normally fitted in a controller cabinet at a lift site. When activated, a car call to the top landing is entered into the system. The appropriate telltale light is illuminated, and the car will respond to the call in the normal way. The CCBL switch is similar to the CCTL switch but referring to the bottom landing.

Referring now to Fig. 7, circuitry is there illustrated for operating the display 102 of Fig. 5. A jack 120a receives a door zone (DZ) signal on a line 122, an up correction run safety limit (URS) signal on a line 124, and a down correction run safety limit (DRS) on a line 126, a down increment position (IPD) signal pulse on a line 128 and an up increment position (IPU) signal pulse on a line 130 from the simulator board 26. Upon receiving any of the signals 122, 124, 126, 128, 130 a corresponding LED 132, 134, 146, 138, 140 will thus become illuminated by virtue of a zero volt DC signal on a line 142. In other words, each of the diodes will become illuminated when its corresponding signal is active. A DZ signal is represented by the simultaneous illumination of LV1 and LV2.

A jack 150 provides a five bit count on a plurality of signal lines 152, 154, 156, 158, 160 from the simulator board 26 which together comprise a fast or slow speed position signal for simulating the movement of a lift car up and down a hoistway by means of a plurality of five by seven dot matrix display devices 162, 164, 166, 168, 170. An EPROM 172 is programmed to provide, in response to the slow or fast count on lines 152, 154, 156, 158, 160, a seven bit pattern of consecutive signal lines to a plurality of latches 174, 176, 178, 180.

It will be observed that the output latches have a total of 34 output lines while the dot matrix displays have the capability to have 35 rows of LEDs illuminated. Thus, one of the rows of the LEDs on display 162 and two of the rows on display on 170 are not utilized and eight rows of LEDs are therefore used in each of the four "landings" of display 102.

I.e., referring now to Fig. 5, it will be observed that the display 102 comprises four separate blocks of LEDs in order to simulate the four landings of the simulated hoistway. Eight rows of LEDs are allocated to each block 182, 184, 186, 188. Each block has five columns of LEDs, each column of which is controlled by one of a plurality of signal lines 190, 192, 194, 196, 198 as controlled by the circuitry of Fig. 7B to simulate the opening and closing of the hoistway and car doors.

Thus, for each of the thirty-two possible positions of the simulated car as represented by the five bit code appearing on lines 152, 154, 156, 158, 160, there will be a group of eight consecutive rows of LEDs which must be illuminated. This may be done by have a free running clock 200 provide, say, a two kilohertz square wave to a BCD counter 202 which provides a binary output on lines 204, 206 which are used both to help address the EPROM 172 and by a BCD to decimal converter 208 to select one of the four latches 174, 176, 178, 180 through a buffer 210, according to the binary count on lines 204, 206.

Thus, the position addressing signals from jack 150, in conjunction with the two-bit signal on lines 204, 206, may be used access a table in the EPROM 172 which will illuminate the correct subset of eight sequential rows of LEDs to be illuminated during each cycle of the free-running clock.

In this way, eight rows of LEDs will progress together up and down the simulated hoistway 102 at a speed controlled by the count appearing on signal lines 152, 154, 156, 158, 160. This count is controlled by the

simulator board at either a slow or fast speed, to be described below in connection with Fig. 8.

Referring now to Fig. 7B, a multivibrator 220 produces a square wave at approximately 0.25 Hz on a line 222 to a BCD counter 224. The direction of the count is controlled by a U output on a line 228 or a D output on a line 230 from an EPLD 232. The EPLD 232 receives a door open (DO) command signal on a line 234 and a door close (DC) command on a signal line 236 from a jack 102b from the simulator board 26.

If, for example, it is assumed that a not DO signal on line 234 goes to a zero volt indication, DO is required. The U signal on line 228 then goes to a "1" which allows the counter 224 to increment. The output from the counter 224 on lines 240, 242, 244, 246, is fed into the EPLD 232. Internal EPLD logic decodes the count to provide a door state condition such as DOL, DFC, DS, & GS on signal lines 248, 250, 252, 254, respectively. The EPLD 232 also provides outputs on signal lines 256, 258, 260, 262, 264 to simulate door opening. This may be done, for example, by having all of the lamps in all five columns for the eight contiguous rows illuminated to simulate door fully closed. To simulate a door opening, the base of a transistor 266 may be de-energized to extinguish the center column of the eight contiguous rows of LEDs. Next, e.g., a quarter second later, a transistor 268 and a transistor 270 are simultaneously de-energized to extinguish two more columns on either side of the previously extinguished column. Finally, the bases of transistors 272, 274 are de-energized a quarter second later to extinguish the remaining two columns of LEDs at the far ends of the "door". By causing the columns to extinguish every quarter second, a good simulation of a door opening is achieved.

Referring now to Fig. 8, a means for carrying out the simulator 26 of Fig. 2 is illustrated. An integrated circuit 300, which may be in the form of an intel® EPLD

(5C090), provides the five bit count signal on lines 152, 154, 156, 158, 160 to a plug 302 which connects to jack 150 of Fig. 7A.

5 The count on lines 152, 154, 156, 158 and 160 is driven at a fast or slow speed in response to the instruction of the controller 12 of Fig. 1 by means of signals NOT T and NOT G on lines 316 and 356, respectively, after reception of an up (U) or down (D) command from the control 12. The count is incremented at
10 fast speed directly by a signal from an astable multivibrator 304 on a line 308 and is incremented at slow speed by dividing this signal internally to the EPLD 300 by a factor of 4. This accurately represents the speed conditions of a two-speed AC drive lift intended
15 for the simulator embodiment shown.

Now, to get a fuller picture of what occurs on the display 102 of Fig. 5, we may assume all supplies are available, the "lift" is not on independent service and no faults are present, the car is at the third "landing"
20 186 with the door closed and a first floor car call is entered by the student by depressing button 56a. The following sequence then occurs.

The microprocessor-based lift control 12 outputs a NOT D signal and a NOT T signal which signals are
25 received in a jack 312 on signal lines 314 and 316, respectively, which are in turn provided to optocouplers 318, 320 before being provided on optoisolated output lines 322, 324, respectively, to a noninverting buffer 326 before being provided on lines 328, 330 to EPLD 300.
30 The NOT D output sets the direction of the internal U/D counter of the EPLD, and the NOT T signal sets the speed of the clock. At various preset counts, the various outputs required by the system, i.e., DZ, 2LS, 1LS, IPD, IPU are provided on signal lines 326a, 328a, 332, 334,
35 336. These signals are simulative of signals that would come from operative hoistway signaling devices in a real

lift system and are in this case indicative of the car's position in the hoistway.

5 When the microprocessor-based control 12 has received the required number of pulses from "IPD" the NOT T output from the control 12 swaps with NOT G the slow speed output, and the internal counter will now change speed. This will continue until the internal counter reaches a preset count that indicates a door zone has been "reached". The outputs NOT DO and NOT G will be de-
10 energized and the controller 12 will output a NOT DO signal on a signal line 380.

Some outputs of EPLD 300 are connected to LEDs on the display board to give status indications as indicated previously in connection with Fig. 7. Some are connected
15 via a fault EPLD 350 to relays which provide simulated inputs to the microprocessor-based lift control 12 board. The fault EPLD 350 (may also be an intel® 5C090 EPLD) permits or prevents these various relays from energizing depending upon the status of two four-bit switches 352,
20 354, one of which is mounted on the simulator logic board 26 (but inaccessible to the student) and the other on the display board 24.

There are four other signals coming in from the lift control board 12 on jack 312. A slow speed signal, NOT
25 G, is provided on a line 356, a NOT U signal on a line 358, a NOT DO signal on a line 360, and a NOT DC signal on a line 362. These signals are provided, respectively, to optoisolators 364, 366, 368 and 370. The optoisolators, in turn, provide isolated signals on lines
30 372 and 374 to a noninverting buffer 326. The optocouplers 368, 370 provide the NOT DC and NOT DO signals to a jack 376 on lines 378, 380, respectively. Jack 376 connects up to jack 120 in Fig. 7B.

35 The signals on lines 326a, 328a, 332, 334, 336, previously described, from the EPLD 300, are provided to EPLD 350 in order that a selection of faults as selected on switches 352, 354 may be properly indicated to the

microprocessor-based lift control 12 by the simulation of external relays 19a in a simulated "hoistway" (see Fig. 1B). The use of relays is of course a design choice which may easily be avoided by solid state circuitry. In this case, we have selected relays as the best way to provide proper voltages via contact closures to the microprocessor-based lift control 12. Due to the nature of the selected lift control 12 which, of course, is based on an actual lift control (limited car board (LCB) of Otis Lift Company; Part No. A9693A2) of an actual lift manufacturer, it will be understood that the contact closures must be attached to the voltages that the lift control 12 is expecting to "see" from a real hoistway. Thus, in the particular case selected, in the best mode embodiment, the lift control 12 is expecting to "see" 110 volt AC inputs and thirty volt DC inputs while it provides 110 volt AC outputs. It is also responsive to various power supply inputs and to the serial link described previously.

Thus, a jack 400 provides 110 volt AC on a line 412b to a plurality of relay contact which in turn provide output signals on the same jack to the lift control 12 upon closure of their associated contact. These particular contacts are controlled by a series of relays 402, 404, 406, 408, 410, 412, 414, 416, which are in turn controlled through a buffer 418 by a plurality of signals on lines 420, 422, 424, 426, 428, 430, corresponding to a top of car inspection signal (420) a top-down inspection button closure (422) a top-up inspection button closure (424) a top of car emergency stop switch (426) closure, a door fully closed signal (428) and a door open limit signal (430), some of which are from the simulator control panel 22 and routed through the display board 24 as a matter of convenience and terminating on a jack 431.

The relay 402 controls a normally closed contact 402a which provides a signal a line 402b to the control 12 if the student selects top of car inspection on the

control board with a switch 402c (shown in Fig. 5). Relay 404 is also controlled by the TCI signal on line 420 and controls a brake-before-make "form C" relay contact 404a which provides the 110 volt AC signal to the lift control 12 on a line 404b if 110 VAC is present on line 404b via contact 404a under normal service operation, or on the same line 404b if a normally open contact 410a is closed and contact 404a is in the position not illustrated. This condition will occur if 110 VAC is present on line 404b when contact 404a is in the position not illustrated when TCI switch 402c is placed in position INS and switch UIB (up inspection button) on the control panel is depressed (for reference when the lift is being driven up on inspection). With contact 404a in the position not illustrated, a DIB signal may be provided on a line 408a upon relay 408 causing a contact 408b to close upon receiving a TDIB signal on line 422 from a student pushbutton actuation of a switch 408c on the control board 22 of Fig. 5. This causes the lift to travel down at inspection and occurs if switch 402c is in position INS and switch 408c is depressed.

An actuation of the TCI switch 402c also causes the opening of a contact 402d which prevents the signal provided through contact 408b from being fed back to line 404b at an inappropriate time.

The relay 412 controls a normally closed contact 412a which normally provides 110 volts AC on the line 412b to the rest of the circuitry shown except when opened by the energization of relay coil 412 by a TES signal on the line 426. This corresponds to the student actuating a TES switch 412c shown in Fig. 5.

The door fully closed signal on line 428 energizes relay 414 which in turn controls a normally closed contact 414a. The opening in the signal line 428 is there because the signal on 428 is fed first into the EPLD 350 via input dfc on the line 428 and reappears at

the output DFC on a line 435 and is then fed into the relay drive 418. This is done in this way in order that the signal may be easily interrupted during the fault selection part of the training program. The DOL signal on line 430 energizes relay coil 416 to control a normally closed contact 416a which provides the door open limit indication to the remote station 56 of Fig. 6b. The EPLD 350 is responsive to the impulse up (IPU) signal on line 326a, the impulse down (IPD) signal on line 328a, the IP signal on line 338, the down correction run limit (ILS) signal on line 332, and a door zone (DZ) signal on line 336, to provide a plurality of output signals on a plurality of lines 450, 452 to respective latches 454, 456 for energizing a corresponding plurality of relays 458, 460, 462, 464, 466, 468, 470, 472, 474, 476, 478, 480, 482, 484, 486. Each of these relays has an associated normally open or normally closed contact 458a, 460a, 462a, 464a, 466a, 468a, 470a, 472a, 474a, 476a, 478a, 480a, 482a, 484a, 486a.

A jack 500 connects up with a plug on the microprocessor-based control board 12 and carries 30-volt DC inputs to that control board. These may include an IPU signal as controlled by a relay contact 450a, an IPD signal as controlled by a relay contact 460a, an IP signal as controlled by a relay contact 462a, a DZ signal as controlled by a relay contact 464a, a 2LS signal as controlled by a relay contact 466a, and a 1LS signal as controlled by a relay contact 468a.

A jack 502 on a line 470b (presently not used) provides a signal as controlled by a relay contact 470a, a signal as controlled by a relay contact 472a which simulates the door open button being inoperative in response to a DOB inoperative (simulator fault) signal F3 on line 452, a signal on a line 474b as controlled by a relay contact 474a in response to a "NOT DO output doesn't switch" (simulated fault) signal (F4) on line 452 to inhibit the NOT DO output of the controller 12, and 24

volts AC as controlled by a relay contact 476a in response to a signal (F11) indicative of a no 24 VAC supply to the control 12 (simulated fault) which will interrupt the 24 VAC supply to the PC board 12.

5 A jack 504 provides a signal on a line 478b as controlled by a relay contact 478a in response to fault signal F2 (indicative of INS switch made) on line 452 to invoke the INS feature (load nonstop) regardless of switch 84, a signal on line 480b as controlled by a relay
10 contact 480a in response to a fault signal F7 (Remote Station No. 5 inoperative) on line 452 which will disable remote station 58, and a ground common signal as controlled by a relay contact 482a as controlled by a
15 fault signal F8 (indicative of OLS illumination) on line 452 which, when selected, will illuminate OLS, 54 (Fig. 4).

A jack 506 provides the DOL signal as controlled by the relay contact 416a.

A jack 508 provides 30 volts DC on a line 44a to a
20 jack 64 previously described in connection with Fig. 6 for the car call remote stations 56, 58 and the remote stations 52, 60. The ground signal on line 42a is provided by a ground line 42b through the relay contact 484a controlled by the F6 function (simulating a broken
25 30V DC return to car) which interrupts the 30 VDC return in order to disable all car remote stations and associated fixtures. The signal line 49a (L2) serves as one signal line for the serial link and signal line 38a serves as the other leg (L1).

30 For the hall call remote stations 30, 32, 34, 36 of the faceplate in Fig. 6, jack 48 provides the previously described signals on lines 38, 40, 42, 44. Thus, line 44 provides 30 volts DC, line 42 provides a ground line, line 40 provides the L2 signal, and line 38 provides the
35 L1 signal. The L1 and L2 signals are provided through relay contacts 486a controlled by relay 486 which is in turn controlled by fault signal F5 on line 452,

simulating crossed data lines to the hoistway. The operation of this fault signal effectively crosses the data lines (L1 and L2) to the hoistway (hall) fixtures in order to demonstrate the symptoms of such incorrect wiring in a real site environment.

Fig. 9 is an illustration of a matrix which contains a key to various faults which may be simulated by causing various combinations of switches 352, 354 to be effected. It will be noted that each switch is capable of providing four bits to the EPLD 350, and each is thus capable of providing up to 16 different combinations of switch settings, each of which is shown in Fig. 9. Up until now, we have only devised a limited number of simulated faults, and only 11 of these are shown in Fig. 9. As shown, we have allocated the various possibilities for switch settings at random so that each fault can be simulated by several different combinations of the two switches. For example, fault F1 can be simulated by outputting a "2" from switch 352 (S1) and a "2" from switch 354 (S2) as well. Similarly, F1 may also be simulated by outputting a "2" from switch 352 and a "7" from switch 354. In this way, the instructor can have flexibility in selecting faults without "giving away" exactly which switch settings create particular fault conditions as between different sets of students.

The faults we have selected are by no means exhaustive, but include, among others, a "no DFC signal (F1)", a "LNS switch made" fault (F2), a "DOB inoperative" fault (F3), a "NOT DO output doesn't switch" fault (F4), a "crossed data lines to hoistway" fault (F5), a "broken 30 V DC return to car" fault (F6), a "remote station No. 5 inoperative" fault (F7), an "OLS illuminated" fault (F8), a "no IPU signal" (F9), and a "no 24V AC supply to LCB" fault (F11).

As previously mentioned, the various switch settings of switches 352, 354, one of which is set by the instructor inside the unit, out of view of the student,

and the other of which is set by the student himself in accordance with the instructional materials provided, set up a particular fault for simulation. For example, the F6 fault on signal line 452 from the EPLD device 350 is triggered in response to, for example, switch 352 (S1) being in position "6", and switch 354 (S2) being in position "3" as shown in Fig. 9. This is intended to simulate a broken 30V DC return to car fault condition and does this by having the EPLD detect the switch settings of switches 352, 354 at positions "6" and "3", respectively, and then provide an F6 upward signal on line 452 for energizing relay 484 which in turn causes contact 484a to open, thereby removing the 30V DC return to the "car". Recall that jack 64 goes to the car call remote stations, and the jack 508 provides the serial link to the limited car board 12.

Although the invention has been shown and described with respect to a preferred embodiment thereof, it should be understood by those skilled in the art that the foregoing and various other changes, omissions, and additions in the form and detail thereof may be made therein without departing from the scope of the invention.

CLAIMS

1. A lift training device, comprising:
 - a plurality of input devices for providing a corresponding plurality of input signals;
 - 5 a simulator, responsive to said input signals for providing a plurality of condition signals indicative of a corresponding plurality of simulated lift conditions;
 - a microprocessor-based lift control, responsive to said condition signals, for providing a plurality of
 - 10 command signals wherein said simulator is responsive to said command signals for providing a plurality of output signals; and
 - a plurality of output devices, responsive to said output signals, for manifesting said conditions by
 - 15 displaying information.
2. The device of claim 1, further comprising:
 - fault selection means for providing a fault signal,
 - wherein said simulator is responsive to said fault signal for providing one or more of said output signals for
 - 5 manifesting a condition indicative of said fault.
3. The device of claim 1 or 2, further comprising:
 - a test tool, responsive to data signals stored in said microprocessor-based lift control, for providing
 - display signals indicative of said simulated lift
 - 10 conditions.
4. The device of claim 1, 2 or 3, wherein said input devices, simulator, microprocessor-based lift control and output devices are packaged in a portable case.
5. A lift training device substantially as hereinbefore described with reference to the accompanying drawings.