(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: 0 154 069
A2

(12) EUROPEAN PATENT APPLICATION

(21) Application number: 84303094.1

(22) Date of filing: 08.05.84

(51) Int. Cl.⁴: E 06 C 5/04
B 66 C 23/90

(30) Priority: 08.03.84 GB 8406094

(43) Date of publication of application:
11.09.85 Bulletin 85/37

(84) Designated Contracting States:
DE FR GB IT

(71) Applicant: MERRYWEATHER AND SONS LIMITED
Belliver Industrial Estate
Roborough Plymouth, PL6 7BW(GB)

(72) Inventor: Manners, Anthony John Francis
36, North Rise Llanishen
Cardiff CF4 5RN Wales(GB)

(74) Representative: Abbott, David John et al,
Abel & Imray Northumberland House 303-306 High Holborn
London, WC1V 7LH(GB)

(54) A control system for an elevatable and extendible structure.

(57) A digital computer based control system for a turntable ladder mounted on a vehicle is arranged to limit extension and minimum elevation angle of the ladder in accordance with the intended loading of the ladder. The system performs initial checks on parts of the system and will permit only manual control at low speed where the operational state of a part involved is unsatisfactory or outside the limits. In addition to monitoring the stabilising jacks on the vehicle and preventing movement of the ladder which would tend to increase an excessive bending force on it, the system automatically plumbs the ladder so that its rounds are horizontal. The system can also be applied to control a cage or platform on a telescopic boom.

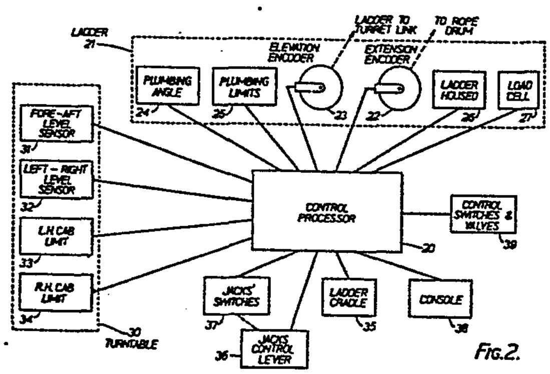


FIG.2.

EP 0 154 069 A2

0154069

A CONTROL SYSTEM FOR AN ELEVATABLE AND EXTENDIBLE STRUCTURE

This invention relates to a control system for an elevatable and extendible structure and is especially but not exclusively applicable to the control of a turntable extending ladder mounted on a fire engine.

Turntable ladders are usually mounted on fire engines so that they can be taken rapidly to the scene of a fire or other disaster for the purpose of rescuing trapped people. A difficulty which arises in the operation of a turntable ladder is that the ladder is often extended transversely of the vehicle and the weight of an additional person at the top of the ladder can produce a sufficiently large moment to overturn the vehicle even if it is supported by stabilising jacks. The operators of such a ladder are aware of the limitations of its use, but as rescues are frequently carried out in emergency conditions the stresses of such conditions can cloud the judgment of the operator. In order to avoid having too great dependence on the operator's judgment of the extended length of a ladder and its angle of inclination indicators of these values are sometimes provided in association with an indication as to whether the use of the ladder will be safe with one, two or more persons on it. Whilst such indications would enable the ladder to be used safely at all times, it is possible that the operator could be distracted at a crucial instant and permit the configuration of the ladder to become dangerous for its intended use.

It is an object of the present invention to provide a control system which would enable the ladder to be used up to the limits of its safe operation without the need for the operator to keep a close eye on the indications of its length and elevation.

According to one aspect of the present invention there is provided a control system for an elevatable and extendible structure in which a limit, dependent on the load on the structure and the actual extended length of the structure, is imposed on the elevation, and a limit, dependent on the load on the structure and the actual elevation angle of the structure, is imposed on the extended length of the structure.

According to a second aspect of the present invention there is provided a control system for an elevatable and extendible structure having first means responsive to an elevation angle of the structure to produce an indication of the angle and second means responsive to the extended length of the structure to produce an indication of the length, wherein the system includes means for entering a proposed mode of use of the structure and is responsive to the indications produced by the first and second means and to the proposed mode of use to impose limits on the elevation angle and extended length of the structure.

The modes of use of the structure may include indications of the loadings to be applied to the structure and the limits may be determined by the likelihood of the structure being overturned by the loading applied to it.

The structure may be a turntable ladder which may be mounted on a suitable vehicle to form a fire engine or fire appliance. Alternatively, the structure may be a cage or platform on an elevatable telescopic boom mounted on a vehicle for rescue and maintenance applications.

Control signals for the structure may be applied to it through the system from manually operable input devices. The system may be arranged so that as the elevation or extension approaches the limit value the maximum rate of change of the variable is limited to a lower speed.

The system may include numerical displays of the elevation angle and the extended length, a display of the selected mode of operation, and means for indicating when the limits are reached. A graphical display of the disposition of the structure may also be provided.

Where the structure is to be mounted on a vehicle it may be provided with means for preventing the structure from colliding with the cab or other part of the vehicle by inhibiting movements likely to cause a collision. The system may also be used to monitor the correct operation of stabilising jacks on the vehicle where such are provided.

If the structure is a ladder it may be provided with sensing means producing an indication of the inclination of the rounds (rungs) of the ladder to the horizontal, and the system may be responsive to that indication automatically to produce output signals for correcting the inclination. In addition, the extension may be adjusted to values such that the rounds on adjacent ladder sections are aligned.

The structure may be provided with a load cell responsive to bending forces on the structure, for example due to the structure striking part of a building in performing a required movement. The system may respond to signals from the load cell to inhibit such movement of the structure as would increase the bending forces.

The system may be provided with an override switch allowing slow movement of the structure under manual control outside the limits imposed by the system. The system may include tests on the operational state of the various monitoring devices and may permit manual control only where a device is suspect.

In order that the invention may be fully understood and readily carried into effect it will now be described with reference to the accompanying drawings, of which:-

FIGURE 1 shows a fire engine with a turntable ladder suitable for control by a system according to the present invention;

FIGURE 2 is a block diagram of one example of a system according to the present invention based on the information flow in the system;

FIGURE 3 is a flow diagram showing part of the operation of the ladder control system;

FIGURE 4 is a flow diagram showing the initialisation and error detection of the operation of the system;

FIGURE 5 is a diagram of the system shown in Figure 2 but divided in accordance with the structural components of the system; and

FIGURE 6 shows the details of the graphic display produced by the system.

The fire engine shown in Figure 1 consists of a vehicle chassis having a cab 1 with an extending ladder 2 mounted on a turret 3 on a turntable 4 on the platform 4A of the chassis. The ladder 2 is supported by a gimbal, not shown, and is elevated by a single dual concentric hydraulic ram 5 extending between the turret 3 and brackets 6 on the underside of the ladder 2. The plumbing of the ladder, that is to say the levelling of its rounds or rungs which is necessary when the engine is standing on an inclined surface, is effected by two hydraulic rams one on each side of the ladder of which that on the left-hand side has the reference number 7. Further details of the mounting of the ladder on the turret are given in British Published Patent Application No. 2 105 298A.

The ladder 2 is extended by means of a wire rope system which may be as described in British Published Patent Application No. 2 105 398A, the wire system being operated by a drum, not shown, and an hydraulic motor driving the drum. The operator of the ladder is provided with a seat 8 and has controls and display equipment on a console 9.

For accommodating the ladder 2 whilst the engine is being driven there is provided a cradle 10 just behind the cab 1 and on the chassis of the engine there are provided four jacks of which two having the references 11 and 12 are shown, which jacks can be extended diagonally downwards for the purpose of stabilising the engine when the ladder 2 is erected.

Figure 2 shows in block diagrammatic form a control system for the operation of the turntable ladder shown in Figure 1 and includes a control processor 20 which is connected to receive inputs from the ladder 2 representing its disposition and the loads on it. These inputs are included in the broken rectangle 21 and include a digital shaft encoder 22 connected to the rope drum driving the reeving system for extending and retracting the ladder 2 and a second shaft encoder 23 connected by a parallelogram or similar linkage between the ladder 2 and the turret 3 so as to produce a digital output representing the elevation angle of the ladder 2 relative to the turret 3. In addition, the ladder is provided with an electromagnetic sensor (Tilt unit 2) which produces an analogue output representing the inclination to the horizontal of the rounds of the ladder 2; this sensor is represented by the block 24. An analogue to digital converter is included in the processor 20 to convert the analogue output to digital form to represent the inclination of the rounds of the ladder. On the turret 3 are mounted further sensors represented by the block 25 which detect whether the inclination of the turret is too great for the plumbing movement provided to level the rounds of the ladder 2; these limits are typically 7° in either sense. The block 26 represents a switch on the ladder 2 which is operated when the ladder is fully retracted or housed. Block 27 represents a combination of load cells which are built into the ladder on the main ladder stringers just forward of the junction between the stringers and the ladder frame to produce outputs representing the loads up and down and from one side to the other on the ladder so as to detect when the ladder is fouling on the building, for example.

The turntable 4 has other sensors included in the broken rectangle 30 in Figure 2. Two of the sensors, 31 and 32, are electromagnetic tilt sensors which produce analogue outputs which are converted to digital signals representing the fore and aft tilt and the left and right tilt of the platform respectively. The two other sensors, 33 and 34, respond to the orientation of the turntable 4 on the platform 4A and produce signals which are used as described below to prevent the ladder 2 colliding with the cab 1 and to assist in parking the ladder on the cradle 10. The cradle itself has a switch or other means for detecting when the ladder 2 is resting on it and this is shown as block 35 in Figure 2.

The stabilising jacks of which two, 11 and 12, are shown in Figure 1 are extended and retracted hydraulically in response to a manual control lever (not shown). The position of this lever is fed to the control processor 20, Figure 2, from switches represented by the block 36. The jacks themselves also have switches which are operated when the jacks are sufficiently extended, and these switches are represented by the block 37. Obviously all the jacks must be secured or locked in the extended position, before the ladder 2 can be used safely up to its operational limits.

The operator's console 9 (Figure 1) has various controls, display devices and warning lamps which are used as described below to cause the ladder 2 to be moved to the required position and to provide monitoring information to assist the operator in controlling the ladder. The console is represented in Figure 2 by the block 38.

The control of the ladder itself and the other parts of the fire engine is performed in response to outputs from the processor 20 using electric motors, electromagnetic devices and solenoid valves to manipulate mechanical and hydraulic equipment. These are represented by the block 39. The nature of the controlling devices and the ways in which they are controlled will become apparent from the following description of the system in operation.

From a consideration of Figure 2 it will be apparent that the control processor receives two sets of inputs - those set manually from controls on the console and those monitoring the status and disposition of the mechanisms under control - and produces two sets of outputs - those applied to devices regulating the application of power to the controlled mechanisms and those producing displays to the operator of the status and dispositions of the controlled mechanisms. The manually set inputs are:-

1. System on/off
2. Ladder extend
3. Ladder retract
4. Ladder rotate left
5. Ladder rotate right
6. Ladder rounds alignment
7. Jacks extend
8. Jacks retract
9. Ladder elevate

10. Ladder depress
11. Intended ladder loading
12. Manual override switch - processor off-switch

The pairs of inputs 2 and 3, 4 and 5, and 7 and 8 may each be provided by three position controls having an off position to which the control is spring loaded between the two active positions.

The monitoring inputs are:-

1. Ladder length
2. Ladder elevation
3. Angle of ladder rounds to horizontal(Tilt unit 2)
4. Orientation of the ladder relative to the cab
5. The loading on the ladder - up/down forces
6. The loading on the ladder - sideways forces
7. "Inclination of ladder too great to permit complete plumbing" switches
8. Turntable tilt - fore-aft (Tilt unit 1)
9. Turntable tilt - left-right (Tilt unit 3)
10. "Ladder fully retracted" switch
11. Ladder cradle switch
12. "Jacks extended and locked" switches
13. "Jacks retracted" switches

Of these inputs, numbers 1, 2, 3, 5, 6, 8 and 9 are digital and are either derived directly from shaft encoders or similar devices or from analogue signals by analogue to digital converters. All the other inputs except number 4 are two-state ones being derived from switches. The orientation of the ladder relative to the cab has four states:away from the cab, too near the left, too near the right, and centrally disposed over it. These signals may be generated by a combination of switches or by two electromagnetic sensors resposive to elements on the turntable.

The outputs from the control processor which are applied to devices for regulating the power applied to controlled mechanisms are all electrical signals which are amplified sufficiently to perform the tasks allotted to them, which depend on the nature of the regulating device. For example, the ladder extension and retraction is effected by a wire rope system using a drum driven by an hydraulic motor, whereas the ladder elevation and plumbing are effected by hydraulic rams. A motor speed control circuit could be used for the hydraulic motor and solenoid operated hydraulic valves could be used to control the ladder extension. The control outputs are as follows:-

1. Ladder extension
2. Ladder retraction
3. Ladder elevate
4. Ladder depress
5. Ladder plumbing (and to docking angle when low over the cab)
6. Turntable rotate - left and right
7. Jacks - down
8. Jacks - up

A half speed operation of numbers 1, 2, 3 and 4 is provided, which is used as the parameter approaches the required value. Half speed operation is also possible under manual control with the processor switched off.

The displays on the console, which are provided by the other outputs of the control processor, are as follows:-

1. Numerical display of ladder length
2. Numerical display of ladder elevation
3. Graphic display of ladder disposition and stability limits of intended loading
4. Stability zone warning lamps: green, amber, red.
5. Plumbing indicators (lamps)
6. Normal and excessive loads on the ladder (lamps) and audible warning devices including an indication of the direction in which the load acts
7. Round alignment completed
8. Jacks - extended and locked

In addition indications of error conditions are displayed and details of these will become apparent from the description of the system in operation. The graphic display may be substantially as described in British Published Patent Application No. 2 108 746A and as shown in Figure 6 of this application.

The purpose of the system is to prevent the ladder being inadvertently used outside its stability limit. When the system is first switched on the control processor checks that all of the inputs to it are reasonable, that the ladder length and elevation correspond to it being parked on the cradle and that a valid expected man-loading of 1, 2 or 8 is entered. Ladder operation is inhibited until the jacks are extended and locked - this could include a check that all four are set firmly on the ground. The system may also indicate other pre-conditions for operation which are not satisfied, such as low fuel for the engine supplying electrical and hydraulic power or a fault withe the engine itself. The fault indication may involve flashing of a lamp and identification of the nature of the fault on one of the numerical displays, for example, which may be adapted to display alphabetic and numeric characters. If a fault has occurred the operator may override the system and use full manual control at half speed.

If all of the pre-conditions are satisfied and the "jacks set" signal is received, the green stability lamp is lit and the disposition of the ladder is displayed numerically and on the graphic display. The ladder can then be raised from the cradle and rotated, elevated and extended as required. As soon as the ladder has left the cradle plumbing is automatic and continuous. As the ladder approaches the stability limit for the intended loading the green lamp goes out and the amber lamp is flashed until the limit is reached when the red lamp is lit and the ladder movement is stopped. Further movement of the ladder under control of the system is only possible in directions away from the limit, i.e. retraction or elevation.

Impact of the ladder with the cab is prevented by the system, with the result that the ladder can be brought over the cab only if the elevation angle is sufficient to give clearance. When the ladder is central over the cab it can be lowered on to the cradle to park it.

As mentioned above, shaft encoders are used to provide digital coding relative to angular movement for elevation and ladder length. The elevation shaft encoder is mounted at the side of the turret and is operated by a parallelogram type mechanical linkage attached to the gimbal beam. The ladder length encoder is driven by a rear shaft from a gear box located at the left hand end of winch drum and is in synchronism with the mechanical output shaft for the mechanical ladder length indicator. The 'rounds aligned' output is also derived from the shaft encoder output for ladder extension in that 'rounds aligned' shaft codes are identified by the processor and signalled accordingly when 'round alignment' is selected by the operator.

The elevation shaft encoder is orientated to the turret and corrections are necessary to ensure that the angular datums, with the exception of parking on the ladder cradle, are referenced to the true vertical irrespective of attitude of platform. The data for the necessary correction is applied to the processor by inclinometer type Tilt Units. Tilt Unit 1 is located within the console and senses gimbal frame tilt in the fore and aft axis. Tilt Unit 2 is located on the gimbal beam and controls plumbing by sensing tilt in relation to the horizontal. Tilt Unit 3 is located within the console at 90 degrees to the fore and aft axis of the ladder and is used exclusively to sense deviation between the plumbing datum and the ladder cradle angular datum when making up the ladder to the headrest.

The Tilt Units generate analogue voltages related to angle of tilt in one plane only. The analogue voltages are converted into a digital code. In the case of the Tilt Unit 1 the voltages are converted to a digital code and by summation with shaft encoder information within the processor, results in an output of true angular reference about the horizontal. The true reference is used by the processor as the basis for comparison with the pre-programmed operational envelope limitations and the ladder loading selection made by the operator. Both the true reference and operational envelope are displayed on the graphic display.

When parking the ladder on the cradle because the inclinometer mounted on the gimbal beam will plumb to the vertical at 90 degrees to the fore and aft axis of the ladder it will invariably be necessary to correct the angle of the plumbing beam so that it is parallel to the cradle when the ladder is parked. Tilt Unit 3 is mounted on the gimbal frame and will sense the tilt on the gimbal frame, which with the ladder central will provide the datum for comparison of the difference between the cradle and plumbing beam. The signals from Tilt Unit 3 are inhibited until the ladder is detected by the processor to be central with the headrest and moving through 10 degrees of elevation towards the cradle. At this point the processor will compare the angular difference between Tilt Unit 3 and the gimbal beam inclinometer inputs. The processor will then initiate the appropriate plumbing control which will cause the rounds to move into parallel alignment with the ladder cradle. Plumbing is not influenced by Tilt Unit 3 except during the first 10 degrees of ladder movement with the ladder central.

Certain aspects of processor programming are under direct control of the operator and this is in the selection of the 1 man, 2 man, and 8 man loads which set the operational limits for loading and stability. When the selected program is exceeded, i.e. the processor system detects that the ladder position and speed is about to exceed the selected operating envelope limitations, the processor will automatically initiate slow and stop signals as required.

Ladder normal and side loads are derived from circuits within a 'Load Cell' unit which accepts and interprets signals from two transducer strain detectors and associated amplifiers, mounted on the main ladder stringers just forward of the junction between stringers and ladder frame. The Load Cell converts amplified transducer outputs into continuous down load and side load inputs which are used to drive the load indicator meters. In addition the Load Cell detects maximum left, right and down strain outputs from the transducers and provides the necessary signals as additional inputs to the processor so that corrective control may be initiated. An overload situation is also detected and signalled to the processor and to the operator both audibly and by lamp.

Ladder side impact is detected as an abnormal loading and is applied to the processor by the Load Cell. The processor initiates STOP outputs to relays controlling hydraulic solenoid operated valves when rotation load limits are reached. As there is no SLOW control for the rotation operation a STOP signal only is initiated. The processor will allow rotation away from the STOP in the normal way.

For control of the ladder close to the cab the processor receives control signals from two proximity detectors as follows:

The two detectors are mounted on the turntable of the gimbal frame and are used to centralise the ladder and also prevent rotation of the ladder at below 6^{o} elevation within a 45 degree arc of the base frame forward centre line to prevent collision with the vehicle cab. A metal target is centred on the base frame and provides a segment 45 degrees either side of the turntable base so that with the ladder in line with the cradle each detector is just within the operating arc of the target. Any movement from the centre line will result in the appropriate detector (left or right) not sensing the target and providing an output to the processor. It follows that with no signals from either detector the ladder is outside the 45 degree quadrant either side of the base frame centre line. In this case the processor will permit the ladder to be moved to the maximum depression limits for ladder bridging operations. During the ladder parking operation the processor will automatically align the ladder to the cradle by reference to the two tilt units, before the ladder reaches the cradle.

In addition, two detectors mounted to detect targets attached to the gimbal beam are set to sense the 7 degrees maximum plumbing limits. A signal from either sensor may cause the processor to inhibit control to the plumbing hydraulic circuits. At the same time the ladder plumbed indicator will also be inhibited. The system may be arranged to carry out the automatic plumbing as far as it can whilst producing an indication that the ladder is not fully plumbed.

A flow diagram, shown in Figure 3, represents the sequence of operations performed by the processor unit.

Faults may be present in the system before commencement of ladder operation or may occur during system operation. At start-up the control processor checks the validity of the following system transducers:

(1) "Jacks extended and locked" and jack lever input circuits

(2) Left and right cab protection proximity detectors

(3) Elevation and extension shaft encoders

(4) Tilt Units 1 to 3 (i.e. Gimbal beam, Gimbal frame fore and aft, Gimbal frame left and right)

(5) Load cell inputs

(6) Maximum plumbing detectors

(7) Ladder fully retracted switch

(8) Man loading switch settings

Once the processor has checked the validity of the above transducer inputs, it will assume that the transducers and the respective circuits are serviceable and the inputs are correct for ladder operation.

All ladder operations are inhibited until a "Jacks extended and locked" signal is received by the processor. The ladder may be manually operated without the processor by switching OFF all electrical circuits or by switching OFF the processor unit power supply at the switch on the side of the unit. The ladder may then be operated at half speed, but there would be no stability limit cut-out and no 'stops' except the ladder fully retracted stop. The load cell and its indicators will remain functional if the processor unit only is turned OFF.

The "Jacks retract" signal is an immediate cancellation of the "Jacks extended and locked" signal and inhibits normal ladder control in the same manner as if a "Jacks extended and locked" signal was not received. The fault is indicated by flashing stability lamps and display of the appropriate fault on the digital display. The ladder may be operated manually provided the jacks are firmly on the operating surface.

The left and right cab proximity detectors should both be active with the ladder central at start-up but if one or both are inactive then a fault will be assumed and once the ladder has been elevated above eight degrees it cannot be depressed below eight degrees. The processor will not permit depression below eight degrees until the manual override switch is operated and it will then allow depression below 8 degrees while causing the CENTRAL indicator lamp to illuminate and the stability lamps to flash ON and OFF. If a detector fault occurs during ladder operation the processor cannot recognise the fault.

The elevation and extension shaft encoders are essential for the correct control of the ladder by the processor. At start-up the processor checks validity codes approximating zero to +2.5 degrees elevation and 30ft +1/0.1ft in ladder length. If either of these checks is incorrect the processor cannot accurately control the ladder within the correct operational limits and should indicate the fault and stop operation of the ladder. It can then be switched OFF thus removing stability limit control.

The Tilt Units 1 to 3 provide analogue outputs and the only fault that the processor will recognise is an invalid voltage input in which case the appropriate fault condition will be displayed.

If the load cell signals are detected active by the processor on start-up the processor will cause the stability lamps to flash and will display the appropriate error code on the digital display until the load cell reverts to normal inputs or the load cell system is switched off. If the signals are activated during ladder operation the processor assumes them to be valid and reacts accordingly. If excess side load is signalled the processor inhibits rotation towards the load and only enables rotation away from the side loading. If excess downloading is signalled the processor inhibits all ladder operation except retraction, and monitors the override switch. When the override switch is operated depression, elevation and rotation is enabled so that the fault may be cleared by the operator.

If either of the two maximum plumbing detectors is active at the initial condition of start-up it will either by due to an electrical fault or the ladder is located seven degrees out of true with the cradle. The appropriate fault code would be displayed and manual override would be available. Normal ladder operation using manual plumbing control will be possible but on return to the cradle the processor will display an error coding to indicate that inspection/maintenance is required. Maximum plumbing will be limited by the mechanical stops.

The initiation of and fault detection in the ladder control circuits is summarised in the flow diagram shown in Figure 4.

The ladder fully retracted switch is normally active at start-up but if not the processor will permit normal ladder operation and the invalid check will be held in memory. When the ladder is subsequently approaching the fully retracted position a stop will be initiated at, say, 31 ft preventing further movement. The stability lamps will flash and the appropriate error code will be displayed. The manual override switch may be operated to permit further retraction of the ladder. If the fully retracted switch is active at start-up and is active when the ladder extension circuits show that the ladder has moved awar from the fully retracted position no fault is displayed. The HOUSED indicator lamp will remain illuminated clearly indicating the fault.

The man loading switch is monitored by the processor for valid inputs which are applied to the appropriate stability limits for the selected operating envelope. If an invalid input is detected by the processor the operating envelope for the 1 man scale is reverted to. The reversion can be checked by comparing the load scale lamps and the LCD display.

Figure 5 shows in block form the circuit of the system shown in Figure 2 divided in structural units instead of in accordance with their functions. In Figure 3 the processor unit 50 is connected directly to the ladder units 51, the console display cabinet 52, the load cell 53 and the three tilt units 54, 55 and 56. The processor unit 50 is also connected through circuit box 57 to console panel 58 and fulcrum frame junction box 59. The console panel 58 is connected to telephone unit 60 and engine control unit 61 controlling engine 62. The telephone enables the operator to communicate with a man up the ladder. In general, the engine 62 is not the unit which propels the vehicle but provides the hydraulic and electrical power for the ladder and its turntable.

The fulcrum frame junction box 59 is connected through slip rings 63 between the turntable 4 and the platform 4A to the engine control unit 61 and through cab circuit 64 to chassis circuit 65 and battery 66.

The processor unit 50 may be a conventional microcomputer with a microprocessor connected through data and address busses to random access memory and read-only memory storing the program data. The busses will also be connected to input/output interface devices to receive and transmit the signals.

The circuit box 57, fulcrum frame junction box 59 and slip rings 63 merely provide interconnections connecting the processor unit 50, which is located in the console 9 (Fig.1), to the ladder (for certain signals only), to the telephone unit and the engine which are also carried on the turntable, and through the slip rings to the chassis circuit and the cab circuit.

The ladder units 51 include the elevation and extension shaft encoders each of which provides a 12 bit parallel input connected directly to the processor unit

50. An indication of the stability state of the ladder is provided at its head in the form of 3 lamps, one red, one amber and one green, which are lit in the same way as the corresponding stability lamps on the console. The energisation for the stability lamps on the ladder is fed through the circuit box 57 as are the power supplies for the shaft encoders. The "ladder housed" status output indicating that it is fully retracted is returned to the processor unit 50 through the circuit box 57 as well.

Each of the three tilt units 54, 55 and 56 receives its power supply from the processor unit 50 and selectively returns high and low output signals to the unit 50 indicating the amount of tilt. The polarity of the low output indicates the sense of the tilt.

The load cell 53 receives its energisation from the processor unit 50 and produces as inputs to that unit down load and side load signals as well as signals indicating that a predetermined maximum down load, left load and right load have been reached. In addition an overload signal is produced.

Since the console display cabinet 52 produces indications of the status of the system as outlined above it only receives inputs, mostly from the processor unit 50 but also from the ladder units 51 (the housed signal), the console panel 58 (e.g. the number of men to be on the ladder) and the chassis circuit 65 (indicating the position of the jacks and whether the ladder is parked).

As mentioned above the display includes numeric indications of the elevation and length of the ladder as well as the graphic display shown in Figure 6, together with indicator lamps. In addition the processor unit 50 produces indications of faults and breakdowns in the form of error numbers on the numeric displays. The display cabinet may include alphanumeric display means enabling error codes to be displayed. Indications other than those provided by the control system of the invention may be produced on the cabinet 51, e.g. an indication that the hydraulic pressure for elevating the ladder is satisfactory.

The console panel 58 has the control switches for the system and also includes controls for the engine 62 and for the telephone 60. As mentioned above, the chassis circuit 65 monitors the jacks and the ladder parked status; it feeds corresponding signals into the system and the cab circuit 64 transmits them.

Figure 6 shows some details of the graphic display produced by the system which as mentioned above is substantially the same as the display described in published British Patent Application No. 2 108 746A. As shown in Figure 6, the display 70 consists of a plurality of selectively energisable liquid crystal or light emitting diode elements arranged to form sectors radiating from a centre, the sectors being divided into approximately rectangular elements by circumferential lines about the same centre. The sectors represent 5° intervals in the ladder elevation in a range from 10° below horizontal (indicated as -10°) to 80° with a lowermost sector representing from -10° to -15°. The operation of the display is such that a line of elements in a sector is energised if the actual elevation angle lies between the limits defining the sector, the length of the line representing the extended length of the ladder in a range from 30 rounds to 99 rounds and each element corresponding to an interval of 3 rounds, this being the minimum length difference usable with a 4-section ladder, intermediate values not permitting round alignment. In Figure 6, a line 71 of elements is shown energised indicating that the ladder elevation is between 25° and 30° and its length is 87 rounds. The ranges of values include their upper limits. At the centre from which the sectors radiate are an 80° sector 72 and a 17° sector 73. The sector 72 is energised to produce a colour red if the ladder is elevated to an angle in excess of 76°. The sector 73 is energised whenever the ladder is below -15°. Three vertical lines 74, 75 and 76 are marked over the elements representing the disposition of the ladder and these represent the maximum horizontal reach of the ladder when carrying 1, 2 or 3 men respectively. The display includes a diagram 77 for showing the intended loading on the ladder, which may be 1 man, 2 men, 3 men or 8 men. The diagram 77 is energised in such a way as to show the appropriate number of pin-man figures. Eight-man working is only permissible when the ladder is bridged to a wall or building.

The display 70 is operated by the processor unit 50 (Figure 5) in response to the digital values representing the elevation and length of the ladder. These are represented by the blocks 78 and 79 and are connected through a decoder 80 to display drivers 81 energising the display 70. A stop condition detector 82 is connected to respond to the elevation and length values to produce outputs representing the stability status of the ladder in its intended mode of use entered via a line 83. Since the ground on which the vehicle is standing may not be level and the stability status of the ladder depends on its true angle of elevation it is necessary to correct the elevation value obtained from the shaft encoder 23 (Figure 2) by adding to it (in the correct sense) the tilt of the turntable obtained from the sensor 31 (Figure 2), which is also referred to as tilt unit 1. The tilt value represented by block 84 is an analogue signal and is converted to digital form by converter 85 and added to the elevation value. This addition would in practice be performed by the processor unit. A round alignment signal represented by block 86 is combined with the ladder length value 79 to provide an indication when the length is correct.

In a modification, the display may be arranged so that instead of only a single line of elements being energised, a block of elements filling the sector from the horizontal line to the ladder elevation angle is energised up to the length of the ladder.

The display 70 is constructed using conventional light emitting diode or liquid crystal display techniques.

In the system described the movements of the ladder are decided upon by the operator who uses levers and switches to set the orientation, elevation and length of the ladder to the values he thinks are required, and the system slows down such movements as the ladder approaches its stability limits for the intended use and stops movement beyond the limits. The system could be arranged to have further control on the ladder movement so that it can be brought to a required position as quickly as possible within the constraints of the stability limits.

The system may be modified by the omission of any of the described features or the addition of extra features.

WHAT WE CLAIM IS:

1. A control system for an elevatable and extendible structure in which a limit, dependent on the load on the structure and the actual extended length of the structure, is imposed on the elevation, and a limit, dependent on the load on the structure and the actual elevation angle of the structure, is imposed on the extended length of the structure.

2. A control system according to claim 1 in which the limits are used to restrict the moment of the load on the structure about the mounting of the structure.

3. A control system according to claim 2 in which manual control at full speeds of the elevation and extension of the structure is provided within ranges of values subject to the limits, and manual control at reduced speeds is possible outside the ranges.

4. A control system according to claim 1, 2 or 3 including a further manual control input for indicating a mode of use for the structure, thereby defining an expected load which is used as a basis for deriving the limits.

5. A control system according to claim 4 wherein the structure is a turntable ladder mounted on a suitable vehicle to form a fire appliance.

0154069

6. A control system according to claim 4 wherein the structure is a cage or platform on an elevatable telescopic boom mounted on a vehicle.

7. A control system for an elevatable and extendible structure having first means responsive to an elevation angle of the structure to produce an indication of the angle and second means responsive to the extended length of the structure to produce an indication of the length, wherein the system includes means for entering a proposed mode of use of the structure and is responsive to the indications produced by the first and second means and to the proposed mode of use to impose limits on the elevation angle and extended length of the structure.

8. A control system according to claim 7, wherein the indication of the extended length is used in combination with the proposed mode of use to derive a limit on the elevation angle, the indication of the elevation angle is used in combination with the proposed mode of use to derive a limit on the extended length, and the proposed modes of use indicate probable loadings on the structure, whereby the limits are determined to restrict the likelihood of the moment of the loading about the mounting of the structure exceeding a particular value.

9. A control system according to claim 8 including manual input means for setting required values of the extension of the structure and its elevation angle, the system producing control outputs for control elements for the structure until the first and second means indicate that the required values have been attained or one or more limits are reached.

10. A control system according to claim 8 or 9 including numerical displays of the elevation angle and the extended length of the structure, a display of the selected mode of operation and means for indicating when the limits are reached.

11. A control system according to clain 8, 9 or 10 including a graphical display representing the disposition of the structure.

12. A control system according to any of claims 7 to 11 wherein the structure is a cage or platform on an elevatable telescopic boom mounted on a vehicle.

13. A control system according to any of claims 7 to 11 wherein the structure is a turntable ladder with sensing means producing an indication of the inclination of the rounds of the ladder to the horizontal, the system being automatically responsive to that inclination to produce output signals for correcting the inclination, and to realign the rounds with a cradle as the ladder is returned to a rest position on it.

14. A control system according to claim 13 in which the extension of the structure is automatically adjusted to a value at which the rounds of adjacent sections of the ladder are aligned.

15. A control system according to claim 12, 13 or 14 in which the rate of change of the extension and/or the elevation angle is restricted as the or each limit value is approached.

16. A control system according to claim 16 having a throttle value which is actuated to restrict the flow of hydraulic oil for adjusting extension or elevation angle as the or each limit value is approached.

17. A control system according to claim 12, 13, 14 or 15 including digital processor means responsive to control signals from different sources in digital form to produce digital control output signals in accordance with the required operation of the system.

18. A control system according to claim 17 in which the structure is mounted on a vehicle with stabilising jacks, wherein the system includes means for monitoring the position of the jacks and is arranged to inhibit normal operation if the jacks are not extended and locked.

19. A control system according to claim 17 or 18 including load cell means responsive to bending forces on the structure, the system being arranged to inhibit such movement of the structure as would tend to increase the bending forces.

20. A control system according to claim 17, 18 or 19 including override switch means permitting movement of the structure at restricted speeds outside the limits imposed by the system.

21. A control system according to claim 17, 18, 19 or 20 wherein initially tests are performed on the operational state of parts of the system and indications are produced of those parts whose operational state is not satisfactory, and the system being arranged to permit manual control at reduced speed of any operations involving a part whose operational state is not satisfactory.

22. A control system for a truntable ladder mounted on a vehicle substantially as described herein with reference to the accompanying drawings.

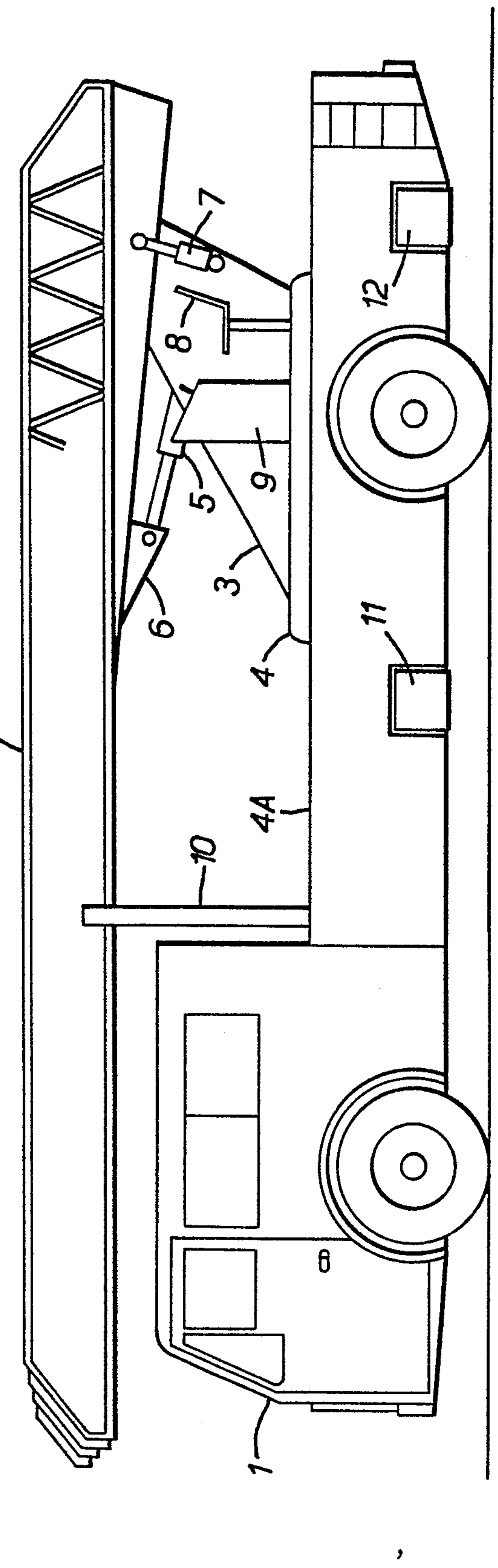
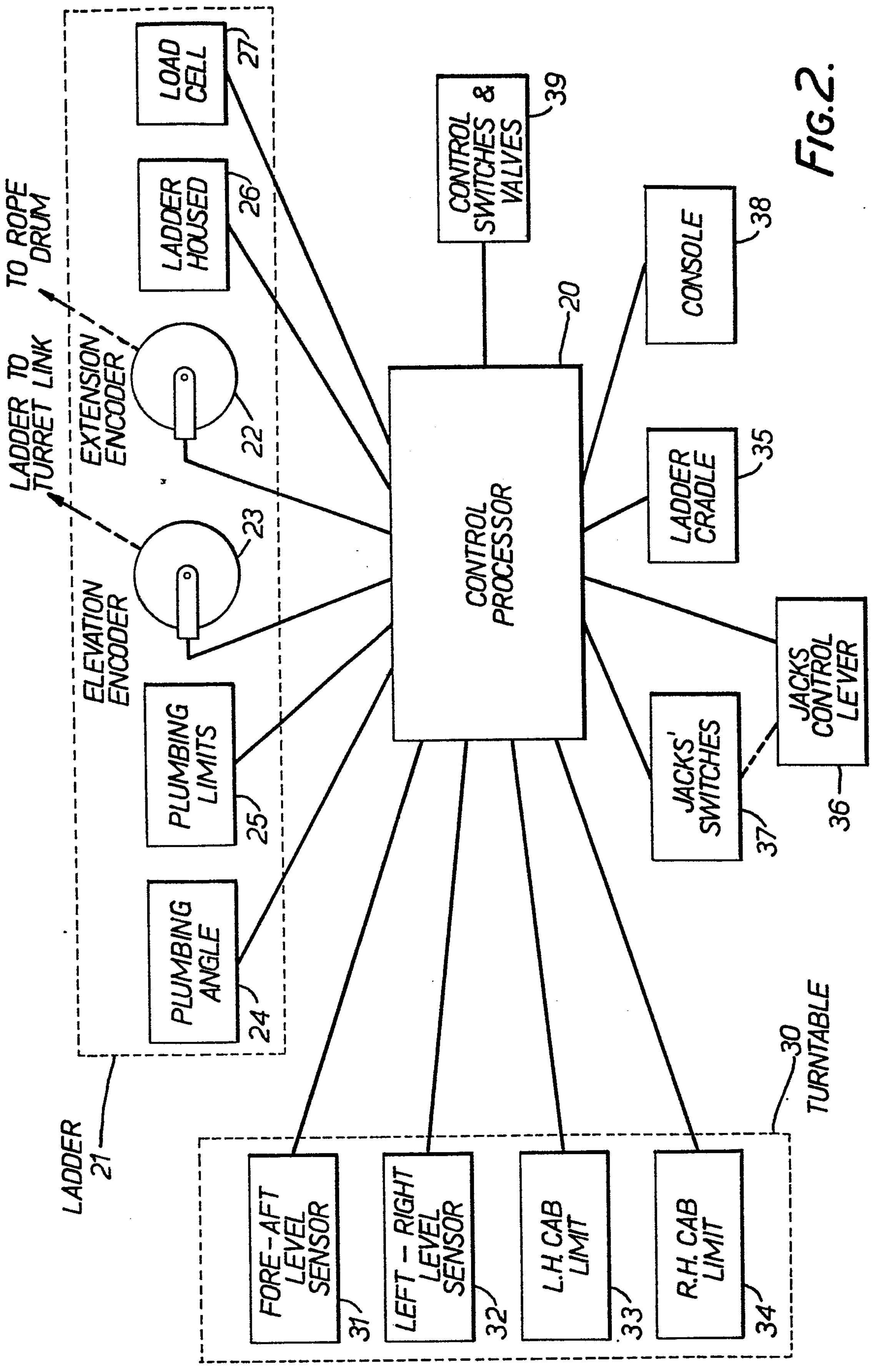


FIG. 1.



LADDER 21
LOAD CELL 27
LADDER HOUSED 26
TO ROPE DRUM
LADDER TO TURRET LINK
EXTENSION ENCODER 22
ELEVATION ENCODER 23
PLUMBING LIMITS 25
PLUMBING ANGLE 24
CONTROL SWITCHES & VALVES 39
CONSOLE 38
20
CONTROL PROCESSOR
LADDER CRADLE 35
JACKS CONTROL LEVER 36
JACKS' SWITCHES 37
30 TURNTABLE
FORE-AFT LEVEL SENSOR 31
LEFT-RIGHT LEVEL SENSOR 32
L.H. CAB LIMIT 33
R.H. CAB LIMIT 34

FIG. 2.

3/6

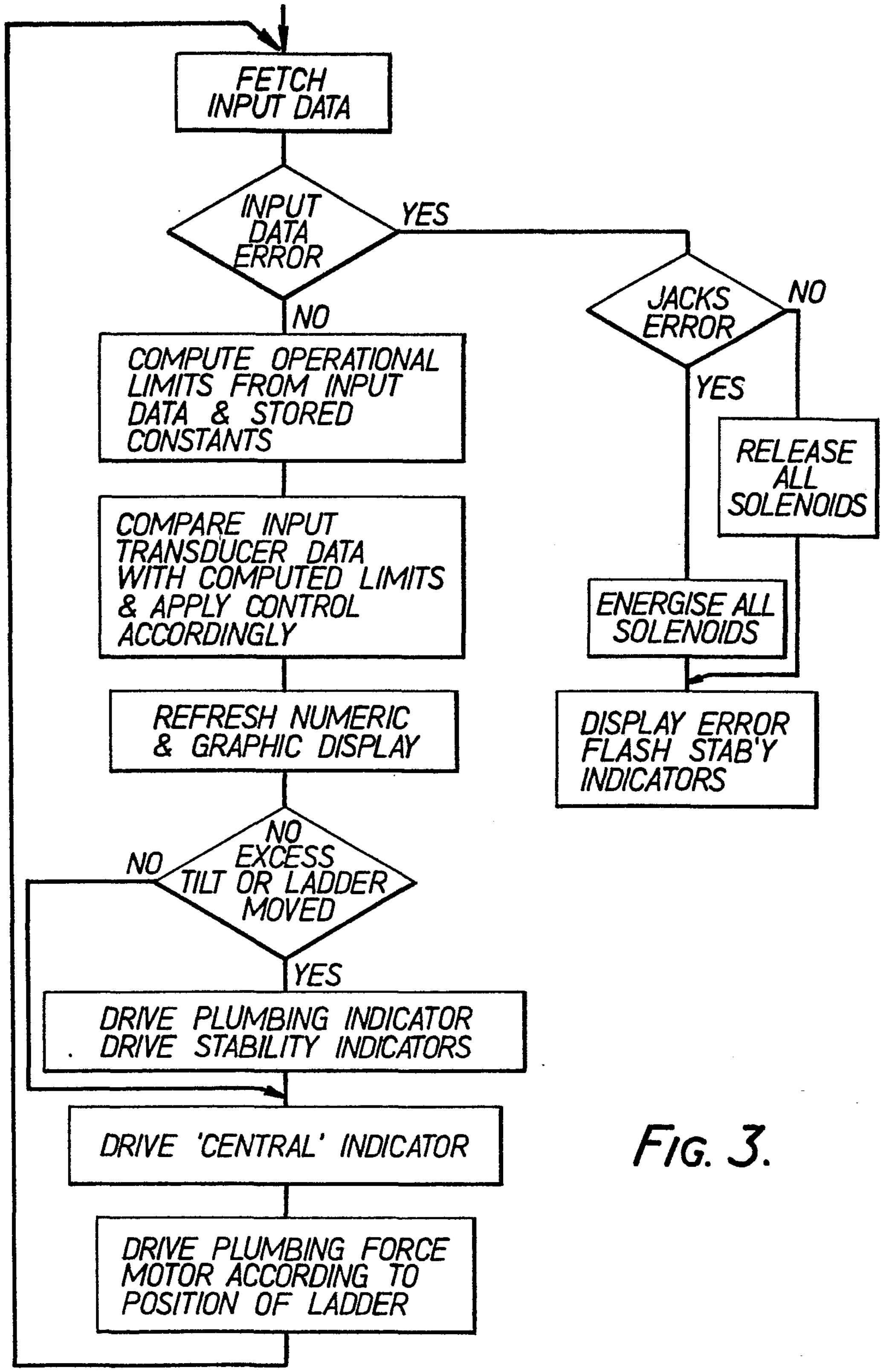

FETCH INPUT DATA
INPUT DATA ERROR
YES
NO
JACKS ERROR
NO
YES
COMPUTE OPERATIONAL LIMITS FROM INPUT DATA & STORED CONSTANTS
RELEASE ALL SOLENOIDS
COMPARE INPUT TRANSDUCER DATA WITH COMPUTED LIMITS & APPLY CONTROL ACCORDINGLY
ENERGISE ALL SOLENOIDS
REFRESH NUMERIC & GRAPHIC DISPLAY
DISPLAY ERROR FLASH STAB'Y INDICATORS
NO EXCESS TILT OR LADDER MOVED
NO
YES
DRIVE PLUMBING INDICATOR DRIVE STABILITY INDICATORS
DRIVE 'CENTRAL' INDICATOR
DRIVE PLUMBING FORCE MOTOR ACCORDING TO POSITION OF LADDER

FIG. 3.

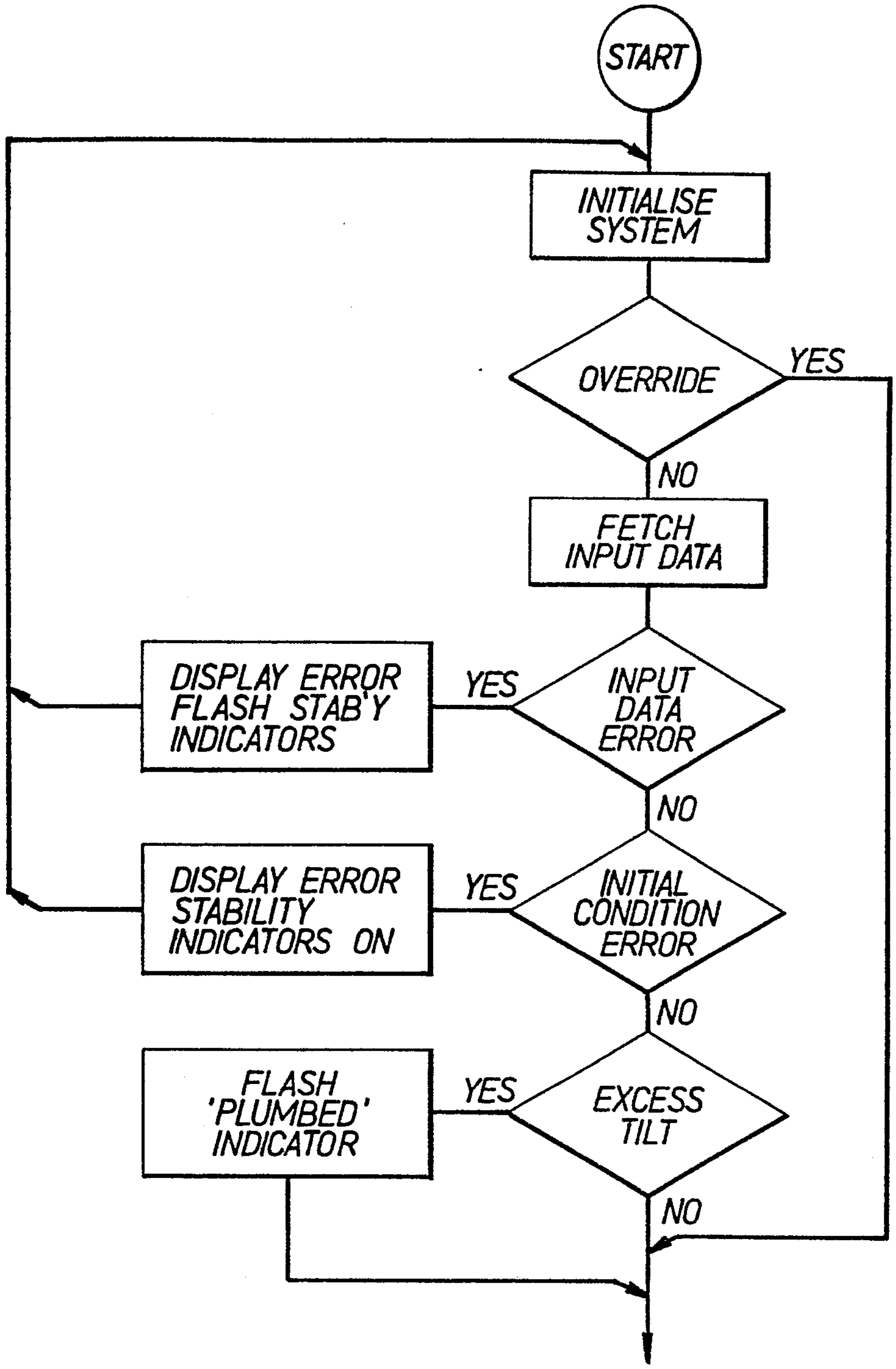

START
INITIALISE SYSTEM
OVERRIDE
YES
NO
FETCH INPUT DATA
INPUT DATA ERROR
YES
DISPLAY ERROR FLASH STAB'Y INDICATORS
NO
INITIAL CONDITION ERROR
YES
DISPLAY ERROR STABILITY INDICATORS ON
NO
EXCESS TILT
YES
FLASH 'PLUMBED' INDICATOR
NO

FIG. 4.

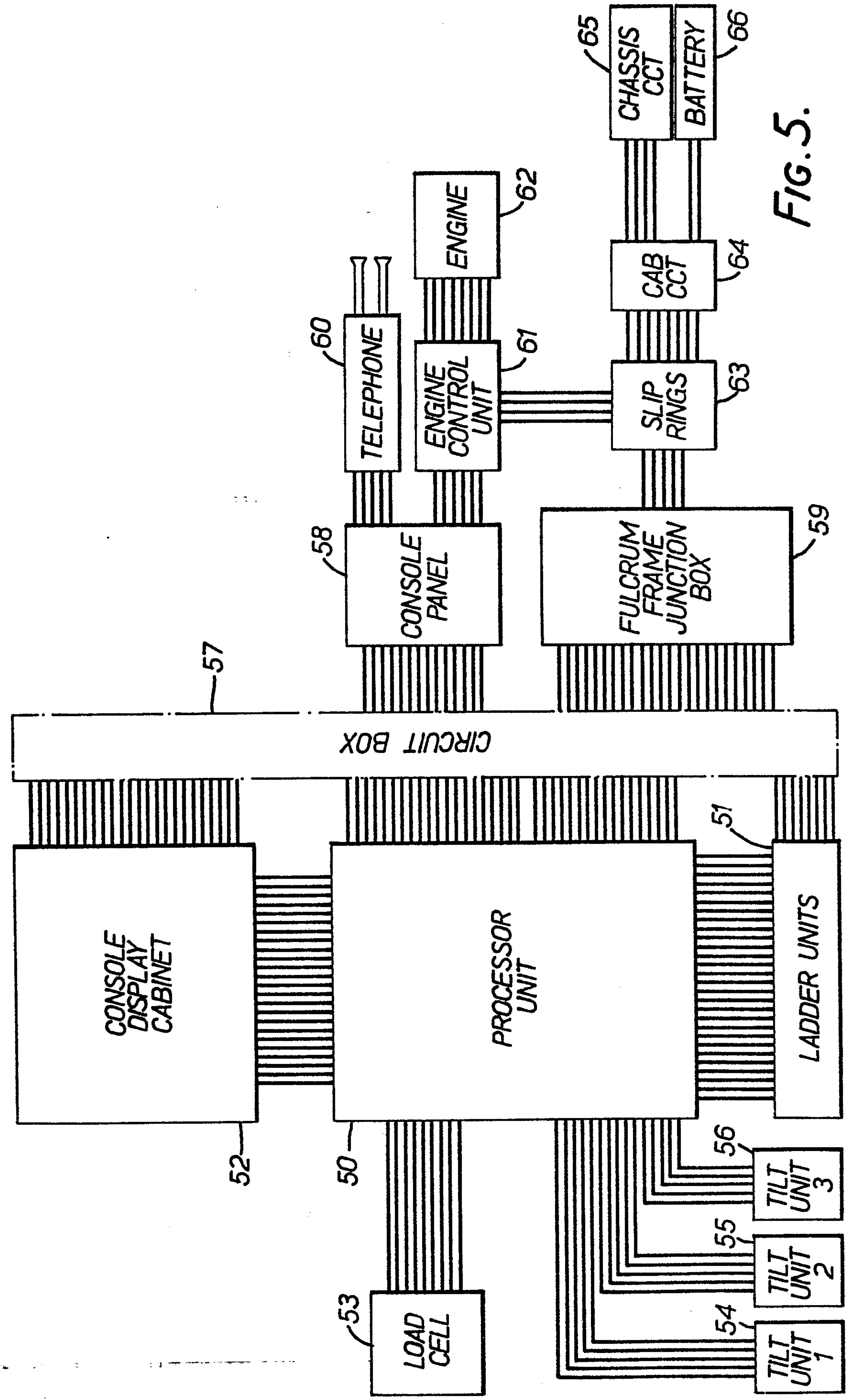

CHASSIS CCT
BATTERY
65
66
ENGINE
62
TELEPHONE
60
ENGINE CONTROL UNIT
61
CAB CCT
64
SLIP RINGS
63
CONSOLE PANEL
58
FULCRUM FRAME JUNCTION BOX
59
57
CIRCUIT BOX
CONSOLE DISPLAY CABINET
PROCESSOR UNIT
LADDER UNITS
51
52
50
TILT UNIT 3
56
TILT UNIT 2
55
TILT UNIT 1
54
LOAD CELL
53

FIG. 5.

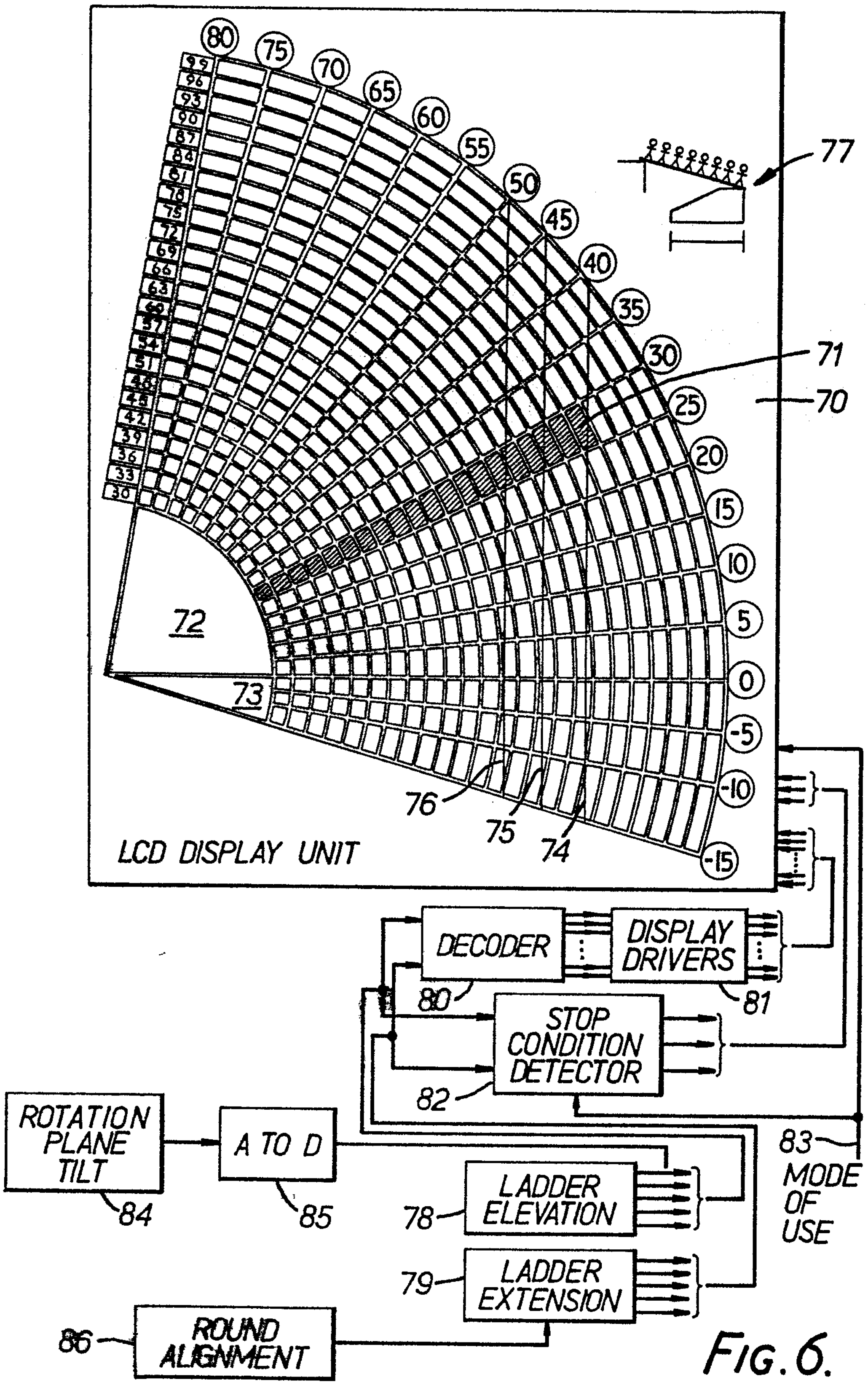

80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
-5
-10
-15
99
96
93
90
87
84
81
78
75
72
69
66
63
60
57
54
51
48
45
42
39
36
33
30
77
71
70
72
73
76
75
74
LCD DISPLAY UNIT
DECODER
80
DISPLAY DRIVERS
81
STOP CONDITION DETECTOR
82
ROTATION PLANE TILT
84
A TO D
85
83
MODE OF USE
LADDER ELEVATION
78
LADDER EXTENSION
79
86
ROUND ALIGNMENT

FIG. 6.