

SPECIFICATION

An automatic emergency levelling device for a lift

The present invention relates to an automatic emergency levelling device for a lift. When used in this specification the term "lift" will be understood to refer not only to passenger lifts but also to goods lifts or hoists. Emergency levelling is required when, due for example to a power failure the lift comes to rest between two adjacent horizontal levels at which it stops in normal use (the floors of a multi-storey building in the case of a passenger lift). The levelling device then operates to displace the lift to one or other of these levels or floors.

In particular the present invention relates to an automatic emergency levelling device for a cable lift controlled by a winch driven by a three phase electric motor normally supplied from a three phase mains supply. A known emergency lift levelling device for such a lift includes a commutation circuit which is automatically activated, if the lift-car comes to rest in a position intermediate between two normal stopping levels, to switch on an auxiliary electric drive motor which is fed by means of an accumulator battery and which operates to drive the winch of the lift to carry the lift-car to one of the said two normal stopping levels. An emergency levelling device of this general type is described in German patent No. 1506404. This known device, however, has a notable constructional complexity, is of large size partly due to the need for a separate auxiliary motor for emergency use, and requires a considerable extra labour for its installation. The auxiliary motor is required, however, because the emergency power supply is of direct current type whereas the normal drive motor requires a three phase alternating supply. The present invention seeks to provide an automatic emergency levelling device which does not require the use of an auxiliary electric motor for driving the lift winch in an emergency.

According to the present invention, there is provided an automatic emergency levelling device for a cable-operated lift worked by a winch driven by a three phase main drive electric motor normally fed from a three phase A.C. mains supply, comprising a commutation circuit which is automatically activated if the main power supply fails while lift-car is between two possible stopping levels, the said commutation circuit operating, when activated, to bring into operation first electric converter means fed from an electric accumulator battery and operable to supply the main drive motor with a three phase A.C. supply to drive it, and second electric converter means operable to convert the direct current fed from the accumulator battery into a single phase alternating supply for feeding to winch brake control circuit, means for automatically reversing the direction of rotation of the three phase electric motor after an initial rotation in a first direction, and electronic comparator means which

determine the direction of rotation of the three phase electric motor which requires the smallest force and which cause the motor to run in this direction to displace the lift car to one of the said two levels.

The levelling device according to the present invention has the advantage over known devices of this general type of a greater simplicity of construction, a greater economy, a smaller size and a greater reliability, which can be obtained by the extensive use of electronic components.

One embodiment of the present invention will now be more particularly described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a schematic circuit diagram, partly in block diagram form, of an embodiment of the invention;

Figure 2 is a schematic diagram of the electronic circuit of the embodiment shown in Figure 1;

Figure 3 is a table of binary logic states presented at the output of a first component of the circuit of Figure 2,

Figure 4 is a waveform diagram showing the waveforms at the outputs of certain of the components of the circuit of Figure 2, helpful in explaining the operation of the circuit, and

Figure 5 is a table of binary logic states presented at the output of a second component of the circuit of Figure 2.

Referring now to the drawings, in Figure 1 there is shown a lift control mechanism including an asynchronous three phase electric motor 1 for driving the winch (not shown) of the lift, and a power supply device 2 to be connected to the mains electricity distribution network for providing a three phase A.C. supply for feeding to the motor 1 and a single phase A.C. supply for feeding the other devices of the lift control mechanism.

An emergency power supply device is shown within the broken outline 3. This provides, in the event of an emergency involving a loss of mains power, a three phase A.C. output to the motor 1 and a single phase A.C. output to the other devices of the lift control mechanism.

Within the broken outline 4 is shown a commutation circuit which operates to detect failure of the mains supply and activate the emergency power supply 3. This latter includes an accumulator battery 5 the negative terminal of which is earthed. Across the terminals of the battery 5 is connected the output of a battery charger 6 of known type. The battery charger 6 is fed in normal operating conditions with single phase A.C. by the main power supply device 2 whereby to maintain the battery 5 fully charged at all times so that it is always available in the event of an emergency situation when it will be required.

The emergency power supply device 3 also includes an electronic circuit 7 for transforming, in the event of an emergency, the direct current fed to its inputs 8, 9 by the battery 5, into a three phase A.C. supply, for feeding to the asynchronous three phase main electric drive motor 1 which

serves, in accordance with the invention, also as an emergency motor, and a single phase A.C. supply for feeding to the other devices of the lift control mechanism as will be more fully described below. The three phase A.C. supply appears across a first set of three output terminals 10a, 10b and 10c of the electronic circuit 7, and the single phase A.C. supply appears across a second set of two output terminals 11a and 11b.

The asynchronous motor 1 of course requires, for normal operation, a three phase supply at a much higher voltage than that obtainable from an accumulator battery. However, the electronic circuit 7 generates a three phase A.C. at a very low frequency in such a way that the impedance of the motor (which is proportional to the frequency of the supply) becomes very low and allows the generation of a magnetic flux sufficient for developing a torque capable of moving the lift even though the voltage of the three phase A.C. emergency supply is very low.

The commutation circuit 4 includes a relay having a relay coil 12 and three pairs of contacts 12a, 12b and 12c. The coil 12 is connected in series with a diode 13 across a single phase output of the power supply device 2 by two conductors 14, 15. The coil 12 is therefore excited at all times whilst the normal single phase A.C. supply is present, and in such conditions maintains two contacts 12a, 12b in the positions indicated in solid outline in Figure 1 and identified by the reference I. In this position the contacts 12a, 12b feed a brake control circuit 16 of the winch (not shown) of the lift with the single phase A.C. supply provided by the main power supply device 2. In the event of an emergency involving loss of the voltage provided by the main power supply 2 whilst the lift is in motion between two levels, the relay coil 12 is de-energised and the contacts 12a, 12b thus commute from the position I to the position indicated in broken outline and identified with the reference II in Figure 1.

The commutation device 4 also includes a second relay having a relay coil 17 connected across the battery 5 by conductors having one of the contact pairs 12c of the first relay, and a switch 18, in series therein. The switch 18 is controlled by the lift-car; it opens and remains open when the lift-car (not shown) is located at a stopping level, and closes when the lift is in movement between two levels. This switch 18 may be constituted, for example, by a magnetic switch mounted on the lift-car and operated by the effect of the proximity of metal plates (not shown) fixed in appropriate positions to define each stopping level of the lift. The relay contact 12c, as described above, is normally open and closes upon de-energisation of the coil 12. Thus the relay coil 17 is only energised in an emergency situation when the main power fails while the lift is between two stopping levels. When energised this relay coil causes the closure of a pair of normally open relay contacts 17a, 17b. In parallel with the second relay coil 17

is a third relay coil 19 which is energised upon closure of the relay contacts 17a, 17b. This third relay coil 19 controls two relay operated three pole switches 19a, 19b and three normally open relay contacts 19c, 19d and 19e. Upon the occurrence of an emergency situation as defined above the relay coil 19 is energised and the three pole relay operated switch 19a, which is normally closed, becomes open, whilst the three pole relay operated switch 19b, which is normally open, becomes closed. Likewise the normally open contacts 19c, 19d, 19e also become closed. Closure of the contact 19e causes the connection of the electronic circuit 7 to the battery 5; consequently the three pole switch 19b, which is now closed, completes the circuit from the three phase output 10a, 10b, 10c of the electronic circuit 7 to the main drive motor 1. At the same time the single phase outputs 11a, 11b of the electronic circuit 7 are connected through the now closed contacts 19c, 19d and the relay contacts 12a, 12b which have been commuted to the position II, to the brake control circuit 16 of the winch.

Referring now to Figure 2, the electronic circuit 7 includes a fixed frequency pulse generator 20, constituted, for example by an astable multivibrator, for providing control pulses to the input of a binary signal generator 21 having six outputs respectively indicated 22, 22a, 23, 23a, 24, 24a. The outputs 22a, 23a, 24a are complementary to the outputs 22, 23, 24 respectively in the sense that whenever at one of the outputs 22, 23, 24 there is present a '1' signal, at the corresponding output 22a, 23a, 24a, there is present an '0' signal and vice versa. The binary signal generator 21 is programmed to emit cyclically at its outputs successive predetermined combinations of binary logic states; one example of such combinations is illustrated in the table of Figure 3. These logic states simulate, in digital form, the values which at certain times in the cycle are assumed by the three phases of a three phase A.C. supply. Each new combination of binary logic states is generated when the binary signal generator 21 receives a new control pulse from the pulse generator 20.

In Figure 4, there are shown four wave-forms A, B, C, D. The curve A represents, as a function of time t, a series of seven successive control pulses emitted by the pulse generator 20. The curves B, C and D represent the waveforms correspondingly provided from the outputs 22, 23, 24 of the binary signal generator 21, as a function of the angle ωt , where ω is the instantaneous phase angle of the waveforms B, C and D, and t is time. The waveforms B, C and D are thus graphic representations of the binary states shown in the columns of the table of Figure 3 relating to the outputs 22, 23 and 24.

The successive combinations generated by the binary signal generator 21 are such that the sequence of the states appearing successively at each of the output pairs 22, 22a and 23, 23a and 24, 24a constitutes a periodic square waveform

the frequency of which is dependent on the frequency of the pulses from the pulse generator 20. The waveform appearing at the outputs 22, 23, 24 (and correspondingly at outputs 22a, 23a, 24a) are phase displaced from one another by 120° (as illustrated in Figure 4) and thus represent a three phase electrical supply.

The binary signal generator 21 can be made in any known way, using integrated logic circuits, for example shift registers controlled by the pulse generator 20, or else can be made by using programmable read only memories (PROM) and an associated addressing circuit, again controlled by the pulse generator 20.

The outputs 22, 22a, 23, 23a, 24, 24a of the binary signal generator 21 are connected via a decoupler device 47 which will be described in greater detail below to the inputs of three pairs of digital power amplifiers indicated with the numerals 25 to 30 and connected together with their outputs in pairs as indicated in Figure 2. The outputs of the amplifiers 25 and 26 are connected together at a junction point 31 and feed the output terminal 10c of the electronic circuit 7. Likewise the pairs of amplifiers 27, 28 and the pair of amplifiers 29, 30, have their outputs connected together at junction points 32 and 33 respectively and feed the output terminals 10b, 10a respectively of the electronic circuit 7. Each of the amplifiers 25 to 30 is saturated when a signal at logic level '1' is fed to its input and is non-conductive (turned off) when the signal at its input is at logic level '0'. Thus, in the event of an emergency as defined above, there appears at the outputs 31, 32, 33, a three phase A.C. supply each phase of which reaches a maximum value substantially equal to the voltage of the battery 5. The frequency of this supply is dependent on the frequency of the pulse generator 20.

Between the digital amplifiers 26, 28 and 30 and earth there is connected a current sensitive circuit which detects the current flowing in the digital power amplifiers 25 to 30, when these are operating in the event of an emergency, and provides at its output a voltage signal proportional to this current. The current sensing circuit 34 forms part of an overload protection device which will be discussed in more detail below.

The electronic circuit 7 also includes means for generating a single phase A.C. output from the D.C. supply from the battery 5. For this a fixed frequency pulse generator 35, constituted for example by an astable multivibrator, is provided for the purpose of supplying a control pulse to the input of a binary signal generator 36 having two outputs 37 and 37a respectively. The output 37a is complementary to the output 37. The binary signal generator 36 is programmed to generate cyclically at each output 37, 37a, digital signals in succession such as to constitute a periodic square waveform at a frequency dependent on the output frequency of the pulse generator 35. The outputs 37, 37a are connected to the inputs of two digital power amplifiers 38, 39. Each of the digital amplifiers 38, 39 is saturated when the signal at

its input is at logic level '1' and is non-conducting when the signal at its input is at logic level '0'. A step-up transformer generally indicated 40 has a primary winding 40a connected to the outputs of the amplifiers 38, 39; the secondary winding 40b of this transformer is connected to the output terminals 11a and 11b of the electronic circuit 7. A central tapping 40c of the primary winding 40a is connected to the battery 5 through the terminal 9 of the electronic circuit 7 for supplying the digital amplifiers 38, 39. In operation, in the event of an emergency as defined above, across the terminals of the secondary winding 40b of the transformer 40 there appears a single phase A.C. supply having a maximum value substantially equal to the voltage of the battery 5 and a frequency dependent on the frequency of the pulse generator 35.

Another current sensitive circuit 41 is connected between the digital amplifiers 38, 39 and earth, for detecting the current flowing in the amplifiers 38, 39, when operating, and for providing at its output a voltage signal proportional to the said current. The function of this current sensitive circuit 41, which forms part of a current overload protection device, for the amplifiers 38, 39 will be further discussed below.

Overload protection of the amplifiers 25 to 30 is provided by a circuit 42 which has an input connected to the output of the current sensitive circuit 34. This overload protection circuit 42 includes a comparator 43 for comparing the voltage signal fed to it from the current sensitive circuit 34 with a reference voltage derived from the voltage of the battery 5 by means of a potentiometer 44. The comparator 43 is connected to a one-shot circuit 45, constituted, for example, by a monostable multivibrator, the output of which is connected to the control input 46 of the decoupling circuit 47 through an OR gate 48. The decoupling circuit 47, the input terminals of which are indicated with the reference numerals 47a, 47b, 47c, 47d, 47e, 47f, 47g and 47h, is interposed, as described above, between the outputs 22, 22a, 23, 23a, 24, 24a of the binary signal generator 21 and the inputs of the amplifiers 25 to 30, and also between the outputs 37, 37a of the binary signal generator 36 and the inputs of the amplifiers 38 and 39.

If, for any reason during operation, the current in the amplifiers 25 to 30 exceeds a maximum allowable value the voltage signal from the measuring circuit 34 will exceed the reference voltage which is set to define this maximum allowable value; consequently the threshold comparator 43 activates the one-shot circuit 45 the output pulse from which, passing through the OR gate 48, arrives at the input of the decoupling circuit 47 and controls it to decouple the binary signal generators 21 and 36 from their respective amplifiers 25 to 30 and 38, 39 for the whole of the duration of the output pulse from the one-shot circuit 45, thus avoiding any damage to the amplifiers 25 to 30. At the end of the output pulse from the one-shot circuit 45, if the voltage signal

from the current sensitive circuit 34 still exceeds the reference voltage the operation of the protection circuit 42 is repeated, the one-shot circuit 45 producing a second output pulse; if on the other hand the voltage signal from the current sensitive circuit is below the reference voltage the decoupling circuit 47 allows the connection between the binary signal generators 21, 36 and the amplifiers associated therewith to be remade, thus resuming normal operation of the electronic circuit 7.

Also connected to an input of the OR gate 48, and through this to the input of the decoupling circuit 47, is a second overload protection circuit 49 operable to prevent current overloads in the amplifiers 38, 39. The second overload protection circuit 49 comprises a comparator 50 for comparing the voltage signal from the output of the current sensitive circuit 41 with a reference voltage derived from the voltage of the battery 5 by means of a potentiometer 51. The comparator 50 is connected to a one-shot circuit 52 for the control of the decoupling circuit, in the event of an overload being detected in the amplifiers 38, 39, in the same way as described in relation to the overload protection circuit 42.

There is also provided a control circuit 53 for preventing an increase in the speed of rotation of the lift winch if, during the movement of the lift-car, the motor is not sufficiently self braking. The control circuit 53 has an input connected to the output of the current sensitive circuit 34, and its output is connected to the decoupling circuit 47 via the OR gate 48. The said control circuit 53 comprises a comparator 54 for comparing the voltage signal from the current measuring circuit 34 with a reference voltage derived from the voltage of the battery 5 by means of a potentiometer 55. The output of the comparator 54 is connected to the input of a one-shot circuit 56 via a delay circuit 57. The output of the one-shot circuit 56 is connected back to the input of the delay circuit 57 and also constitutes the output of the control circuit 53 which is connected to the decoupling circuit 47 via the OR gate 48 as mentioned above. As is known, in the event of the lift winch motor not being sufficiently self braked, the difference between the weight of the lift-car and the counter weight, which normally constitutes the torsional resistance, becomes the driving torque and the velocity of the lift-car tends to increase dangerously. In such conditions the current consumed by the electric motor 1 becomes extremely small, as does the current in the amplifiers 25 to 30 through which the electric motor 1 is fed in emergency conditions.

However, when the voltage signal from the current sensitive circuit 34 falls below the reference value, the comparator 54 produces a control signal which is fed, through the delay circuit 56, to the one-shot circuit 56 to activate the decoupling circuit 47. In this way the connection between the binary signal generators 21, 36 and their associated amplifiers 25 to 30 and 38, 39 is interrupted and the electronic circuit

7 no longer feeds any voltage to the control circuit 16 of the lift winch brakes, which latter are therefore applied to stop the winch and lock it in position. The delay circuit 57 serves to prevent the operation of the one-shot circuit 56 when the electric motor 1 is just starting since, as the current in the motor builds up from zero it is, for a time, below the threshold value at which the control circuit 53 operates.

The circuit enclosed within the broken line 58 in Figure 2 is a comparator circuit for determining, in the event of an emergency, the direction of displacement of the lift-car which requires the application by the electric motor 1 of the smallest force in order to carry the lift-car to one of the two stopping levels between which it has come to rest. As is known, the current absorbed by an electric motor is proportional to the torsional load applied to it. Therefore, the voltage signal at the output of the current sensitive circuit 34 is proportional to the torsional load applied to the electric motor 1.

The input of the comparator circuit 58 is connected to the output of the current sensitive circuit 34; the output of the comparator circuit 58 is connected to a changeover switch device 59 interconnecting the pairs of output terminals 23, 23a and 24, 24a of the binary signal generator 21 and the corresponding pairs of input terminals 47c, 47d and 47e, 47f of the decoupler circuit 47. The changeover switch device 59 reverses the connections of the said pairs of terminals when it receives a control signal at the logic level '1' from the comparator circuit 58, and may, for example be constituted by a switching relay.

The comparator circuit 58 includes an operational amplifier 60 for comparing the charge on two capacitors 61, 62 respectively connected between a first input 60a of the operational amplifier 60 and earth, and between a second input 60b of the operational amplifier 60 and earth. The output of the operational amplifier 60 is connected to the reset input 63 of a bistable circuit of the RS type constituted by two NAND logic gates 64, 65. The output of the NAND gate 65 is connected, by means of an OR gate 66, to the changeover switch device 59. A fixed frequency pulse generator 67, constituted for example by a monostable multivibrator, is provided for generating control pulses to be fed to the input 68 of a programme circuit 69 having four outputs 69a, 69b, 69c, and 69d. The output 69a is connected, via the OR gate 66, to the changeover switch device 59 for controlling it to commute from one position to the other when the said output 69a has a value at the logic level '1'. The output 69b is connected to the set input 70 of the bistable circuit constituted by the NAND gates 64 and 65. The output 69c is connected to the input of a controlled switching device 71 controlled by the programme circuit 69 for routing the voltage signal coming from the current sensitive circuit 34 from the input 60a to the input 60b of the operational amplifier 60 and vice versa. Finally, the output 69d is connected to the cathode of a diode 72 the anode of which is

connected to the input 68 of the said programme circuit 69. The programme circuit 69 is formed in a manner analogous to the binary signal generator 21.

5 In operation the pulse generator 67 feeds control pulses at a fixed frequency to the programme circuit 69. Each control pulse causes the programme circuit 69 to generate at the outputs 69a, 69b, 69c and 69d binary logic
10 signals in combinations previously memorised in the programme circuit 69. An example of these combinations is illustrated in the table shown in Figure 5. With reference to Figures 2 and 5 the first control pulse starts the first stage, sensing the
15 current consumed by the electric motor 1 when turning in a first direction of rotation which it adopts upon starting up in emergency situations. In this first stage the output 69a of the programme circuit is at the logic level '0' so that the changeover switch device 59 is not activated. The output 69b is at the logic level '1' and maintains the output of the bistable circuit constituted by the NAND gates 64, 65 at the logic level '0'.

25 Contemporaneously the output 69c is at the logic level '0' to maintain closed the controlled switching device 71 at the input of the operational amplifier 60, and the output 69d is at the logic level '1' such that the diode 72 does not conduct upon the occurrence of successive control pulses from the pulse generator 67 which thus pass
30 directly to the programme circuit 69. In this first stage of operation, defined by these logic levels at the outputs of the programme circuit 69, the capacitor 62 is charged to a voltage proportional to the current consumed by the electric motor 1 in the direction of rotation in which it is initially driven to turn, this being proportional to the torsional load which it must overcome when
40 turning in this direction of rotation.

A second control pulse is then produced by the pulse generator 67 and this causes the commencement of the second stage of operation in which the current consumed by the electric
45 motor 1 when turning in the opposite direction of rotation from the initial direction is determined. In this stage the output 69a of the programme circuit 69 changes to the logic level '1' activating the changeover switch device 59 which reverses the connections between the outputs 23, 23a, 24, 24a of the binary signal generator 21 and the inputs 47c, 47d, 47g and 47f of the decoupler circuit 47 in the manner previously indicated, thereby causing an inversion between two of the
50 three phases of the electric current fed to the electric motor 1. Consequently the sense of rotation of the electric motor 1 is reversed. At the same time the output 69b remains at the logic level '1' and therefore the output of the NAND gate 65 remains at the logic level '0'. The output 69c changes to the logic level '1' causing the commutation of the controlled switching device 71 which therefore now supplies the signal from the current sensitive circuit 34 to the input 60a of the operational amplifier 60, thereby charging the
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capacitor 61 to a voltage proportional to the current consumed by the electric motor 1 in the new direction of rotation. This current is proportional to the torsional load which the electric motor must overcome in the new direction of rotation. The output 69d, in this stage of operation is again at the logic level '1' so that the diode 72 remains non conductive upon the occurrence of subsequent control pulse from the pulse generator 67 which are thus still passed to the programme circuit 69.

70 The third pulse emitted by the pulse generator 67 initiates the comparison stage. In this third stage the outputs 69a and 69b of the programme circuit 69 change to the logic level '0'; the output 69c changes to the logic level '1' and the output 69d changes to the logic level '0'. The operational amplifier 60 compares the charges on the two capacitors 61, 62 and if the charge on the capacitor 61 is greater than that on the capacitor 62, the output of the operational amplifier rises to the logic level '1' causing the commutation of the bistable circuit constituted by the NAND gates 64, 65 and the consequent de-activation of the
85 changeover switch device 59 for reestablishing the initial cyclic order of the phases of the electrical supply so that the electric motor 1 again reverses its direction of rotation, returning to the original direction.

90 If, however the charge on the capacitor 61 is lower than that on the capacitor 62, the operational amplifier 60 produces an output signal at the logic level '0'. Therefore the sense of rotation of the electric motor 1 remains unchanged. In this third stage of operation, since the output 69d is at the logic level '0' the diode 72 now conducts upon the occurrence of further pulses from the pulse generator 67 so that these pulses do not reach the programme circuit 69.

105 The total operation of the emergency levelling device of the present invention is thus as follows. As soon as an emergency situation occurs, that is when the normal current from the main power supply 62 fails whilst the lift-car is in progress between two stopping levels, the relay coil 12 becomes de-energised and the relay contacts 12a, 12b commutate to the position II shown in Figure 2, whilst the contacts 12c close. The relay coil 17 is therefore energised by the direct current from the battery 5 arriving through the closed contacts 18 and 12c, causing the closure of the contacts 17a and 17b. Consequently the relay coil 19 is energised, and this causes the opening of the three pole relay operated switch 19a and the closure of the three pole relay operated switch 19b (as well as the closure of the contacts 19c, 19d, and 19e. The electronic circuit 7 is now supplied with power from the battery 5 and generates at its outputs 10a, 10b, 10c a three
115 phase A.C. supply which is fed to the electric motor 1 through the, now closed, three pole relay operated switch 19b. The circuit 7 also generates a single phase A.C. supply which is fed to the brake control circuit 16 of the lift winch through the contacts 19c, 19d, 12a, 12b all of which are
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closed as described above.

The comparator 58 measures the torsional load applied to the electric motor 1 in the initial direction of rotation of the motor 1, and then

- 5 reverses the direction of rotation and measures the new torsional load applied to the motor 1. The direction of rotation of the electric motor 1 which requires the smallest force is then selected in order to move the lift-car to a stopping level.
- 10 When the lift-car reaches a stopping level the contact 18 opens causing de-energisation of the relay coil 17 and the consequent opening of the contacts 17a, 17b. Therefore, the coil 19 is also de-energised and this opens the three pole relay
- 15 operated switch 19b and the contacts 19c, 19d, 19e and, moreover, closes the three pole relay operated switch 19a. The control circuit 16 of the winch brakes is therefore no longer supplied with current and the brakes lock the winch so that the
- 20 lift-car stops securely and stably at the level attained.

If, during the course of emergency operation, there should occur a current overload in the

25 amplifiers 25 to 30 or 38 and 39 of the electronic circuit 7, the protection circuits 42 and 49 operate in the manner described in detail above. Likewise, if during emergency operation the winch should not be sufficiently self braking, the control circuit 53 operates in the manner described in

30 detail above to disconnect the power supply and apply the winch brakes. When the lift has slowed sufficiently the power supply is reconnected and automatic emergency levelling continues.

CLAIMS

- 35 1. An automatic emergency levelling device for a cable-operated lift worked by a winch driven by a three phase main drive electric motor normally fed from a three phase A.C. mains supply, comprising a commutation circuit which is
- 40 automatically activated if the main power supply fails while lift-car is between two possible stopping levels, the said commutation circuit operating, when activated, to bring into operation first electric converter means fed from an electric
- 45 accumulator battery and operable to supply the main drive motor with a three phase A.C. supply to drive it, and second electric converter means operable to convert the direct current fed from the accumulator battery into a single phase
- 50 alternating supply for feeding to a winch brake control circuit, means for automatically reversing the direction of rotation of the three phase electric motor after an initial rotation in a first direction, and electronic comparator means which
- 55 determine the direction of rotation of the three phase electric motor which requires the smallest force and which caused the motor to run in this direction to displace the lift car to one of the said two levels.

- 60 2. A device as claimed in Claim 1, in which the first converter means comprises a pulse generator for providing control pulses at a predetermined frequency to a binary signal generator having three pairs of complementary outputs, the said

- 65 binary signal generator being operable cyclically to generate successive predetermined combinations of binary logic states at the three pairs of outputs to represent three periodic square waveforms the frequencies of which depend on the frequency of the pulse generator, the three square waveforms produced at the three pairs of outputs being mutually phase displaced by 120° , and three pairs of amplifiers for amplifying the signals generated by the said binary signal generator, each pair of
- 70 amplifiers having a common output which is connected to supply a respective phase of the main drive electric motor of the lift.

3. A device as claimed in Claim 2, further including an overload protection circuit for
- 80 protecting the said amplifiers against current overloads, the said overload protection circuit being operable to activate interruptor means for interrupting the power supply to the electric motor when the current in the said amplifiers exceeds a threshold value, and to deactivate the said
- 85 interruptor means when the said current has fallen below the said threshold.

4. A device as claimed in any of Claims 1 to 3, in which the second converter means include a
- 90 pulse generator for providing control pulses at a predetermined frequency to the input of a second binary signal generator having two complementary outputs; the said second binary signal generator being operable to produce at the
- 95 outputs thereof successive predetermined combinations of digital signals to represent a single phase alternating power supply, which signals are fed to two power amplifiers which operate to amplify them to provide at their outputs a single phase A.C. supply.

5. A device as claimed in Claim 4, in which there is further provided a current overload protection circuit for the said amplifiers.

6. A device as claimed in any of Claims 1 to 5, in which the said electronic comparator means for determining the direction of rotation of the main drive motor which requires the least force operates to determine the current consumed by the motor when it is driven first in one direction of rotation and then in the other, the said comparator
- 110 means providing at its output a control signal when the current consumed in the said one direction of rotation is less than the current consumed in the said other direction of rotation, which control signal causes the commutation of a bistable circuit and consequent activation of the said means for reversing the direction of rotation of the motor; a programme device being provided for controlling the motor to run first in the said one
- 120 direction and then in the other before the comparator means operates to determine in which direction of rotation the motor consumes the least current.

7. A device as claimed in any preceding Claim, further including electronic control means for preventing an increase in the speed of rotation of the said winch when it is not sufficiently self braking.

8. A device as claimed in Claim 7, in which the



closed as described above.

- The comparator 58 measures the torsional load applied to the electric motor 1 in the initial direction of rotation of the motor 1, and then
 5 reverses the direction of rotation and measures the new torsional load applied to the motor 1. The direction of rotation of the electric motor 1 which requires the smallest force is then selected in order to move the lift-car to a stopping level.
 10 When the lift-car reaches a stopping level the contact 18 opens causing de-energisation of the relay coil 17 and the consequent opening of the contacts 17a, 17b. Therefore, the coil 19 is also de-energised and this opens the three pole relay operated switch 19b and the contacts 19c, 19d,
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 20 lift-car stops securely and stably at the level attained.

- If, during the course of emergency operation, there should occur a current overload in the amplifiers 25 to 30 or 38 and 39 of the electronic
 25 circuit 7, the protection circuits 42 and 49 operate in the manner described in detail above. Likewise, if during emergency operation the winch should not be sufficiently self braking, the control circuit 53 operates in the manner described in
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CLAIMS

- 35 1. An automatic emergency levelling device for a cable-operated lift worked by a winch driven by a three phase main drive electric motor normally fed from a three phase A.C. mains supply, comprising a commutation circuit which is
 40 automatically activated if the main power supply fails while lift-car is between two possible stopping levels, the said commutation circuit operating, when activated, to bring into operation first electric converter means fed from an electric
 45 accumulator battery and operable to supply the main drive motor with a three phase A.C. supply to drive it, and second electric converter means operable to convert the direct current fed from the accumulator battery into a single phase
 50 alternating supply for feeding to a winch brake control circuit, means for automatically reversing the direction of rotation of the three phase electric motor after an initial rotation in a first direction, and electronic comparator means which
 55 determine the direction of rotation of the three phase electric motor which requires the smallest force and which cause the motor to run in this direction to displace the lift car to one of the said two levels.

- 60 2. A device as claimed in Claim 1, in which the first converter means comprises a pulse generator for providing control pulses at a predetermined frequency to a binary signal generator having three pairs of complementary outputs, the said

- 65 binary signal generator being operable cyclically to generate successive predetermined combinations of binary logic states at the three pairs of outputs to represent three periodic square waveforms the frequencies of which depend on the frequency of
 70 the pulse generator, the three square waveforms produced at the three pairs of outputs being mutually phase displaced by 120° , and three pairs of amplifiers for amplifying the signals generated by the said binary signal generator, each pair of
 75 amplifiers having a common output which is connected to supply a respective phase of the main drive electric motor of the lift.

3. A device as claimed in Claim 2, further including an overload protection circuit for
 80 protecting the said amplifiers against current overloads, the said overload protection circuit being operable to activate interruptor means for interrupting the power supply to the electric motor when the current in the said amplifiers exceeds a
 85 threshold value, and to deactivate the said interruptor means when the said current has fallen below the said threshold.

4. A device as claimed in any of Claims 1 to 3, in which the second converter means include a
 90 pulse generator for providing control pulses at a predetermined frequency to the input of a second binary signal generator having two complementary outputs; the said second binary signal generator being operable to produce at the
 95 outputs thereof successive predetermined combinations of digital signals to represent a single phase alternating power supply, which signals are fed to two power amplifiers which operate to amplify them to provide at their outputs
 100 a single phase A.C. supply.

5. A device as claimed in Claim 4, in which there is further provided a current overload protection circuit for the said amplifiers.

6. A device as claimed in any of Claims 1 to 5,
 105 in which the said electronic comparator means for determining the direction of rotation of the main drive motor which requires the least force operates to determine the current consumed by the motor when it is driven first in one direction of
 110 rotation and then in the other, the said comparator means providing at its output a control signal when the current consumed in the said one direction of rotation is less than the current consumed in the said other direction of rotation,
 115 which control signal causes the commutation of a bistable circuit and consequent activation of the said means for reversing the direction of rotation of the motor; a programme device being provided for controlling the motor to run first in the said one
 120 direction and then in the other before the comparator means operates to determine in which direction of rotation the motor consumes the least current.

7. A device as claimed in any preceding Claim,
 125 further including electronic control means for preventing an increase in the speed of rotation of the said winch when it is not sufficiently self braking.

8. A device as claimed in Claim 7, in which the



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electronic control means for preventing an increase in the speed of rotation of the winch comprises a circuit for generating an electrical signal representing the current in the electric drive
5 motor, connected to an input of a further comparator for comparing this signal with a reference signal representing a threshold value; the output of the said comparator activating safety means for interrupting, for a predetermined period
10 of time, the power supply to the motor when the

current in the motor is lower than the threshold value; delay means being provided for preventing the intervention of the said safety means during starting from rest of the motor when the current therein is for a certain time lower than the said
15 threshold value.

9. An automatic emergency levelling device for a cable-operated lift, substantially as herein described with reference to and as shown in the
20 accompanying drawings.