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OPERATIONAL CONTROL SYSTEM FOR LIFTAND ELEVATOR MACHINERY

The present invention refers to an operational control system for lift and elevator machinery and particularly refers to an operational control system for electrodynamic braking adapted to be connected to the machinery of existing lift or elevator equipment. The operational control system according to the invention is intended to be used in connection with a one-speed A.C. asynchronous motor of the short-circuit type forming part of a machinery provided with a simple mechanical brake.

In older lift and elevator equipment provided with machinery of the one-speed type comprising a mechanical brake, braking is performed directly from full speed by means of mechanical braking. This means that the wear of the the brake linings will be rather great in particular at braking speeds up to 0.7 m/sec. In this type of mechanical braking the levelling accuracy or stop-plane accuracy will be low, for example ± 35 mm or more. A level difference of this order of magnitude between the bottom of the lift cage and the stop plane involves problems for passengers using invalid carriages. Recently authorities and institutions have shown increasing interest for invalidity problems. In this connection the Swedish

building code requires a threshold height of at most 25mm.

In order to improve the stop-plane accuracy and to reduce wear it is possible to make use of the electrodynamic braking properties of a two-speed motor. The lift
5 is stopped by shifting over the current supply to the motor from the high-speed winding to the low-speed winding. This is performed at a certain spacing from the stop-plane. The motor feed is interrupted when the speed of the lift has reached about 0.2 m/sec. and at this speed
10 the mechanical brake takes over. If the above mentioned solution is used in order to remove the drawbacks of an exclusively mechanical braking this means that the existing one-speed motor either must be complemented by an additional fine-adjusting equipment or must be replaced by
15 a two-speed motor which cannot be considered to be economically acceptable.

It is an object of the present invention to provide an operational control system for lifts and elevators (speed 0.6-0.7 m/sec.) which are provided with mechanically
20 braked one-speed A.C. asynchronous motors, this novel system being of a simple construction and yielding high stop-plane accuracy. A further object of the invention is to use the existing brake of the lift in order additionally to increase the braking effect if the
25 available electrodynamic braking effect is too low due

to the rated output of the motor or to accidental overload.

It is a further object of the invention to bring about a retardation which is comfortable for the passengers while at the same time the wear of the mechanical brake is kept to a low level which means a reduced amount of servicing.

According to the invention, we propose an operational control system for electrodynamic braking of lifts or elevators including a one-speed A.C. asynchronous motor of the short-circuit type equipped with a mechanical brake, characterized by means for sensing the speed of the lift, a D.C. source for feeding the field windings of the A.C. asynchronous motor to produce a rectified magnetic braking flow through the rotor of the said asynchronous motor to produce electrodynamic braking, integrating means for integrating the output signal from said speed sensing means to generate a reference signal for the retardation distance, converting means having a square root extracting function to linearize the reference signal for the retardation distance, first comparator means for comparing the output signal indicating the speed with the linearized signal for the retardation distance to produce a fault signal for controlling an electric control signal for said D.C. source, and second

comparator means for comparing the fault signal with a reference level corresponding to the maximum possible electrodynamic braking to produce a signal for activating the mechanical brake of the motor.

5 By a one-speed A.C. asynchronous motor of the short-circuit type is meant an induction motor e.g. a squirrel cage motor. We therefore provide means for sensing the speed of the lift, the speed output signal from the sensing member being compared to a reference output
10 signal as derived from the same speed output signal in order to control a linear speed change in time during braking of the lift towards a stop plane, the braking comprising both electrodynamic and mechanical braking.

An embodiment of the invention will be described by
15 example and with reference to the drawings, in which:

Figure 1 is a block diagram showing the control electronics of the braking system according to a preferred embodiment of the invention;

Figure 2 is a time diagram of an idealized braking
20 process, in which Fig. 2A shows the retardation distance as a function of time during braking from 0.7 m/sec. to standstill with a retardation of 0.5 m/sec^2 ;

Figure 2B shows the output voltage from an integrator yielding an electric output signal proportional
25 to the retardation distance passed, and

Figure 2c shows in the upper half of the diagram the output voltage from the device sensing the number of revolutions and in the lower half of the diagram the output signal from the device producing the reference signal and consisting of an analogue square root extracting circuit;

Figure 3a shows the output signal from the fault signal comparator as a function of time;

Figure 3b shows the output signal from a pilot oscillator thyristor control of the braking flow in the A.C. asynchronous machine; and

Figure 3c represents shower control pulses as a function of time resulting from comparison between pilot oscillator voltage and fault output signal.

By reference to the block diagram of Figure 1 an embodiment of the braking system according to the invention will now be described. A contact S which is actuated from the keyboard in the lift cage is opened at a certain distance from the desired stop plane. The field effect transistors F_1 and F_2 operating as switches are rendered non-conductive and the output voltages of integrator 2 which is determined by resistance R_1 and R_2 starts falling from this starting output voltage value (10 Volt) according to the integrator formula.

$$e_s = - \frac{1}{RC} \int e_{\text{tacho}} dt$$

where e_{tacho} is the output voltage from a tachometer 1 connected to the drive shaft of the lift motor and RC

5 the time constant of the integrator. The output voltage of the integrator corresponds to the distance which the lift will pass during the retardation because

$$10 \quad s = \int_0^{t_r} v(t) dt$$

where s is the braking distance and t_r is the retardation time, $v(t)$ thus corresponding to $e_{\text{tacho}}(t)$. Constant

retardation is desirable and a retardation course with

15 constant retardation is shown in Figures 2a and 2c. When the retardation is constant, i.e. the braking force is constant, there is obtained an output signal from integrator e_s according to Figure 2b with respect to time.

In order to enable it to be used as a speed reference, a

20 conversion of $e_s(t)$ is performed to a linear function

$e_R(t)$ in the square root extracting circuit 3 (see

Figure 1) according to Figure 2c. The signal $e_R(t)$ is

fed via a filter $R_3C_1R_4$ to the input of a control

amplifier A_1 with the feedback circuit $R_6C_3C_4$. The out-

25 put signal from the tachometer 1 is fed via a voltage

divider P_1 into the same input via a filter $R_7C_2R_8$ and

the tachometer signal is so adjusted that its value at

the moment of braking is of the same order of magnitude

as the output signal from the root extracting circuit 3.

If $e_v = -e_r$ and the sum of the resistances R_3 and R_4 equals the sum of the resistances R_7 and R_8 , the resulting current in the operational amplifier A_1 will equal 0 and the output signal from the control amplifier A_1 is determined by R_5 and the adjustment of the potentiometer P_2 . In the braking moment E_r and E_v have the same amount. If after some m sec the tachometer signal has an amount slightly greater than the integrated speed value, a positive difference integration voltage will appear on the PI-amplifier A_1 (Proportional Integral). This causes the output voltage e_E to decrease (compare Fig. 3a) which means that an increasing number of firing pulses (compare Fig. 3c) is obtained on the control of the thyristor T_h which is series-connected to the motor winding L of the driving motor. An increase of the control pulses to the thyristor yields an increased braking current to the motor winding L and accordingly an increased retardation. An excessive retardation, on the other hand, yields a negative input signal to amplifier A_1 which causes the braking current to the motor winding L to decrease. In the above described way the retardation is kept closely constant irrespective of the load of the lift. In certain types of lift machineries, due to the load-rated output of the drive motor, the D.C. braking is not sufficient

in connection with heavier load. According to the invention, this problem is solved by means of comparing amplifier A_2 one input of which is connected to the output of the control amplifier A_1 where the other input is
5 connected to a voltage level given by a potentiometer P_4 corresponding to the maximum possible D.C. braking effect. With potentiometer P_4 the maximum D.C. braking to the motor can be adjusted from the available maximum D.C. braking (fully open thyristor) to a lower value, where the
10 thyristor cannot fully open. Thus, the desired retardation curve can be obtained by simultaneous mechanical and electrodynamic braking. The operation of the mechanical brake is performed by activating switch S_1 .

When the lift approaches the stop plane in a time
15 process which is ideal according to Figure 2a and 2c, the thyristor is preferably blocked when a predetermined low speed has been achieved which is determined by the comparing amplifier A_4 the output of which is connected via a diode D_4 and a resistance R_{10} to the output of the saw
20 tooth generator 4. The one input of A_4 is connected to the tachogenerator while the other one is connected to a voltage divider R_{11} , R_{12} . When A_4 reverses, the motor is switched off via switch S_2 whereby also the input signal on A_3 is caused to cease. The locking of the lift is
25 performed at a distance of 5 mm from the stop-plane

provided that a low value e_s is detected by the comparing amplifier A_5 , one input of which is connected to the output of the integrator 2 and the other input of which is connected to a voltage divider R_{13} , R_{14} . The output signal from
5 said voltage divider determines the locking point. When comparator A_5 is reversed, switch S_3 is activated to operate the locking brake.

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CLAIMS:

1. An operational control system for electrodynamic, braking of lifts or elevators including a one-speed A.C. asynchronous motor of the short-circuit type equipped with
5 a mechanical brake, characterized by means for sensing the speed of the lift, a D.C. source for feeding the field windings of the A.C. asynchronous motor to produce a rectified magnetic braking flow through the rotor of the said asynchronous motor to produce electrodynamic braking,
10 integrating means for integrating the output signal from said speed sensing means to generate a reference signal for the retardation distance, converting means having a square root extracting function to linearize the reference signal for the retardation distance, first comparator means
15 for comparing the output signal indicating the speed with the linearized signal for the retardation distance to produce a fault signal for controlling an electric control signal for said D.C. source, and second comparator means for comparing the fault signal with a reference
20 level corresponding to the maximum possible electrodynamic braking to produce a signal for activating the mechanical brake of the motor.

2. An operational control system as claimed in claim 1,
25 characterized in that the speed sensing means is a tacho-



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meter connected to the shaft of the lift driving motor.

3. An operational control system for electrodynamic

braking of lifts or elevators constructed and arranged

substantially as herein described with reference to any

5 of the Figures of the drawings.

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