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[54] **ELEVATOR CONTROL APPARATUS**

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[52] **U.S. Cl.** ....**187/29 R**

[51] **Int. Cl.** **B66b 1/18**

[58] **Field of Search**...187/29

[56] **References Cited**

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[57] **ABSTRACT**

An elevator control apparatus which operates a plurality of elevators so as to serve a plurality of landing floors evenly, wherein the imaginary position of each elevator is determined in accordance with the space between each elevator and the succeeding one, a service zone of each elevator being established between the imaginary positions of each elevator and the preceeding one, and the elevator being stopped when a call is produced within the service zone.

9 Claims, 12 Drawing Figures

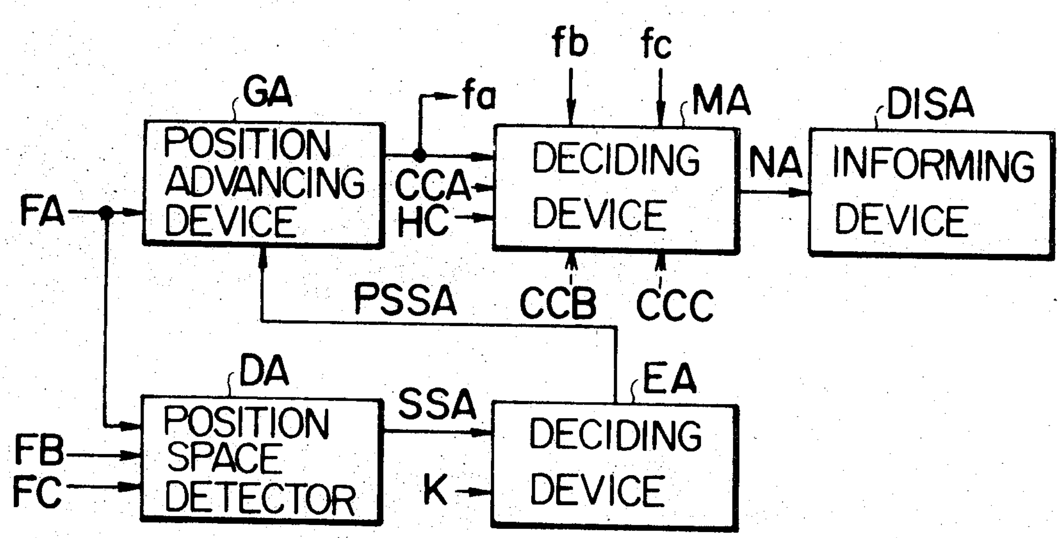

FIG. 1

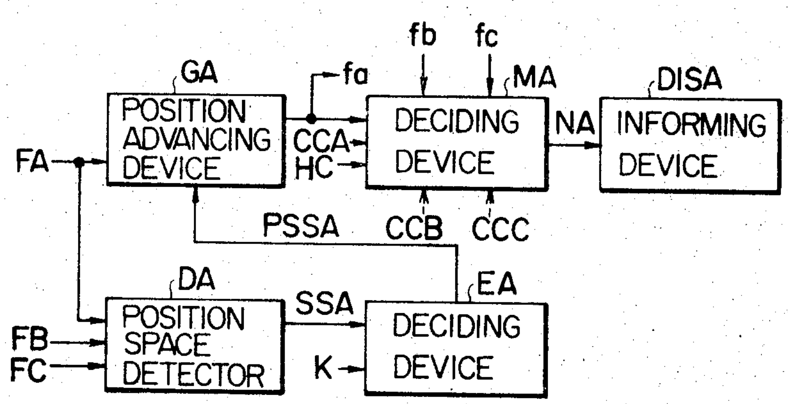

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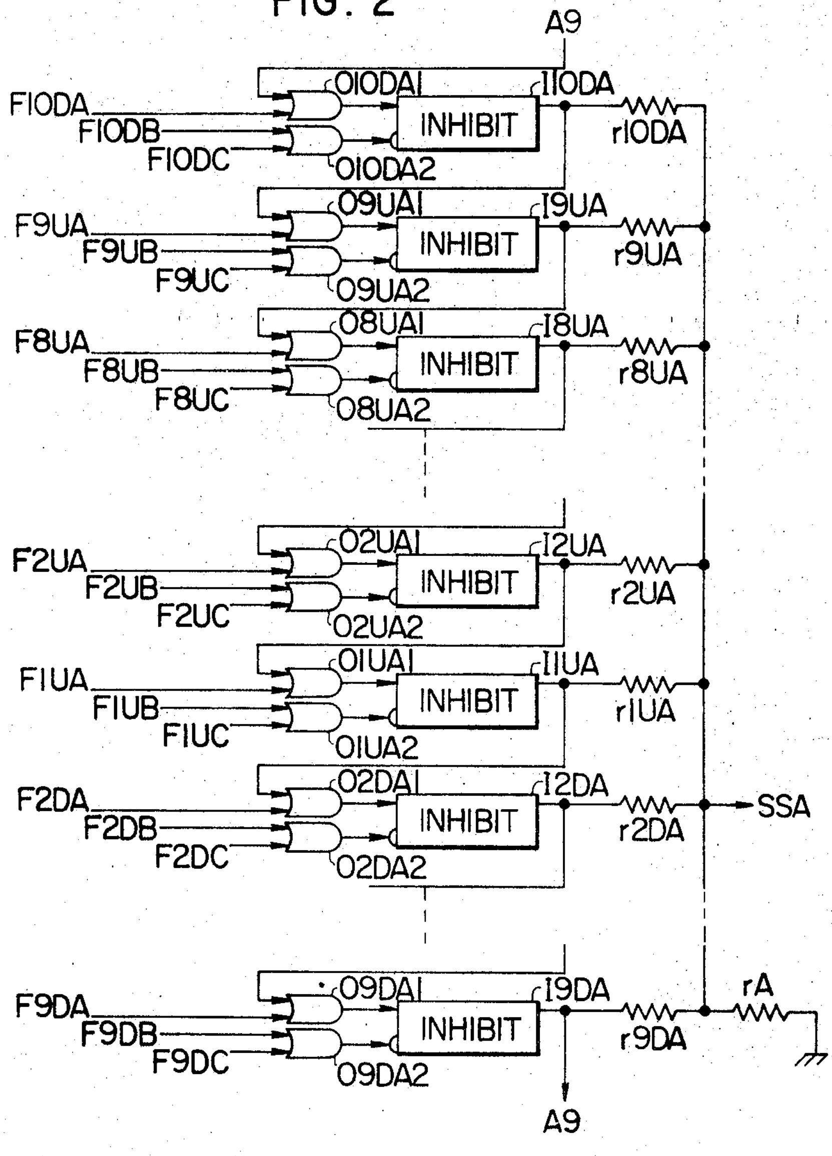
FIG. 2



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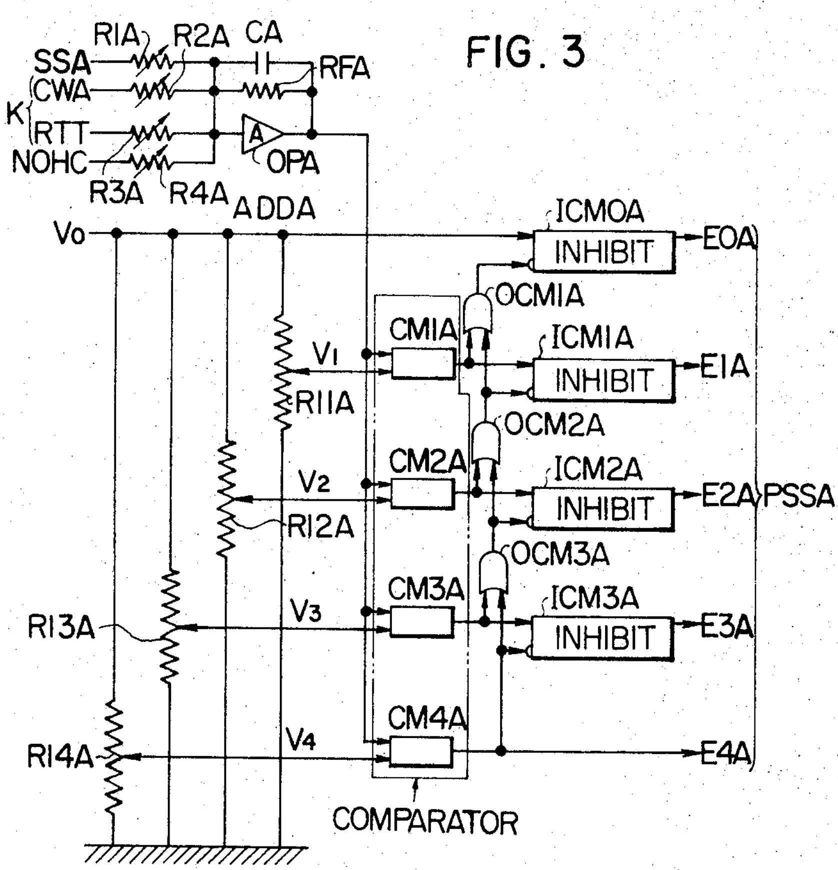

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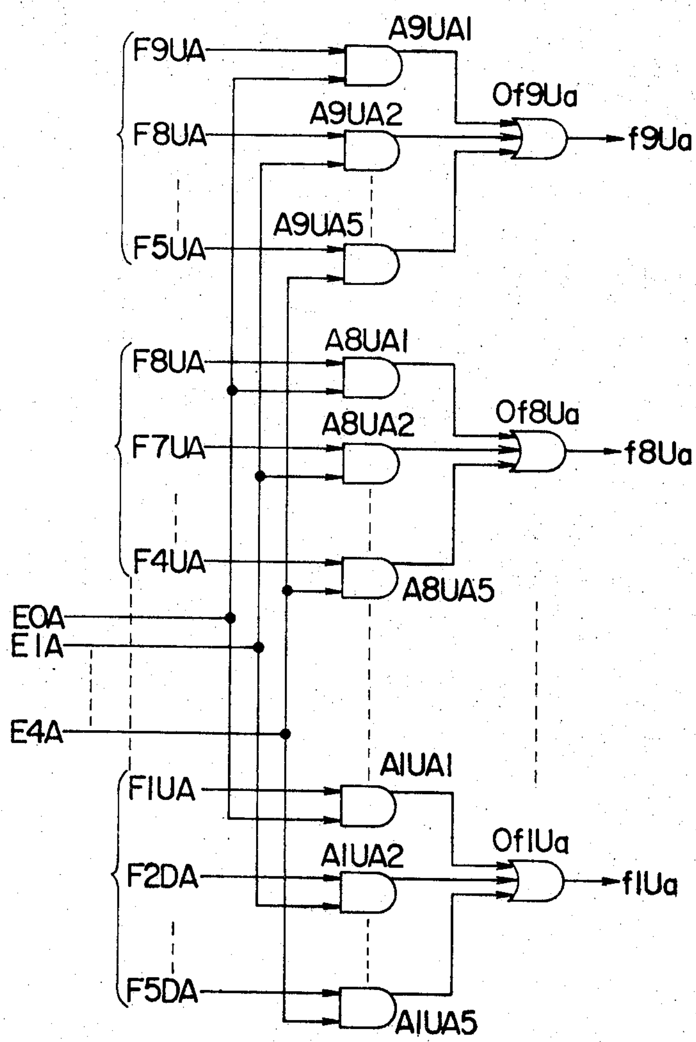
FIG. 4



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Patented April 24, 1973 3,729,066

9 Sheets-Sheet 5

FIG. 5a

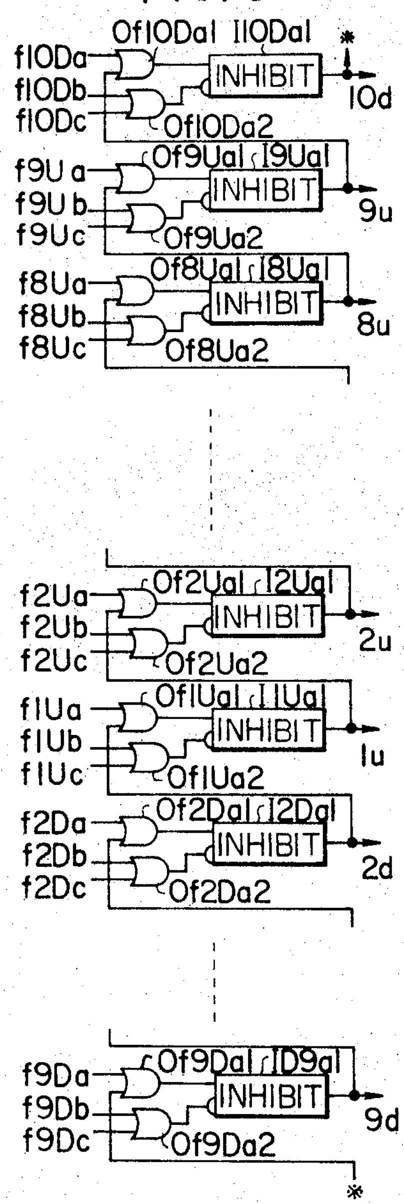
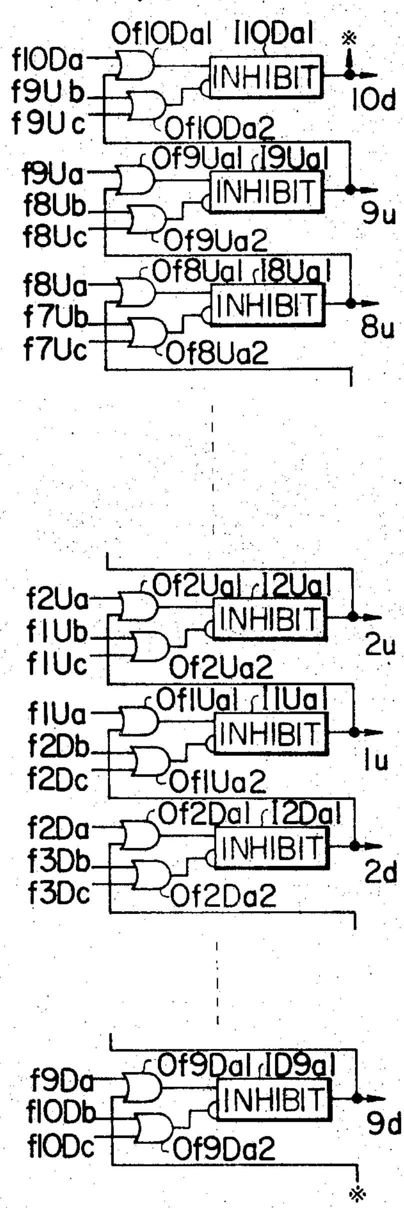


FIG. 5b



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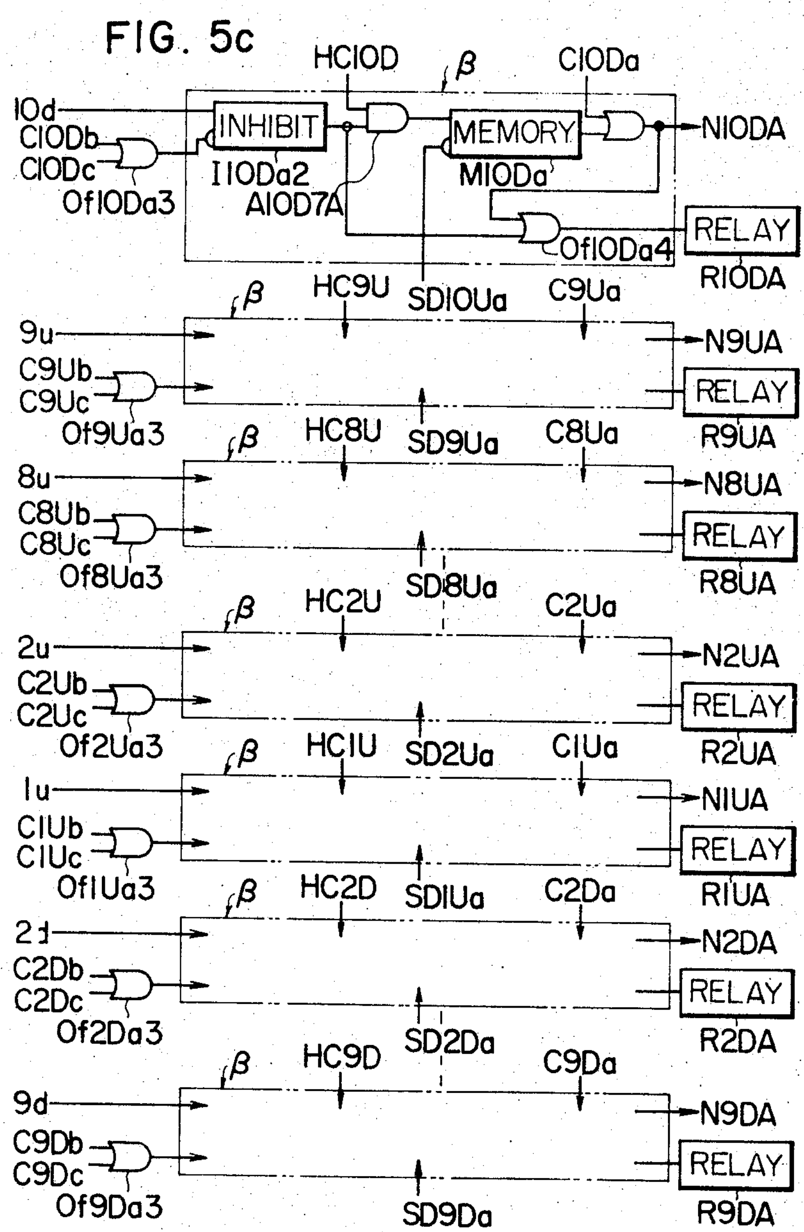

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FIG. 5d

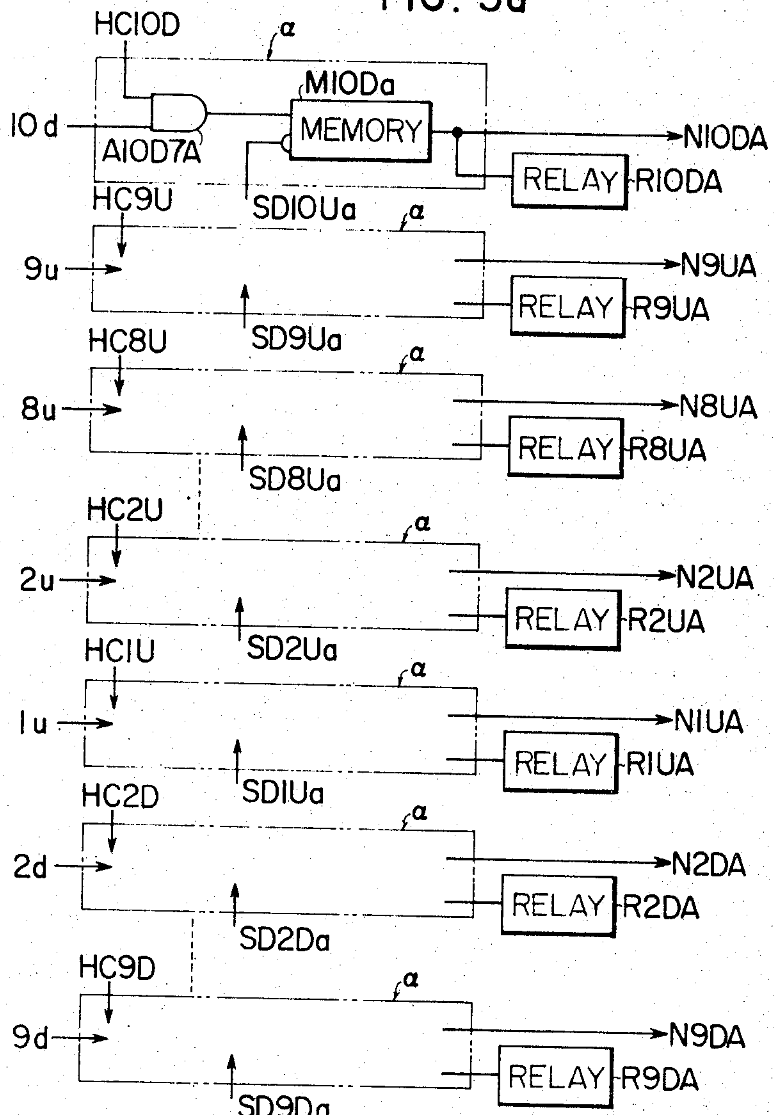

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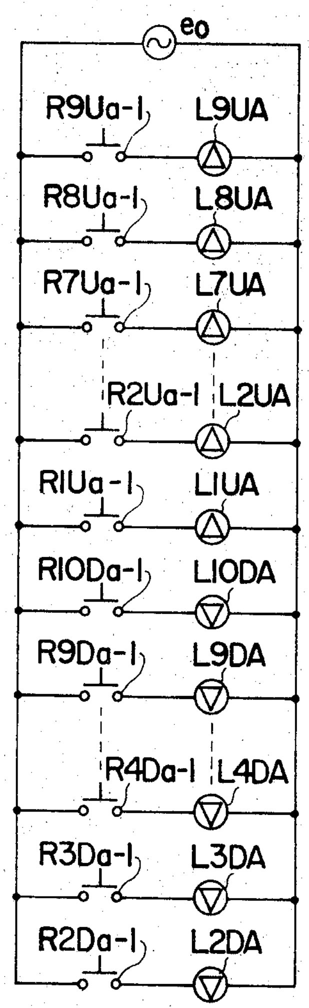
FIG. 6



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Patented April 24, 1973 3,729,066

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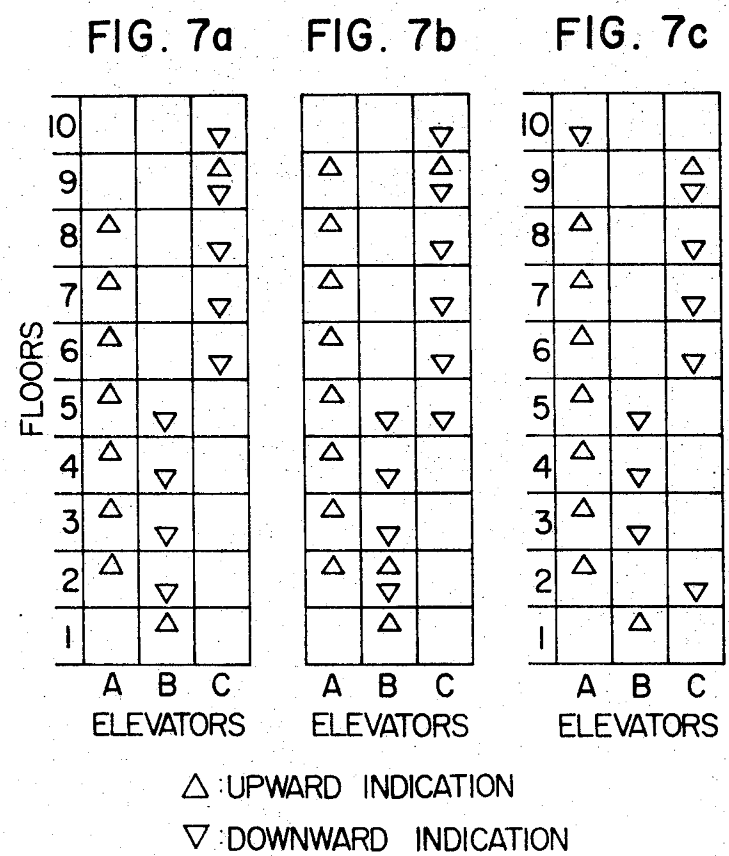

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ELEVATOR CONTROL APPARATUS

BACKGROUND OF THE INVENTION

This invention relates to an elevator control apparatus which operates a plurality of elevators so as to serve a plurality of landing floors evenly.

If a plurality of elevators are arranged in parallel and serve a plurality of landing floors, those elevators must be prevented from being operated in a group at the same time. The space between the elevators must be adequate, but need not be always equal in distance; it is desirable to make the waiting time of passengers at each floor the same. Various types of control apparatuses have been provided, but each apparatus has failed to satisfy the need for prompt service as described.

SUMMARY OF THE INVENTION

Accordingly, it is an object of this invention to provide a new control apparatus which controls the operation of a plurality of elevators so as to serve the various floors with adequate spacing from each other.

According to one aspect of an embodiment of this invention, the control apparatus includes means for determining a service zone for each elevator, the service zone being shifted according to the condition of operation of the elevators.

Other detailed objects and aspects of this invention will become apparent upon reading the specification and inspection of the drawings and will be particularly pointed out in the claims.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram of an embodiment according to this invention;

FIG. 2 shows a detailed circuit of a position space detector DA used in the embodiment shown in FIG. 1;

FIG. 3 shows a detailed circuit of the deciding device EA in FIG. 1;

FIG. 4 shows a detailed circuit of the position advancing device GA in FIG. 1;

FIGS. 5*a* and 5*b* show detailed circuits of a part of the deciding device MA in FIG. 1;

FIGS. 5*c* and 5*d* show detailed circuits of the remaining part of the deciding device MA in FIG. 1;

FIG. 6 shows a detailed circuit of the informing device DISA in FIG. 1; and

FIGS. 7*a* to 7*c* show service indications of the elevators according to the different embodiments of this invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

FIG. 1 is a block diagram of an embodiment according to this invention. Hereinafter, the explanation will relate to three elevators A, B and C which are operated between the first floor and the tenth floor. The block diagram in FIG. 1 shows only an apparatus for controlling the elevator A. The same apparatus is also provided to control the elevators B and C, respectively. It is, of course, within the ordinary application of applicants' invention to be able to change the number of elevators employed and the number of floors serviced.

Referring to FIG. 1, a position space detector DA detects the space between the elevator A and the nearest succeeding elevator thereto by comparing a signal FA with signals FB and FC. The signals FA, FB and FC represent the positions of the elevators A, B and C, respectively, and the position signal normally corresponds to the floor the elevator is stopping at. However, when the elevator is running, the position signal corresponds to the nearest floor that the elevator is able to stop at. If the elevator, during an upward operation, passes the fourth floor, the position signal corresponds to the fifth floor in the low speed of the elevator, to the sixth floor in the middle speed, and to the seventh floor in the high speed because the elevators require a certain deceleration distance according to the speed in order to stop comfortably. An output signal of the detector DA, that is, a space signal SSA, is applied to a position space deciding device EA, wherein the space signal SSA is represented by the number of floors. The signal SSA is compared with a reference signal K in the deciding device EA. The reference signal K, which designates the appropriate space between the two elevators by the number of floors, is determined as follows:

In case of a normal demand condition, it is desired that all elevators be distributed evenly with respect to all of the floors. Therefore, the appropriate space *FS* is

$$FS=(f-1)\times 2/n$$

where f is the number of floors served by the elevators and n is the total number of elevators employed. For example, if f=10 and n=3 as described in the aforementioned example, *FS* becomes six floors. Namely, if the elevator A capable of responding to the upward call is at the second floor, the elevator B is at the eighth floor in the upward operation and the elevator C is at the sixth floor in the downward operation. Further, the appropriate space *FS* should be changed by demand conditions of the elevator, such as the number of passengers in the cage of each elevator, distribution of the destinations required by the passengers, the number of the hall calls and so on.

The deciding device EA produces an output signal in accordance with the difference between the reference signal K and the space signal SSA. The output signal of the device EA is applied to a position advancing device GA as a position advancing signal PSSA. The device GA produces an imaginary position signal fa in accordance with the signal PSSA. If the signal SSA is nearly equal to the reference signal K, the device EA does not produce the signal PSSA, so that the imaginary position signal *fa* is equal to the position signal FA. If the signal SSA becomes smaller than the reference signal K, the signal PSSA is produced and the imaginary position signal *fa* is advanced thereby. The imaginary position signal represents the nearest floor that the elevator is capable of serving in response to hall calls. Although the elevator can decelerate and stop in response to a hall call produced on a certain floor, if the floor is behind the floor designated by the imaginary position signal, the elevator does not serve the called floor.

The imaginary signal *fa* is applied to a device MA for deciding whether the elevator A can serve the called floor, and it is also applied to the corresponding devices MB and MC (not shown) for the elevators B and C. The device MA detects the presence of various signals ahead of the floor designated by the imaginary position signal *fa*. The first ones of the various signals are imaginary position signals *fb* and *fc* of the elevators B and C. A service zone of the elevator A, therefore, is limited to the floors between the signal *fa* and either of the signals *fb* or *fc*. The details will be explained later. The second ones are cage call signals CCB and CCC, which are produced by request of passengers in the elevators B and C. The floors corresponding to these signals CCB and CCC are excepted from the service zone of the elevator A. The third one is a hall call signal HC which is produced by request of waiting passengers in the elevator hall of each floor. If there is the signal HC in the service zone, a stopping instruction is given to the elevator A. The last one is a cage call signal CCA of the elevator A itself, which is given priority to other signals. When the cage call signal CCA is produced, the stopping instruction is given to the elevator A irrespective of the service zone. As mentioned above, the output NA of the device MA becomes the stopping instruction, and simultaneously it is applied to an informing device DISA to turn on indicating lamps.

The detailed circuits of each device described above and their operations will be explained hereinafter, referring to the accompanying drawings.

FIG. 2 shows an example of a detailed circuit of the position space detector DA in FIG. 1. In this figure, F1UA to F9UA are position signals during the upward operation of the elevator A, and F2DA to F10DA are position signals during the downward operation of the elevator A. Similarly, F1UB to F9UB and F2DB to F10DB, and F1UC to F9UC and F2DC to F10DC are position signals of the elevators B and C, respectively. These signals are generated in accordance with the operation of each elevator by known apparatuses and control means (not shown). Each signal is utilized as follows:

For example, the signal F2UA is applied to an INHIBIT gate I2UA through an OR gate 02UA1. On the other hand, the signal F2UB or F2UC is supplied to an inhibit terminal of the gate I2UA through an OR gate O2UA2. An output of the gate I2UA is applied to a resistor *r*2UA, and simultaneously to an INHIBIT gate I1UA through an OR gate O1UA1. The gate O2UA1 also receives an output of an INHIBIT gate I3UA (not shown). The same circuits are constructed for each floor, and the output of the INHIBIT gate for a certain floor is applied to an input terminal of the INHIBIT gate for the just previous floor in a running direction through the OR gate. Therefore, an output of the INHIBIT gate I9DA in the bottom of the drawing is applied to an OR gate O10DA1 in the top of the drawing to construct the circular circuit by means of the INHIBIT gates and the OR gates.

If the elevator A is at the eighth floor and the elevator B is at the second floor, signals F8UA and F2UB are present. The signal F8UA is fed to the INHIBIT gate I8UA through an OR gate *o*8UA1. The output of the gate I8UA is applied to a resistor r8UA. Succeedingly, an INHIBIT gate I7UA (not shown) is turned on by the output of the gate I8UA and an output of the gate I7UA is applied to a resistor *r*7UA (not shown). This is repeated through to an INHIBIT gate I3UA and a resistor *r*3UA (both not shown). Although an output of the gate I3UA is fed to an input terminal of the gate I2UA through the gate O2UA1, the gate I2UA does not produce the output since the signal F2UB is applied to an inhibit terminal of the gate I2UA through the gate O2UA2. As a whole, the outputs of each INHIBIT gate, that is output voltages, are applied to six resistors *r*8UA to *r*3UA. The voltage across a resistor *r*A is proportional to $6r_o/r$, where r is the individual resistance value of *r*1UA to *r*9UA and *r*2DA to *r*10DA, and r_0 ($<<r$) is the resistance value of *r*A.

Generally speaking, if the number of INHIBIT gates producing the output is k, the voltage across the resistor *r*A is proportional to kr_0/r. This becomes the signal SSA. As described above, the circuit shown by FIG. 2 is the circuit for obtaining the space between the elevator A and the nearest succeeding elevator thereto

The obtained space signal SSA is applied to the position space deciding device EA to be compared with the reference signals. FIG. 3 shows an example of the detailed circuit of the position space deciding device EA in FIG. 1.

In this figure, an adder ADDA consists of a plurality of input resistors RI to R4A, a capacitor CA and a feedback resistor RFA, and an operational amplifier OPA. The signal SSA is applied to the resistor RIA. The other resistors R2A to R4A receive signals such as the number of passengers in a cage of the elevator A (CWA), the time for reciprocating operation of the elevator between the first floor and the tenth floor (RTT), and the number of hall calls (NOHC). The output of the adder ADDA is as follows:

$$-r_{fa}\{(\mathrm{SSA})/(r_{1a})+(\mathrm{CWA})/(r_{2a})+(\mathrm{RTT})/(r_{3a})+(\mathrm{NOHC})/(r_{4a}\}$$

where r_{1a} to r_{4a} and r_{fa} are resistance values of the resistors R1A to R4A and RFA, respectively. For simplification, the resistors R2A to R4A are regarded as having values close to infinity in the following explanation. The output of the adder ADDA, therefore, is proportional to only the signal SSA. R11A to R14A are resistors for providing reference voltages $\overline{V}_1$ to $\overline{V}_4$. The value of the reference voltages $\overline{V}_1$ to $\overline{V}_4$ correspond to five to two floor differences respectively. These references $\overline{V}_1$ to $\overline{V}_4$ are compared with the output of the adder ADDA in respective comparators CM1A to CM4A. Each comparator produces an output when the output of the adder ADDA becomes smaller than the respective reference thereof. If the signal SSA corresponds to a two floor difference, all comparators CM1A to CM4A produce outputs. The output of the comparator CM4A is applied to an inhibit terminal of an INHIBIT gate ICM3A. The output of a comparator CM3A is inhibited thereby. Also, the output of the comparator CM4A or CM3A is applied to an inhibit terminal of an INHIBIT gate ICM2A through an OR gate OCM3A. An output of a comparator CM2A is inhibited thereby. An output of a comparator CM1A and an input of an INHIBIT gate ICM0A are inhibited similarly. In consequence, only the output of the comparator CM4A is present as a position advancing signal PSSA, which is a four floors advancing signal E4A. Further, if the signal SSA corresponds to a four floor difference, the comparators CM1A and CM2A produce outputs, whereas the comparators CM3A and CM4A do not produce outputs. The output of the comparator CM1A is inhibited by the gate ICM1A, and the signal E1A is not produced. The signal EOA is inhibited since an output of the comparator CM2A is applied to an inhibit terminal of the gate ICMOA through an OR gate OCM1A. Therefore, only the signal E2A is present, and it becomes a two floors advancing signal.

The remaining signals EOA, E1A and E3A are also produced in the same way, which designate zero floor, one floor and three floors advancing signals, respectively. Further, the signal EOA means that the imaginary position signal *fa* coincides with the position signal FA. The position advancing device GA which receives the position advancing signals to produce the imaginary position signals, is shown in FIG. 4. This figure shows only a device which produces the imaginary position signals between the first floor and the tenth floor in the upward direction. A group of circuits for each floor consists of five AND gates and an OR gate. For the ninth floor, for example, the position signals F9UA to F5UA are applied to the AND gates A9UA1 to A9UA5, respectively. The position advancing signals EOA to E4A are also applied to the gates A9UA1 to A9UA5, respectively, as one more input of each AND gate. An output through an OR gate O*f*9U*a* becomes the imaginary position signal *f*9U*a*. For the eighth floor, the position signals F8UA to F4UA and the position advancing signals EOA to E4A are applied to a group of AND gates A8UA1 to A8UA5 in the same manner as the ninth floor. An output through an OR gate O*f*8U*a* becomes the imaginary position signal *f*8U*a*.

In this manner, the position signals which are given to the AND gates are shifted by one signal every floor. For that reason, a position signal F2DA in the downward operation is first used in a group of circuits for an imaginary position signal *f*4U*a* (not shown), and position signals F2DA to F5DA in the downward operation are applied to four AND gates A1UA2 to A1UA5 of the last group, respectively. If the position signal is F5UA and the position advancing signal is E4A, the AND gate A9UA5 produces the output. The output through the OR gate O*f*9U*a* becomes the imaginary position signal *f*9U*a*. If the position signal is F8UA and the position advancing signal is EOA, the AND gate A8UA1 produces the output which becomes the imaginary position signal *f*8U*a*. In the latter example, the position signal coincides with the imaginary position signal.

The following explanation will relate to the service zone of the elevator A which is determined by applying these imaginary position signals and others.

FIGS. 5*a* and 5*d* show examples of the detailed circuit of the device MA in FIG. 1. The former two of these figures show the different examples of the circuit for deciding the service zone of the elevator A. In FIG. 5*a*, for example, a circuit for the second floor consists of two OR gates O*f*2U*a*1 and O*f*2U*a*2 and an INHIBIT gate I2U*a*1. One of two inputs of the gate O*f*2U*a*1 is the imaginary position signal *f*2U*a* of the elevator A, and its output is applied to the gate I2U*a*1. The two inputs of the gate O*f*2U*a*2 are the imaginary position signals *f*2U*b* of the elevator B and *f*2U*c* of the elevator C. An output of the gate O*f*2U*a*2 is fed to an inhibit terminal of the gate I2U*a*1. An output of the gate I2U*a*1 becomes a signal representing the floor capable of being served by the elevator A, and simultaneously it is fed to an OR gate O*f*3U*a*1 (not shown) for the third floor. One more input of the gate O*f*2U*a*1 is an output of the INHIBIT gate I1U*a*1 for the first floor. In this manner, an output of each INHIBIT gate is applied to the OR gate of the advanced floor by one in a direction of operation, therefore, an output of the INHIBIT gate I10D*a*1 in the top of the drawing is fed to an OR gate O*f*9D*a*1 at the bottom of the drawing. The circular circuit is constructed by an alternate arrangement of the INHIBIT gates and the OR gates. FIG. 5*b* shows another circuit for deciding the service zone of the elevator A. The only difference between FIGS. 5*a* and 5*b* is in the inputs of the gates O*f*1U*a*2 to O*f*9U*a*2 and O*f*2D*a*2 to O*f*10D*a*2. A functional difference caused by the above difference will be explained later.

The operation of the device above-described is as follows. It is assumed that the imaginary position of the elevators A, B and C are the second floor in the upward, the fifth floor in the downward, and the ninth floor in the upward, respectively. Thus, the signals *f*2U*a*, *f*5D*b* and *f*9U*c* are generated in the above case. The signal *f*2U*a* is applied to the gate I2U*a*1 through the gate O*f*2U*a*1. The gate I2U*a* 1 produces its output since there is no inhibit signal from the gate O*f*2U*a*2. The output of the gate I2U*a*1 is applied to the INHIBIT gate I3U*a*1 through an OR gate O*f*3U*a*1. The gate I3U*a*1 produces its output thereby. This is repeated up to the INHIBIT gate I8U*a*1. An output of the gate I8U*a*1 is applied to the INHIBIT gate I9U*a*1 through an OR gate O*f*9U*a*1; however, since the signal *f*9U*c* is applied to the inhibit terminal of the gate I9U*a*1 through an OR gate O*f*9U*a*2, the gate I9U*a*1 does not produce its output. Accordingly, the outputs of the gates I2U*a*1 to I8U*a*1 appear on terminals 2*u* to 8*u*, respectively. These outputs represent the service zone in which the elevator A is able to serve in response to hall calls produced therewithin. If the other elevator B or C is able to serve a certain floor in the service zone, the floor may be excepted from the service zone of the elevator A. Details of this control will be explained later by referring to FIG. 5*c* or 5*d*.

If the elevators B and C do not serve any floors in the service zone of the elevator A, namely, there are no cage calls of the elevators B and C therewithin, the informing device DISA indicates that the elevator A is able to respond to upward hall calls between the second floor and the eighth floor. The same devices are shown in FIG. 5*a* decide service zones of the elevators B and C. The whole indication of the informing device DISA is as shown in FIG. 7*a*. It is clear from FIG. 7*a* that the device shown by FIG. 5*a* does not make the service zone of each elevator overlap. In the device shown by FIG. 5*b*, the inhibit inputs of each INHIBIT gate are different from that in FIG. 5*a*. For example, the inputs of the gate O*f*2U*a*2 in FIG. 5*a* are *f*2U*b* and *f*2U*c*, whereas that of the gate O*f*2U*a*2 in FIG. 5*b* are *f*1 U*b* and *f*1 U*c*. In the operation of the circuit shown in FIG. 5*b*, it is not different from the case of FIG. 5*a* in that the gate I2U*a*1 produces its output. But, since the signal *f*9U*c* is so arranged as to be fed to an inhibit terminal of the gate I10D*a*1 through an OR gate O*f*10D*a*2, the gate I10D*a*1 does not produce its output. The gate I9U*a*1 produces its output. The device in FIG. 5*b* is different from the device in FIG. 5*a* in this point. Accordingly, the device in FIG. 5*b* can made the service zone of each elevator overlap by one floor, as shown in FIG. 7*b*.

Signals obtained in this manner, which represent the service zone of each elevator, are fed to devices producing a stopping instruction. These devices are surrounded by one chain line in FIG. 5*c*. As the structure of these devices β is all the same, the following explanation will be provided only with respect the structure and the operation of one typical device. If the 10th floor is within the service zone of the elevator A, the signal appears on the terminal **10***d*. At this time, if a cage call of the elevator B or C is not registered, the signal on the terminal **10***d* is fed to a relay **R10DA** through the INHIBIT gate **I10D***a***2** and an OR gate *Of***10D***a***4**. The relay **R10DA** is excited to close its contact. The relay **R10DA** is an indicating relay in the informing device **D1SA** and its contact is connected in series with an indicating lamp. A circuit of the informing device D1SA is shown in FIG. **6**. The contact **R10D***a***1** of the relay **R10DA** is closed and the lamp L10DA is turned on by the electric source e_o. Similarly, in FIG. **6**, **R1U***a***–1** to **R9U***a***–1** and **R2D***a***–1** to **R9D***a***–1** are contacts of the relay **R1UA** to **R9UA** and **R2DA** to R9DA in FIG. **5***c*, respectively. Lamps L1UA to L9UA and L2DA to L10DA connected to these contacts in series are provided for the respective floors. For instance, the lamps L2UA and L2DA are provided for the second floor. When the lamp L2UA is turned on, this indicates that the elevator A is able to respond to the upward hall call produced in the second floor, and when the lamp L2D is turned on, this indicates that the elevator A is able to respond to the downward hall call produced on the second floor. The same is true of the indication by the other lamps. The turn-on of the lamp **L10DA** indicates that the elevator A is able to respond to the downward operation. In such a condition, if the hall call **HC10D** in the tenth floor is produced, the AND gate **A10D7A** in FIG. **5***c* produces an output in response to both the output of the gate **I10D***a***2** and the hall call **HC10D**. A memory circuit **M10D***a* memorizes the output of the gate **A10D7A**. An output of the circuit **M10D***a* is applied to another control means (not shown) as the stopping instruction **N10DA**. Receiving the instruction **N10DA**, the other control means operates to stop the elevator A at the 10th floor. The above-described other control means is a known speed control means. When the elevator A stops, a signal **SD10U***a* is produced to reset the circuit **M10D***a*. Further, in this circuit, a cage call **C10D***a* produced in the elevator A has a priority. When the cage call **C10D***a* is present, the instruction **N10DA** is produced. Although the 10th floor is without the service zone of the elevator A and the hall call **HC10D** is not present.

If the other elevator B or C is due to stop at the 10th floor in response to the respective registered cage call, the cage call **C10D***b* or **C10D***c* is fed to an OR gate **Of10D***a***3** to inhibit the output of the gate **I10D***a***2**. In this case, although the hall call **HC10D** is present, the stopping instruction N10D*a* is not given to the elevator A. The elevator A need not stop at the 10th floor, since the elevator B or C serves these floors, and the floors served by the other elevator are excepted from the service zone of the elevator A. An example of the indication in this case is shown in FIG. 7*c*. The service zone of the elevator A in FIG. 7*c* is between the second floor and the tenth one, and the ninth one served by the elevator C is excepted from the service zone of the elevator A.

If the relation to the other elevator B or C need not be considered, the devices β can be simplified as shown in FIG. **5***d*. The operation of these devices is similar to that of FIG. **5***c* in greater part. When the signal **HC10D** is produced, the gate **A10D7A** produces its output on condition that the signal on **10***d* is present. The circuit **M10D***a* memorizes the output of the gate **A10D7A** to produce the stopping instruction **N10DA**. The relay **R10DA** is excited to produce the indication. When the elevator A is stopped in response to the instruction **N10DA**, the signal **SD10U***a* is produced to reset the circuit **M10D***a*.

Having thus described this invention, it is obvious that various modifications within the knowledge of workers in the art may be utilized without departing therefrom.

It is to be understood also that although the invention has been described with specific reference to a particular embodiment thereof, it is not to be so limited, since changes and alterations therein may be made which are within the full intended scope of this invention as defined by the appended claims.

We claim:

1. In an elevator control apparatus for operating a plurality of elevators so as to serve a plurality of landing floors evenly, the improvement comprising first means for generating an imaginary position signal of an elevator which is advanced of the actual position of the elevator, second means for establishing a service zone of an elevator by utilizing the imaginary position signals of the elevator and another elevator in which zone the elevator is able to serve in response to hall calls, and third means for altering the imaginary position signal so as to shift the service zone according to conditions of the operation of the elevators.

2. An elevator control apparatus as claimed in claim 1, wherein said third means includes means for changing said imaginary position signal of the elevator according to the space between each elevator and the just succeeding elevator.

3. An elevator control apparatus as claimed in claim 1, wherein said third means includes means for changing said imaginary position signal of the elevator according to the number of passengers in a cage of the elevator.

4. An elevator control apparatus as claimed in claim 1, wherein said third means includes means for changing said imaginary position signal of the elevator according to the number of hall calls.

5. An elevator control apparatus as claimed in claim 1, wherein said second means includes means for causing said service zones of said elevators to partially overlap each other.

6. An elevator control apparatus as claimed in claim 1, wherein said second means includes means for excepting floors served by other elevators from said service zone of the given elevator.

7. An elevator control apparatus as claimed in claim 1, further comprising means for actuating the elevator having a service zone including a produced hall call to respond to the hall call.

8. An elevator control apparatus as claimed in claim 1, further comprising means for producing a stopping instruction only when a hall call is produced within the service zone.

9. An elevator control apparatus as claimed in claim 1, further comprising means for indicating an elevator capable of responding to a hall call in a landing floor when the hall call is produced at the landing floor.

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