United States Patent [19]

Clark

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[45] **June 24, 1975**

[54] **ELEVATOR SYSTEM**

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[73] Assignee: **Westinghouse Electric Corporation,** Pittsburgh, Pa.

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

[51] **Int. Cl.** **B66b 1/30**

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

[56] **References Cited**

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Assistant Examiner—W. E. Duncanson, Jr.
Attorney, Agent, or Firm—D. R. Lackey

[57] **ABSTRACT**

An elevator system including one or more elevator cars mounted in a structure to serve the floors therein. When the demand for elevator service is at and above a predetermined level the elevator cars operate at rated maximum velocity and acceleration. When the demand falls below the predetermined level, the cars automatically operate in a reduced maximum velocity and/or accleration mode.

41 Claims, 9 Drawing Figures

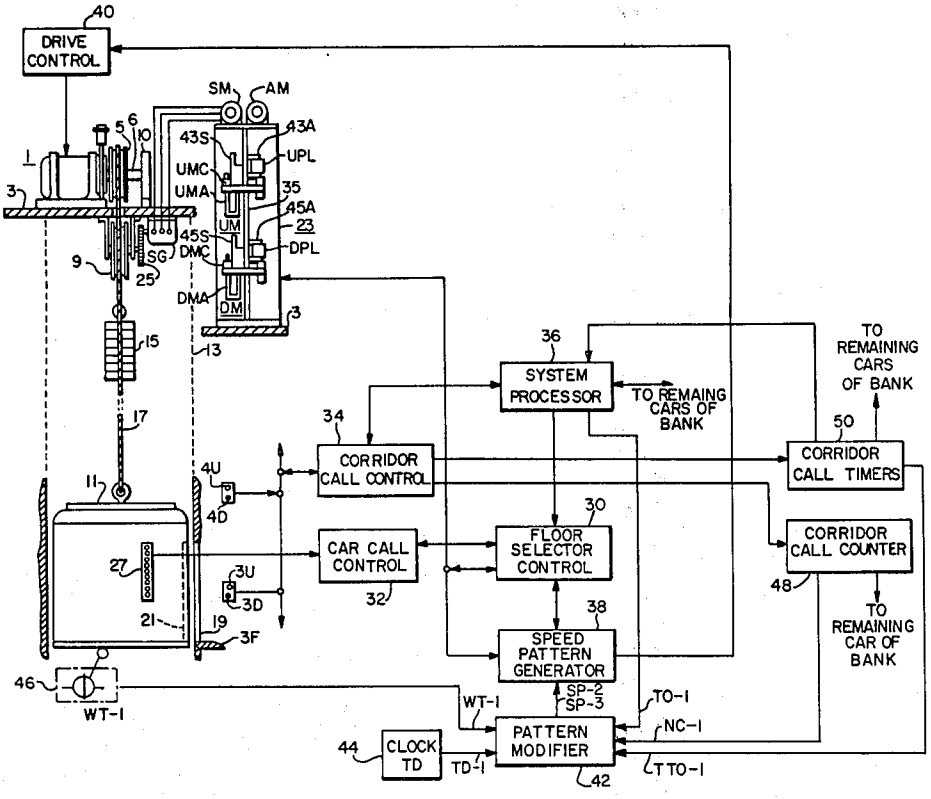
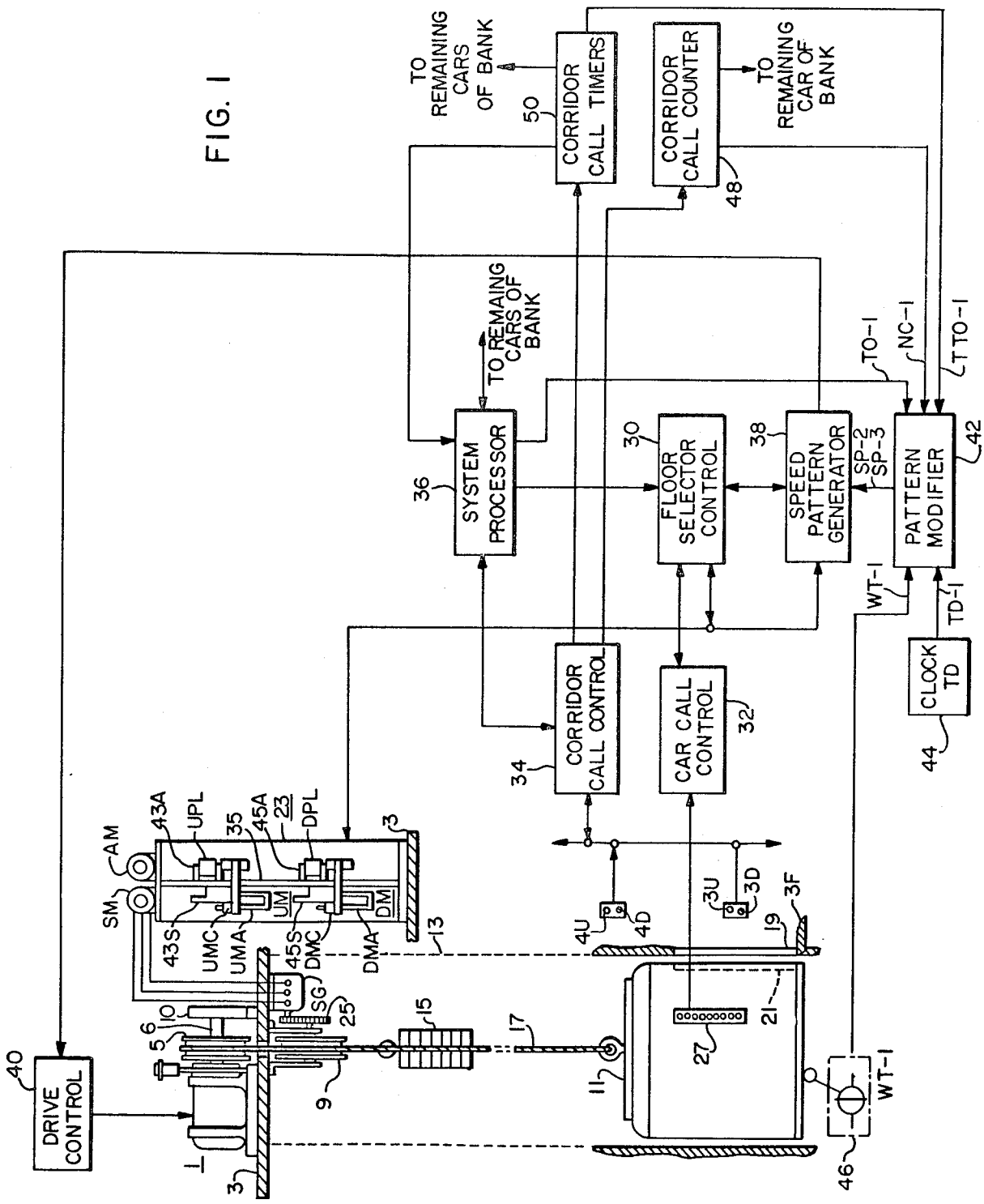


FIG. 1


TO REMAINING CARS OF BANK
50
CORRIDOR CALL TIMERS
CORRIDOR CALL COUNTER
48
TO REMAINING CAR OF BANK
TO REMAING CARS OF BANK
TO-1
NC-1
TTO-1
36
SYSTEM PROCESSOR
30
FLOOR SELECTOR CONTROL
38
SPEED PATTERN GENERATOR
SP-2
SP-3
PATTERN MODIFIER
42
WT-1
TD-1
CLOCK TD
44
34
CORRIDOR CALL CONTROL
CAR CALL CONTROL
32
AM
43A
UPL
35
45A
23
DPL
3
SM
43S
UMC
UMA
UM
45S
DMC
DMA
DM
13
4U
4D
3U
3D
3F
19
SG
25
10
6
5
15
17
21
27
11
9
1
3
40
DRIVE CONTROL
46
WT-1

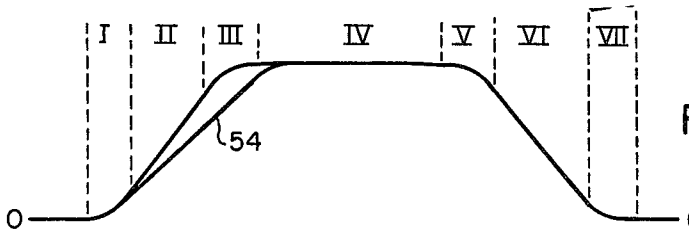


FIG. 2A

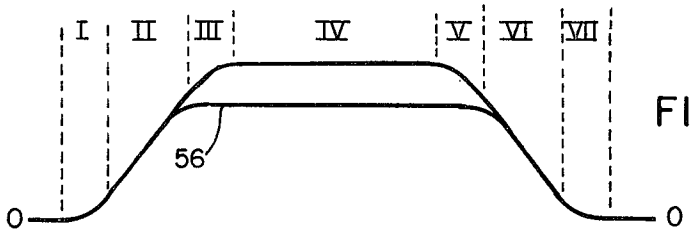


FIG. 2B

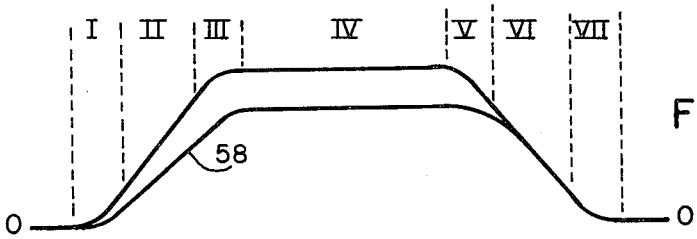


FIG. 2C

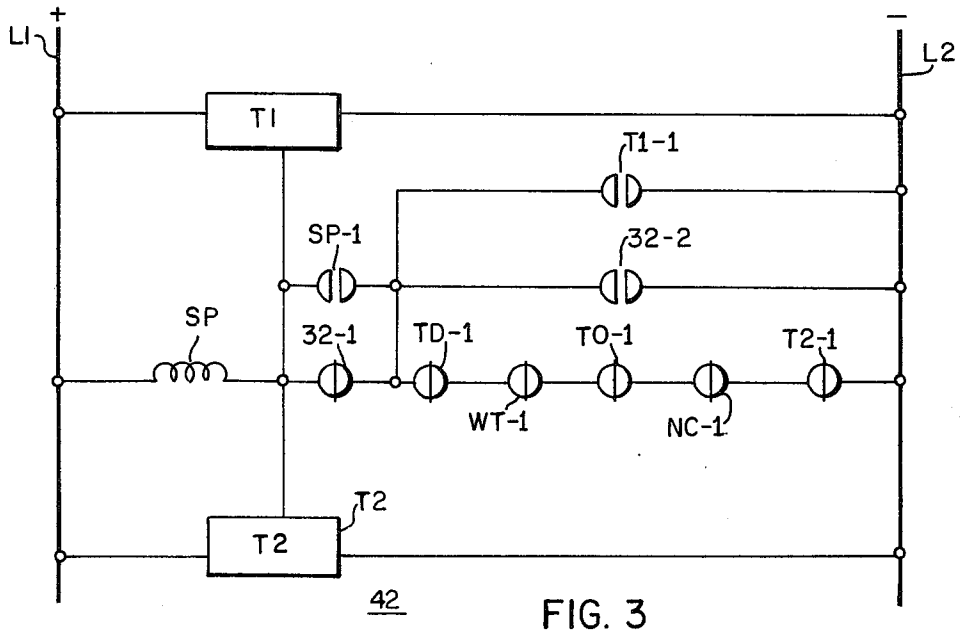


FIG. 3

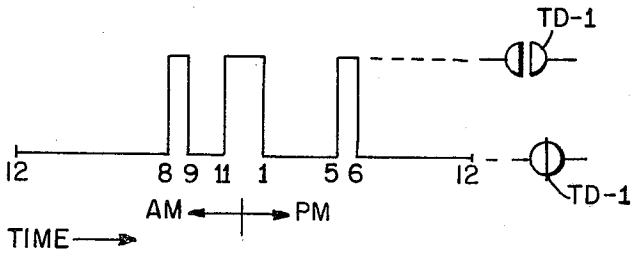


FIG. 4

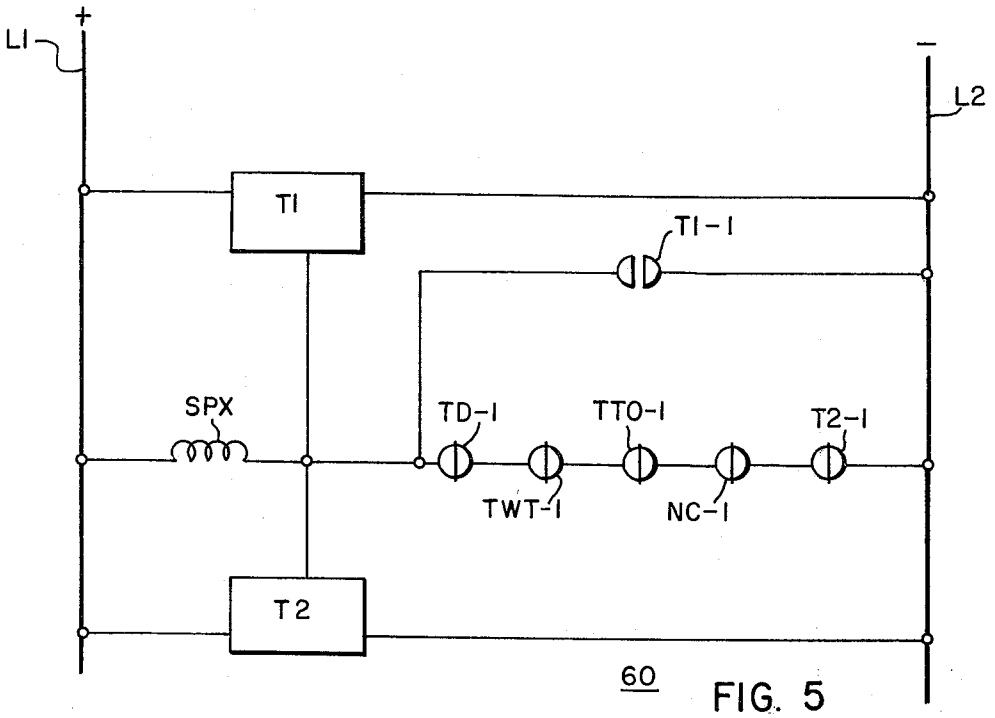


FIG. 5

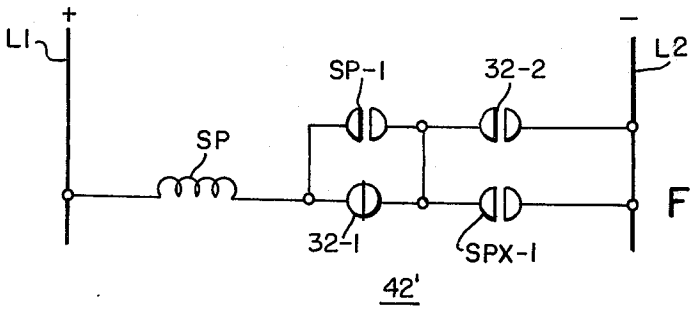
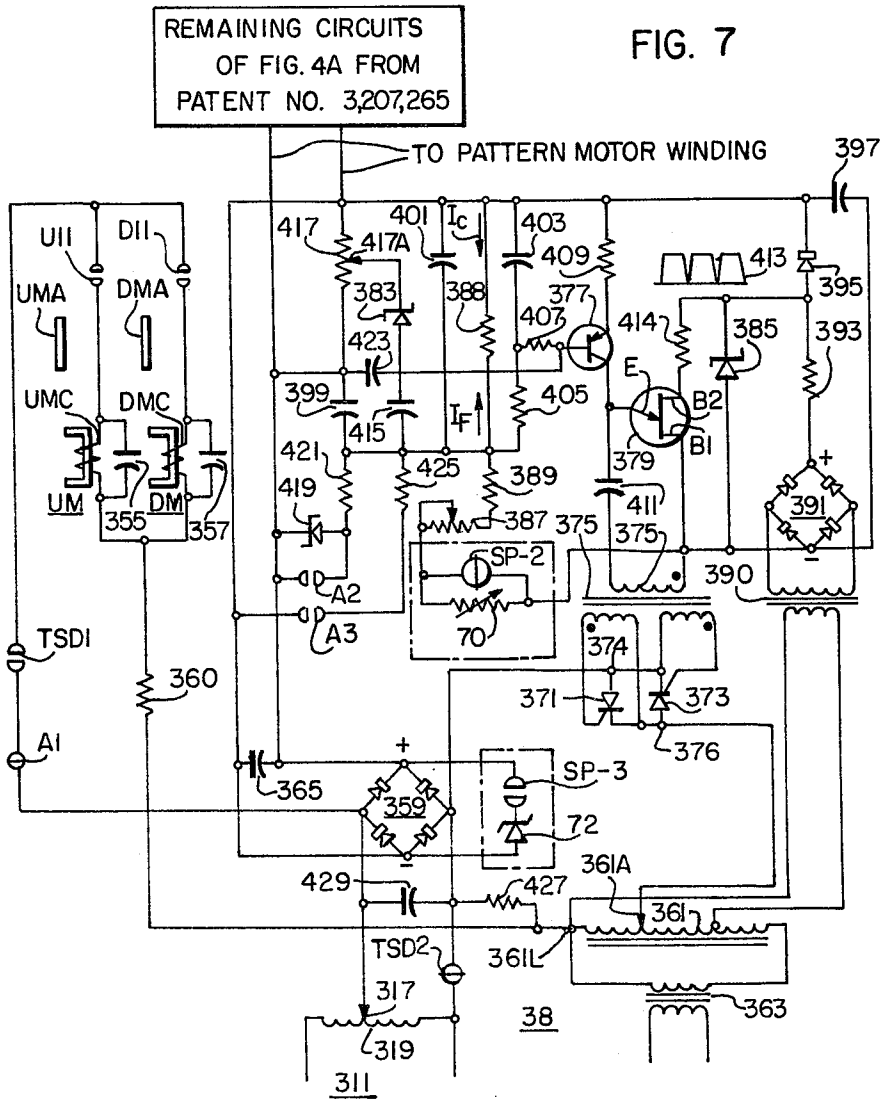


FIG. 6

FIG. 7


REMAINING CIRCUITS OF FIG. 4A FROM PATENT NO. 3,207,265
TO PATTERN MOTOR WINDING
UII
DII
UMA
DMA
UMC
DMC
UM
DM
355
357
TSDI
AI
360
417
417A
401
Ic
403
409
383
388
377
407
423
399
415
IF
405
421
419
425
389
387
A2
A3
SP-2
70
365
359
SP-3
72
429
427
361A
361
361L
TSD2
317
319
311
38
363
413
395
414
385
393
E
B2
B1
379
411
375
391
390
374
371
373
376
397

ELEVATOR SYSTEM

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates in general to elevator systems, and more specifically to apparatus for controlling the operation of one or more elevator cars.

2. Description of the Prior Art

High speed elevator systems of the prior art are designed to minimize waiting time between the entry of a corridor call and the arrival of an elevator car at the floor of the call, and between the registration of a car call and the delivery of the passenger to the requested destination. Accordingly, the elevator cars are accelerated from a stopped condition to a predetermined maximum constant acceleration using the maximum values for the acceleration, and the rate of change of acceleration, which are consistent with passenger comfort. The selected maximum rate of acceleration is continued until the elevator car nears a predetermined maximum velocity, selected to minimize travel time from the starting floor to the destination floor, at which time acceleration is smoothly reduced to zero as the car attains the desired maximum velocity.

SUMMARY OF THE INVENTION

The invention is a new and improved elevator system in which predetermined parameters associated with car movement with respect to time, i.e., jerk, acceleration, and velocity, are controlled in response to the intensity of the demand for elevator service. When the demand for elevator service is at and above a predetermined level, the elevator cars are operated in the normal mode with rated maximum values of jerk, acceleration and velocity. When the demand for elevator service drops below the predetermined level, the elevator car is automatically switched to a light traffic mode in which the maximum values of one or more of the parameters associated with the car movement with respect to time are reduced. It is not necessary to follow the same velocity profile used during traffic peaks, during periods of light traffic, in order to maintain good elevator service. The invention maintains good elevator service during all levels of traffic intensity, while flattening power demand curves during periods of light traffic, as well as reducing I^2R losses, and other speed related losses, during periods of light traffic, compared with elevator systems of the prior art which follow the same velocity profile during all levels of traffic intensity.

The invention may switch the cars individually between the peak and light traffic modes, in response to predetermined car related traffic conditions, and all of the cars in response to system related conditions; or, the invention may be bank oriented, switching all the cars from one mode to the other in response to predetermined traffic conditions. Regardless of the embodiment, an individual elevator car is switched between modes only when it is standing at a floor. Once a run is started it maintains its starting mode throughout the run, to prevent undesirable steps in the speed pattern.

The invention also prevents frequent switching between modes by maintaining a mode for a predetermined period of time once a car, or cars have switched modes, overriding brief drops and increases in traffic intensity which would otherwise cause the speed pattern to frequently switch between modes.

The intensity of the demand for elevator service may be sensed indirectly, or directly or both indirectly and directly. For example, the intensity of elevator traffic may be determined indirectly with a system clock synchronized with anticipated traffic peaks, based upon the history of the system.

The intensity of the traffic may be sensed directly by counting the number of calls, corridor calls and/or car calls, in the system at any given instant; the load in the car or cars relative to rated load; the individual or cumulative times for which corridor calls have been registered; the assignment of an elevator car to a priority call, such as a timed out call; an unsatisfied demand for an available car; and the like.

BRIEF DESCRIPTION OF THE DRAWING

The invention may be better understood, and further advantages and uses thereof more readily apparent, when considered in view of the following detailed description of exemplary embodiments, taken with the accompanying drawings, in which:

FIG. 1 is a block diagram of an elevator system constructed according to the teachings of the invention;

FIGS. 2A, 2B and 2C are velocity profiles illustrative of different embodiments of the invention;

FIG. 3 is a schematic diagram of control apparatus constructed according to an embodiment of the invention in which the speed pattern signals of a plurality of elevator cars may be individually modified responsive to peak and light traffic modes, as well as being modified on a collective or bank basis;

FIG. 4 is a graph which illustrates indirect sensing of traffic intensity, utilizing a system clock synchronized with anticipated traffic demand;

FIGS. 5 and 6 are schematic diagrams of apparatus constructed according to an embodiment of the invention in which the elevator cars of a bank of elevator cars have their speed pattern signals modified responsive to light and peak traffic modes, as a bank; and

FIG. 7 is a schematic diagram of a speed pattern generator constructed to be responsive to the control apparatus shown in FIG. 3.

DESCRIPTION OF PREFERRED EMBODIMENTS

Referring now to the drawings, and FIG. 1 in particular, there is shown an elevator system constructed according to the teachings of the invention. The present invention may be employed in various types of elevator systems. For purposes of example, it will be described as applied to an elevator system which is similar to that disclosed in U.S. Pat. Nos. 2,874,806 and 3,207,265, which are assigned to the same assignee as the present application, and are hereby incorporated into the present application by reference.

In U.S. Pat. No. 2,874,806 the actual speed of the elevator car is determined by the control of an element such as a lever which is movable with respect to a supporting structure. The element is electromagnetically coupled to the elevator car motor for the purpose of applying a force acting between the element and the supporting structure which is dependent upon the speed of the elevator car. A second force in the opposition to the first force is applied between the element and the supporting structure to serve as a reference or pattern representing the desired motor speed. The second force is produced by a second electric or pattern

motor which is energized in accordance with the desired speed and position.

The resultant movement or deflection of the element controls the energization of the elevator car motor and, as a result, the speed and position of the elevator car. Thus, the car motor may be of the direct current type and may have its armature coupled to the armature of a direct current generator to form a variable voltage or Ward Leonard control system. The resultant movement of the element is utilized to control the field excitation of the direct current generator. In the event a static power supply, such as a dual bridge converter, is used to power the direct current drive motor, the output of this pattern system is applied to a resistor and the resulting voltage compared with the feedback voltage from a tachometer generator driven by the drive motor. The difference voltage is used as an error signal which controls the firing angle of the controlled rectifier devices of the dual bridge converter.

Improvements in certain characteristics of the apparatus disclosed in U.S. Pat. No. 2,874,806 are disclosed in U.S. Pat. No. 3,207,265. The improvement patent discloses a continuously variable acceleration transducer, which provides a pattern current for the pattern motor, which accelerates the elevator car at a substantially constant rate according to a predetermined acceleration schedule. The acceleration transducer includes a pair of back-to-back connected controlled rectifiers whose conduction of current is regulated through control of their firing angles by a variable phase gate signal supplied by a pulse generator.

Only the parts of the elevator system disclosed in these patents which are necessary to understand the present invention wil be described in detail, as the patents may be referred to if additional operational details are desired.

While the invention is described with an electromechanical floor selector and an electromagnetic speed pattern generator, it is to be understood that the invention is equally applicable to solid state floor selectors and speed pattern generators, such as those disclosed in U.S. Pat. Nos. 3,750,850 and 3,774,729, respectively, which are assigned to the same assignee as the present application.

More specifically, FIG. 1 is a partially schematic and partially diagrammatic view which illustrates an elevator motor 1 secured to the upper surface of a floor 3, which may be located in the penthouse of a building or structure being served by the elevator system. The elevator motor 1 has a traction sheave 5 secured to its shaft 6. A secondary or idler sheave 9 is secured to the lower surface of the penthouse floor 3. A control unit 10 is operated by the shaft 6 of motor 1. This control unit is employed in controlling the speed of the motor 1.

An elevator car 11 is mounted for movement in a hoistway 13 to serve the various floors or landings of the building associated therewith. The elevator car is connected to a counterweight 15 by means of one or more ropes or cables 17, which pass around the traction sheave 5 and the secondary sheave 9 in a conventional manner. At each floor served by the elevator car, a hoistway or floor door 19 is provided. In addition, the elevator car has a gate 21 which registers with the hoistway door at any floor at which the elevator car is stopped. The doors of the gate may be of conventional construction and may be operated automatically in any conventional way.

In order to register calls for floors desired by passengers traveling in the elevator car, a plurality of car call buttons 27 are provided.

An up pushbutton 3U is provided at the third floor 3F for operation by a person desiring transportation in the up direction. A similar pushbutton would be provided at each of the floors from which a person may desire to travel in the up direction. A down pushbutton 3D is provided at the third floor which may be operated by a person desiring to travel in the down direction. A similar pushbutton would be located at each floor from which a person may desire transportation in the down direction.

Control of certain functions of the elevator car is provided by a floor selector 23 which conveniently may be mounted on the penthouse floor 3. This floor selector has two drive inputs supplied thereto. One is a drive input by an advance motor AM located on the top of the floor selector. The second drive input is supplied for the purpose of driving the floor selector in accordance with movement of the elevator car. Such a drive unit may be provided in any desired manner. For example, the drive may be of the self-synchronous type. Such a drive includes a transmitter or generator SG, which is electrically connected to a receiver or motor SM. The transmitter or generator SG is coupled to the secondary sheave 9 through suitable gearing 25.

The floor selector 23 may be of any suitable type. Conveniently it may be similar to the floor selector described in the aforesaid U.S. Pat. No. 2,874,806 and in U.S. Pat. No. 2,657,763 referenced to in the former patent, and such a floor selector is illustrated generally in FIG. 1.

The control circuitry for floor selector 23 is shown generally at 30.

Car calls, as registered by the pushbutton array 27 are recorded in car call control 32 and directed to the floor selector control 30.

Corridor or floor calls are recorded in the corridor call control 34. The corridor calls are directed to the floor selectors of the various cars, according to the desired supervisory strategy, via a system processor 36. The specific supervisory strategy is not important to the understanding of the invention, and it is not disclosed in detail. Reference may be made to U.S. Pat. Nos. 3,256,958 and 3,292,736, which are assigned to the same assignee as the present application, for supervisory systems which may be used.

A speed pattern generator 38, which is shown in detail in FIG. 7, provides a speed pattern for drive control 40, in response to the floor selector 23 and its control 30. The drive control 40 controls the speed of the elevator drive motor 1 in response to the speed pattern provided by the speed pattern generator 38.

In accordance with the teachings of the invention, a pattern modifier 42 modifies the speed pattern signal provided by the speed pattern generator 38, in response to one or more predetermined conditions related to the intensity of demand for elevator service. When the demand for elevator service is below a predetermined level, the pattern modifier 42 provides a signal which limits to a first maximum value a parameter related to the movement of the elevator car with respect to time, such as velocity, acceleration, or jerk, or any combination of velocity, acceleration and jerk.

When the demand intensity reaches a predetermined level, the pattern modifier provides a signal which allows the controlled parameter, or parameters, to be increased to a higher maximum value on the next run of the elevator car.

The pattern modifier **42** may be responsive to one or molre parameters related to the intensity of demand for elevator service, with FIG. **1** indicating, by way of example, a clock **44** synchronized with anticipated traffic demands during a typical day, providing a signal TD-1 which indicates whether the anticipated traffic is below or above a predetermined level. Additional examples, also shown in FIG. **1,** include: (a) a signal WT-1 from load weighing means **46** on each car, which signal indicates whether the load in the associated elevator car is below or above a predetermined value related to the capacity of the elevator car; (b) a signal TO-1 from the system processor **36** for each elevator car which indicates whether the elevator car has been assigned to answer a priority call, such as a timed out call; (c) a signal NC-1 to all elevator cars from a corridor call counter **48** which counts unanswered corridor calls in the system at any instant, with the signal NC-1 indicating whether the number of such calls is below or above a predetermined magnitude; and (d) a signal TTO-1 from corridor call timers, shown generally at **50,** which indicate whether any corridor call has been registered for a predetermined period of time.

FIGS. **2A, 2B** and **2C** each indicate normal and modified speed pattern signals which may be provided according to different embodiments of the invention. As shown in FIG. **2A,** the speed pattern signal starts at zero when the car is at rest. When the elevator car is requested to accelerate, the speed pattern signal goes through an initial phase I during which the car is accelerated to a predetermined maximum constant acceleration rate, with a predetermined maximum rate of change of acceleration or jerk. Phase II is the constant acceleration phase of the speed pattern signal, and when the maximum speed or velocity of the speed pattern signal is approached, the speed pattern enters phase III which provides a smooth transition between the constant acceleration phase II and the constant velocity phase IV. Phase III is also controlled to a maximum level of jerk. When the elevator car is to stop at a floor, the speed pattern enters phase V which provides a jerk controlled transition between the constant velocity phase IV and a constant deceleration phase VI. As the elevator car nears the selected floor, the speed pattern enters a jerk controlled transition phase VII, which brings the car from constant deceleration to zero speed at floor level.

In a first embodiment of the invention, illustrated in FIG. **2A,** the acceleration phase II is modified to a lower maximum value during light traffic demand, to provide a pattern modification indicated at **54.** The rate of change of acceleration in phases I and III may also be reduced in this embodiment of the invention.

In the embodiment of the invention shown in FIG. **2B,** the constant velocity phase IV is reduced to a lower magnitude, indicated by curve portion **56,** during periods of light traffic.

In the embodiment of the invention shown in FIG. **2C,** the maximum acceleration rate and the maximum velocity, phases II and IV, respectively, are both reduced during periods of light traffic, and the maximum jerk in phases I and III may also be reduced. The modified portion of the speed pattern signal is indicated at **58.**

In the embodiments of the invention shown in FIGS. **2A, 2B** and **2C,** the maximum deceleration rate for the normal mode is unchanged during the light traffic mode, as the amount of energy restored to the electrical system is relatively independent of the rate of deceleration. However, the maximum deceleration rate may be reduced during the light traffic mode, if desired, as the I^2R losses in the armature of the drive motor **1** would be less when the maximum deceleration rate is reduced.

FIG. **3** is a schematic diagram of a pattern modifier circuit **42,** which may be used for the pattern modifier **42** shown in block form in FIG. **1.** The pattern modifier **42** shown in FIG. **3** is for an embodiment of the invention which enables the elevator cars to be individually and/or collectively switched between the normal and light traffic modes, and as such each elevator car would require a similar pattern modifier.

The pattern modifier **42** is illustrated as being responsive to the same traffic indicators shown in FIG. **1,** with the relay contacts shown in FIG. **3** which correspond to the functions shown in FIG. **1** being indicated with the same references. It is to be understood that only one of the traffic indicators need be used, or any number of the traffic indicators in different combinations, or traffic indicators may be used which have not been specifically mentioned.

The control means of pattern modifier **42** which indicates which speed pattern should be generated by the associated speed pattern generator **38** is a relay SP. When relay SP is deenergized it provides a signal, i.e., condition of its associated contacts, which indicates that the speed pattern generated is for the normal traffic conditions, which include peak traffic, and when it is energized its contacts are in the condition which indicate the speed pattern should be switched to the light traffic mode. This arrangement is preferred since if relay SP fails to pick up for some reason, the elevator system would operate with its normal speed pattern signal. However, the circuit could be arranged to deenergize relay SP for the light traffic mode, and to energize relay SP for the normal mode, if desired.

Relay SP is connected to be energized between the electrical conductors L1 and L2, which conductors are connected to a suitable source of electrical potential. The electromagnetic coil of relay SP is connected between conductors L1 and L2 via the contacts of the control means which are related to the intensity of the demand for elevator service.

Contacts TD-1, WT-1, TO-1 and NC-1 are associated with the traffic level indicators, and they, along with contacts **32-1** and **T2-1,** are all serially connected with relay SP between conductors L1 and L2. Contacts TD-1, WT-1, TO-1 and NC-1 are closed when the demand for elevator service is below a predetermined level, and they open in response to their associated detector to indicate traffic at and above a predetermined level.

Contact TD-1 is responsive to the clock **44** shown in FIG. **1,** with clock **44** being synchronized to operate its contacts TD-1 open and closed in response to anticipated traffic demand based upon the operating history of the elevator system. FIG. **4** is a graph which illustrates a traffic demand profile typical of office build-

ings. Contact TD-1 is closed, except for the morning, noon and evening traffic peaks.

Contact WT-1 is responsive to the load weighing means 46 shown in FIG. 1, with contact WT-1 being closed except when the elevator car is loaded to a predetermined percentage of its capacity.

Contact TO-1 is closed except when the system processor assigns the elevator car to serve a priority call, such as a timed out floor call.

Contact NC-1 is closed until the number of unanswered floor calls reaches a predetermined number, at which time contact NC-1 opens.

It will be noted that contacts WT-1 and TO-1 are car related, and their operations would selectively switch the associated elevator car from one mode to the other. They could be made system signals by OR'ing all of the load weighing means of the various elevator cars, to provide a signal WT-1 to all cars simultaneously when any car becomes loaded, and by providing signal TO-1 to all cars when any call becomes timed out, or when any car is specifically assigned to a priority call.

Contact T2-1 is a normally closed contact operated by a timer T2. Timer T2 is not essential to the invention. If used, it prevents the system from switching to the light traffic mode until a predetermined period of time has elapsed since the system switched to the normal mode. In like manner a timer T1 has a normally open contact T1-1 which prevents the system from switching to the speed pattern associated with the normal traffic mode until a predetermined period of time has elapsed since the system switched to the speed pattern associated with the light traffic mode. Contact T1-1 is connected across the serially connected contacts TD-1, WT-1, TO-1, NC-1 and T2-1.

Timer T1 is responsive to the voltage across the electromagnetic coil of relay SP, starting the timed closure of contact T1-1 when voltage is initially applied across relay SP, preventing the traffic responsive contacts from affecting the condition of relay SP until timer T1 times out and opens its contact T1-1.

Timer T2 is also responsive to the voltage across relay SP, starting the timed opening of contact T2-1 when voltage is removed from relay SP, preventing the traffic responsive contacts from affecting the condition of relay SP until timer T2 times out and closes contact T2-1.

Timers T1 and T2 prevent frequent switching between speed pattern signals due to momentary changes in traffic conditions, but the timers are not essential to the invention if frequent switching between the speed patterns is not objectionable. Further, these timers would not be required if the only traffic related signal used is the signal from clock 44.

Contacts 32-1 and 32-2 are operated by a relay 32 (not shown), which is related to car movement. Relay 32 is dropped out when the car is stationary at a floor, and it picks up at the start of a run and remains energized until the car completes its run and is again stationary at a floor. Contacts 32-1 and 32-2 are connected to retain the speed pettern mode existing at the start of the run, throughout the complete run, regardless of a change in the condition of a traffic related contact.

Contact 32-1 is a normally closed contact which is serially connectd between relay SP and the string of serially connected traffic related contacts, and the timer contact TD-1; and, contact 32-2 is a normally open contact which is connected across the serial string of traffic related contacts and the timer contact T2-1. A normally open seal-in contact SP-1 of relay SP is connected across contact 32-1.

In the operation of the pattern modifier 42, with the car at rest and both timers T1 and T2 timed out, and little or no demand for elevator service in the system, the contacts will be in the condition shown in FIG. 3, and relay SP will be energized. The contacts of relay SP in the speed pattern generator 38 will thus set the speed pattern for the light traffic mode, in which one or more parameters related to the movement of the car with respect to time will be reduced, compared with the normal operating mode of the elevator. Contact SP-1 will be closed. If the elevator car is requested to move to answer a car or floor call, relay 32 will pick up and contact 32-1 will open. Relay SP will be held in, however, through contact SP-1, and the serially connected contacts TD-1, wt-1, TO-1, NC-1 and T2-1. As soon as relay 32 picks up, its contact 32-2 closes to thus render contacts TD-1, WT-1, TO-1, NC-1 and T2-1 ineffective for the duration of the run, as the circuit through relay SP will be maintained through contacts SP-1 and 32-2.

If one of the traffic related contacts should open during the run, relay SP will be held in until the car stops and relay 32 drops out. Relay SP will then drop out when the car completes its run, and its contacts in sthe speed pattern generator will now be in a condition to provide a signal which sets the speed pattern for the normal or peak traffic mode. When relay SP drops out, timer T2 opens its contact T2-1 for a predetermined period of time, and even if the traffic related sensor which initially opened its contact to drop out relay SP should reclose its contact, it will have no circuit affect until contact T2-1 closes at the end of the timed period. With relay SP deenergized at the start of a run, its seal-in contact SP-1 will be open, and when relay 32 picks up at the start of the run, its contact 32-1 will open. Thus, relay SP will be deenergized for the duration of the run.

Assuming timer T2 times out and closes its contacct T2-1, and the traffic related contacts are all closed, when the elevator stops contact 32-1 will close to pick up relay SP, contact SP-1 of relay SP will close, and the contacts of relay SP in the speed pattern generator 38 will prepare the speed pattern signal for the light traffic mode. Timer T1 also closes its contact T1-1 to hold relay SP in the light traffic mode for at least the time period of timer T1.

If selectively switching the modes of the cars is not required, or desired, they may be switched as a bank by using a bank program modifier, and a per car program modifier, as shown in FIGS. 5 and 6, respectively. The bank program modifier referred to with reference numeral 60 in FIG. 5 has an auxiliary relay SPX, which controls the operation of relay SP in the per car modifier 42' shown in FIG. 6. The bank modifier 60 is similar to the per car program modifier 42 shown in FIG. 3, except contacts 32-1 and 32-2 are not required, and a seal-in contact for relay SPX is not required. Also, all of the traffic responsive contacts are system related. The load related contacts are referenced TWT-1 to distinguish it from the specific car related contaccts WT-1 of FIG. 3. Contacts TWT-1 may open, for example, when any elevator car in the system becomes loaded, or any two cars, etc. The contacts related to priority calls are referenced TTO-1 in FIG. 6, to distinguish it

from the "assigned to a priority call" contact TO-1 of FIG. 3. Contact TTO-1 may close, for example, when a call, or a predetermined number of calls time out, or when any elevator car is assigned to a timed out call, etc.

In the operation of the bank program modifier of FIG. 5, relay SPX drops out when the traffic level reaches a predetermined magnitude, and it picks up when the traffic level drops to a predetermined magnitude, subject only to switching delays which may be imposed by timers T1 and T2. In other words, relay SPX is operated to either condition without regard as to whether or not elevator cars are operating at that time.

The per car control 42' shown in FIG. 6 translates an operation of relay SPX into an operation of the relay SP associated with the various cars, when each car has completed a run and is standing at a floor. A normally open contact SPX-1 of relay SPX replaces the serial string of contacts TD-1, WT-1, TO-1, NC-1 and T2-1 of FIG. 3, and timers T1 and T2 are not required because their function is provided by the timers with these references in the bank speed pattern modifier 60.

When contact SPX-1 is open at the start of a run, contacts SP-1 and 32-1 will be open for the duration of the run, preventing the energization of relay SP if contact SPX-1 should close during the run. If SPX-1 is closed at the start of a run, relay SP will be energized and when the run starts, contact 32-2 will close to hold relay SP in throughout the run, even though contact SPX-1 should open during the run.

FIG. 7 is a schematic diagram of a speed pattern generator 38 which may be used for the speed pattern generator 38 shown in block form in FIG. 1. The speed pattern generator shown in FIG. 7 has been taken from FIG. 4A of the hereinbefore mentioned U.S. pat. No. 3,207,265, which has been incorporated into this application by reference, with this FIG. 4A being modified by contacts SP-2 and SP-3 of relay SP, of either the FIG. 3 or FIG. 6 embodiment. Contact SP-2 is a normally closed contact connected to reduce the magnitude of the maximum acceleration in the speed pattern signal when relay SP is energized, and contact SP-3 is a normally open contact connected to reduce the maximum velocity level of the speed pattern signal when relay SP is energized. When relay SP is deenergized, the acceleration and velocity portions of the speed pattern signal return to their higher maximum values. Jerk control is not shown in FIG. 7, but it will be obvious from the discussion of FIG. 7 how maximum jerk may be reduced during light traffic periods, if desired.

Only the portions of FIG. 7 necessary to understand the invention will be described, as reference may be made to U.S. Pat. No. 3,207,265 if additional operational details of the remaining circuitry is desired.

More specifically, FIG. 7 illustrates an acceleration transducer or device which controls the current delivered to the pattern motor winding during acceleration of the elevator car. It is desirable for current in this winding to increase linearly with respect to time, thereby bringing the elevator car up to full speed at a substantially constant rate of acceleration. When full speed is reached, it is necessary for the acceleration device to remain fully conductive so that it no longer has control over current in the pattern motor winding.

The acceleration device includes a pair of solid state controlled rectifiers 371 and 373 connected in antiparallel or back-to-back at terminals 374 and 376. Terminal 374 is connected to an input terminal of the pattern rectifier 359 and terminal 376 is connected to a movable tap 361A on an autotransformer 361. The tap 361A is adjusted to set the desired operating level of the pattern current rectifier 359. The gate and cathode electrodes of controlled rectifier 371 are connected across a secondary winding of a pulse transformer 375, and the gate and cathode electrodes of controlled rectifier 373 are connected across another secondary winding of the transformer 375.

Control of conduction of current in the forward direction by the controlled rectifiers 371 and 373 is accomplished by means of the remaining components associated with the acceleration device. These components form a pulse generator which determines the firing angle of the controlled rectifiers by supplying a variable phase gate signal to the primary winding of the pulse transformer 375. The components preferably include various solid state or semiconductor devices such as a transistor 377, a unijunction transistor 379 and two Zener diodes 383 and 385. The unijunction transistor 379 has an emitter electrode E, a first base electrode B1 and a second base electrode B2. The pulse generator employs feedback and thus incorporates means to regulate current buildup in the pattern motor winding to maintain a constant rate of change of such current.

A rheostat 387 may be adjusted to control the rate on increase of the output current of the controlled rectifiers 371 and 373. The adjustment of rheostat 387 determines the value of command current I_c which flows in an error signal resistor 388 in the direction indicated and which is constant for a given setting of the rheostat 387. A resistor 389 may be connected in series with the rheostat 387 to limit the maximum value to which the current I_c may be adjusted by means of the rheostat. This current is derived from a supply which includes a transformer 390, a full-wave rectifier 391, a limiting resistor 393, a blocking diode 395, and a filter capacitor 397. Energy for the primary winding of the transformer 390 may be supplied by the autotransformer 361.

A resistor 70, which may be adjustable if desired, is connected between rheostat 387 and an output terminal of rectifier 391. The normally closed contact SP-2 is connected across resistor 70. Thus, when relay SP is deenergized, resitor 70 is shorted by contact SP-2 and the acceleration rate follows that of the normal speed pattern signal. When relay SP is energized to indicate the light traffic mode of the speed pattern signal is desired, contact SP-2 opens to insert resistor 70 into the acceleration circuit and reduce the maximum value of acceleration according to the magnitude selected for this resistance.

Negative feedback current I_f flows through the resistor 388 in the direction indicated and is proportional to the rate of buildup of voltage across the pattern rectifier 359 and thus across the pattern motor winding through the differentiating action of a feedback capacitor 399. It will be observed that one terminal of the capacitor 399 is connected directly to the positive output terminal of rectifier 359, while the other terminal of the capacitor is connected to the negative output terminal of the rectifier 359 through the resistor 388. A filter capacitor 401 is connected across resistor 388.

The command current I_c and the feedback current I_f flow in opposite directions through the resistor 388. Thus, the voltage across this resistor is proportional to the difference between these currents, i.e., the net or

error signal current I_c—I_f. This voltage through a filter network comprising serially connected capacitor **403** and resistor **405** controls the magnitude of the collector electrode current in the transistor **377.** The base electrode of the transistor is connected to one side of the capacitor **403** through a resistor **407,** while the emitter electrode is connected to the other side of the capacitor through a temperature compensating resistor **409.** The transistor **377** in turn controls the magnitude of the current which flows to charge a capacitor **411.**

When the voltage across capacitor **411,** i.e., the voltage between the unijunction transistor emitter and base electrode, reaches a predetermined value for a given value of voltage between the base electrodes B1 and B2, the unijunction transistor triggers or fires, and the capacitor **411** discharges through the emitter electrode E, the base electrode B1 and the primary winding of the pulse transformer **375.** The voltage pulse produced across the primary winding as a result thereof is applied between the gate and cathode electrodes of the controlled rectifiers **371** and **373** by means of the secondary windings of the pulse transformer. Thus, the controlled rectifier which is forward biased when the pulse is applied will fire or conduct current in the forward direction from its anode to its cathode electrode.

Assuming that the alternating supply voltage has a frequency of 60 Hz., if the voltage across the capacitor **411** does not reach the aforesaid predetermined value within 8.3 milliseconds (one-half cycle), of the alternating supply voltage, the unijunction transistor **379** and consequently the controlled rectifiers **371** and **373** will not fire, and the controlled rectifiers will conduct substantially no current. On the other hand, if the voltage across capacitor **411** reaches such predetermined value to fire the unijunction transistor within about 1 millisecond, each of the controlled rectifiers will conduct current fully, for all practical purposes, during that half cycle of the alternating supply voltage when its anode electrode is positive with respect to its cathode electrode.

The pulse generator thus controls the conduction of the controlled rectifiers and thus the output of the pattern rectifier **359** to increase smoothly and linearly with respect to time. When each of the controlled rectifiers conducts fully over alternate half cycles of the supply voltage, current supplied by the pattern rectifier to the pattern motor winding arrives at its maximum value, and the elevator car reaches full speed. At this time, the feedback current I_f becomes zero, since the output of the rectifier **359** no longer is changing, and the command current I_c flowing in the resistor **388** maintains full conduction of each of the controlled rectifiers over alternate half cycles of the supply voltage.

Contact SP-3 of relay SP and a Zener diode **72** are serially connected across the output terminals of the pattern rectifier **359.** When relay SP is deenergized during the normal traffic mode, contact SP-3 and the Zener diode **72** have no circuit affect. During light traffic when relay SP is energized, Zener diode **72** limits the output voltage of the pattern rectifier **359,** with the breakdown voltage of Zener diode **72** being selected to provide the desired maximum car velocity during the light traffic mode.

In summary, there has been disclosed a new and improved elevator system which operates with a speed pattern signal which provides normal jerk, acceleration and velocity magnitudes when the system traffic is above a predetermined magnitude, with the speed pattern automatically switching to a mode during periods of light traffic, which mode reduces one or more parameters associated with the movement of the car with respect to time. This change in speed pattern in response to demand for elevator traffic reduces the I^2R losses and heating of the drive motor and drive source, it reduces friction and windage losses, it flattens the power usage curves, during those periods when reduced car velocity, acceleration, and/or jerk can be tolerated, and it accomplishes these benefits without undue adverse affect on elevator service. Reduced maximum acceleration and velocity of the elevator car during light traffic will also enable the car to intercept more calls for a given run, operating each car with a higher load per run, thus requiring fewer runs during periods of light traffic, which also conserves electrical power.

I claim as my invention:

1. An elevator system, comprising:

an elevator car mounted for movement in a structure having a plurality of floors,

motive means for moving said elevator car to serve the floors,

means for registering requests for elevator service,

control means providing a speed pattern signal for said motive means, to direct the movement of the elevator car with respect to time in accordance with the speed pattern signal,

and modifying means related to the intensity of demand for elevator service, modifying the speed pattern signal provided by said control means in response to the intensity of demand for elevator service.

2. The elevator system of claim **1** wherein the modifying means includes a clock synchronized according to anticipated demands for elevator service.

3. The elevator system of claim **1** wherein the modifying means includes counting means responsive to the number of requests for elevator service.

4. The elevator system of claim **1** including timing means for timing the registration times of at least certain of the requests for elevator service, with the modifying means including said timing means.

5. The elevator system of claim **1** including load responsive means for determining the load in the elevator car relative to its capacity, with the modifying means including said load weighing means.

6. The elevator system of claim **1** including means responsive to the status of the elevator car, preventing the modification of the speed pattern by the modifying means when said modification would result in a step in the speed pattern signal.

7. The elevator system of claim **1** wherein the modifying means provides at least first and second signals related to the intensity of demand for elevator service, providing a speed pattern signal having a predetermined profile when the demand for elevator service is light, and with the second signal modifying at least one parameter of the speed pattern signal by increasing the magnitude thereof, when the demand for elevator service increases to a predetermined level.

8. The elevator system of claim **7** wherein the at least one parameter of the speed pattern modified by the second signal is the maximum velocity portion of the speed pattern signal.

9. The elevator system of claim 7 wherein the at least one parameter of the speed pattern signal modified by the second signal is the maximum acceleration portion of the speed pattern signal.

10. The elevator system of claim 1 including timing means responsive to the modification of the speed pattern signal for preventing a subsequent modification thereof for a predetermined period of time.

11. An elevator system, comprising:

a plurality of elevator cars mounted for movement in a structure having a plurality of floors,

motive means for each of said elevator cars for moving their respective elevator cars to serve the floors,

means for registering requests for elevator service,

control means for each of said elevator cars, providing a speed pattern signal for its associated motive means, to direct the movement of the associated elevator car with respect to time in accordance with the speed pattern signal,

and modifying means related to the intensity of demand for elevator service, modifying the speed pattern signal provided by each of said control means in response to the intensity of demand for elevator service.

12. The elevator system of claim 11 wherein the modifying means includes means for selectively modifying the speed pattern signals associated with the plurality of cars, according to the intensity of demand for service made on each individual elevator car.

13. An elevator system, comprising:

an elevator car mounted for movement in a structure having a plurality of floors,

motive means for moving said elevator car to serve the floors,

means for registering requests for elevator service,

means for canceling requests for elevator service when a request for service is answered,

first control means to alternatively generate first and second signals for said motive means, said first signal limiting to a first maximum value, a first parameter related to the movement of the elevator car with respect to time, and said second signal limiting the first parameter to a second maximum value, which exceeds the first maximum value,

second control means operable between first and second conditions in response to a second parameter related to the intensity of demand for elevator service, with the first and second conditions indicating demands below and above a predetermined level, respectively,

said first control means being responsive to said second control means, providing the first signal when said second control means is in its first condition, to limit the first parameter to the first maximum value, and providing the second signal when said second control means is in its second condition, to limit the first parameter to the second maximum value.

14. The elevator system of claim 13 wherein the first parameter is the velocity of the elevator car.

15. The elevator system of claim 13 wherein the first parameter is the acceleration of the elevator car.

16. The elevator system of claim 13 wherein the second parameter is the anticipated demand for elevator service based on time, and the second control means includes a clock synchronized with this parameter such that it operates in its first condition during the time of day that the intensity of demand for elevator service is normally below a predetermined level, and it operates in its second condition when the intensity of demand normally is at and above this level.

17. The elevator system of claim 13 wherein the second parameter is the number of unanswered requests for elevator service which exist at any given time, and the second control means includes counting means for determining the current number of such requests.

18. The elevator system of claim 13 including timing means for timing the registration times of at least certain of the requests for elevator service, and wherein the second parameter is related to the registration times of the requests, and the second control means is responsive to said timing means.

19. The elevator system of claim 13 including load responsive means for determining the load in the elevator car relative to its capacity, and wherein the second parameter is related to the magnitude of said load, and the second control means is responsive to said load responsive means.

20. The elevator system of claim 13 wherein the means for registering requests for elevator service includes floor call means for registering requests for elevator service from at least certain of the floors, and car call means for directing the elevator car to the selected floors in response to requests by passengers in the car, the second parameter is the number of of unanswered requests for elevator service from said floor call means, and the second control means includes counting means for determining the current number of such requests.

21. The elevator system of claim 20 wherein the second parameter also includes the number of unanswered requests from said car call means.

22. The elevator system of claim 13 including means responsive to the first control means, preventing the first control means from generating a predetermined one of its signals for a predetermined period of time after switching to the opposite one of its signals.

23. The elevator system of claim 13 including means responsive to the first control means of the elevator car, and to the status of the elevator car, preventing a change in the signal generated by the first means from affecting the motive means until the elevator car has completed a run.

24. An elevator system, comprising:

a plurality of elevator cars, each of said elevator cars mounted for movement in a structure having a plurality of floors,

motive means for each of said elevator cars for moving their respective elevator cars to serve the floors,

means for registering requests for elevator service,

means for canceling a request for elevator service when the request for service is answered,

first control means for each of said elevator cars, said first control means alternatively generating first and second signals for its associated motive means, said first signal limiting to a first maximum value a first parameter related to movement of its associated elevator car with respect to time, and said second signal limiting the first predetermined parameter to a second maximum value, which exceeds the first maximum value,

and second control means for each of said elevator cars, said second control means being operable be-

tween first and second conditions in response to a second parameter related to the intensity of demand for elevator service, with the first and second conditions indicating demand below and above a predetermined level, respectively,

said first control means being responsive to said second control means, providing the first signal when its associated second control means is in its first condition, to limit the first parameter to a first maximum value, and providing the second signal when said second control means is in its second condition, to limit the first parameter to the second maximum value.

25. The elevator system of claim **24** wherein the first parameter is velocity.

26. The elevator system of claim **24** wherein the first parameter is acceleration.

27. The elevator system of claim **24** including timing means for timing at least certain of the requests for elevator service and indicating when a request for elevator service has been registered for a predetermined period of time,

assignment means assigning an elevator car to a request for elevator service which has been registered for the predetermined period of time,

and wherein the second parameter is the assignment of the elevator car to a request for service which has been registered for the predetermined period of time, with the second control means being in its first condition when its associated elevator car is not assigned to such a request, and in its second condition when it is.

28. The elevator system of claim **24** including load responsive means for each of the plurality of elevator cars for determining the load in its associated elevator car relative to its capacity, and wherein the second parameter is related to the magnitude of said load, and the second control means is responsive to said load responsive means.

29. The elevator system of claim **24** including timing means operable from a first condition to a second condition at predetermined times synchronized with the anticipated peak demands for elevator service in the structure, providing the first condition during periods when peak demands are not anticipated and the second conditions when peak demands are anticipated, and wherein the first control means of said plurality of elevator cars are responsive to said timing means to provide the first signal in response to the first condition of said timing means and the second signal in response to the second condition of said timing means.

30. The elevator system of claim **24** including means responsive to the first means, preventing the first means from generating a predetermined one of its signals for a predetermined period of time after switching to the opposite one of its signals.

31. The elevator system of claim **24** including means responsive to the first control means of each of the elevator cars, and to the status of each of the elevator cars, preventing a change in the signal generated by the first means from affecting the associated motive means until the elevator car has completed a run.

32. An elevator system, comprising:

a plurality of elevator cars, each of said elevator cars mounted for movement in a structure having a plurality of floors,

motive means for each of said elevator cars for moving their respective elevator cars to serve the floors,

means for registering requests for elevator service,

means for canceling a request for elevator service when the request for service is answered,

first control means for each of said elevator cars, said first control means alternatively generating first and second signals for its associated motive means, said first signal limiting to a first maximum value a first parameter related to movement of its associated elevator car with respect to time, and said second signal limiting the first predetermined parameter to a second maximum value which exceeds the first maximum value,

second control means operable between first and second conditions in response to a second parameter related to the intensity of demand for elevator service, with the first and second conditions indicating demand below and above a predetermined level, respectively,

said first control means of the plurality of elevator cars each being responsive to said second control means, providing the first signal when it is in its first condition, to limit the first parameter to a first maximum value, and providing the second signal when said second control means is in its second condition, to limit the first parameter to the second maximum value.

33. The elevator system of claim **32** wherein the second parameter is anticipated demand for elevator service based on time and the second control means includes a clock synchronized with this parameter to provide the first condition when the anticipated demand is below a predetermined level and the second condition when the anticipated demand is at and above the predetermined level.

34. The elevator system of claim **32** wherein the means for registering requests for elevator service includes means for registering floor calls from the plurality of floors and the second parameter is unanswered floor calls, and the second control means includes counting means for counting the number of unanswered floor calls, said second control means being in its first condition when the number of such calls is below a predetermined value, and in its second condition when the number of such calls is at and above this value.

35. The elevator system of claim **34** wherein the means for registering requests for elevator service also includes means for registering car calls from the plurality of elevator cars with the second parameter also including car calls, and the second control means includes counting means for counting the number of car calls, as well as the number of unanswered floor calls.

36. The elevator system of claim **32** including timing means for timing the registration times of at least certain of the requests for elevator service, and wherein the second parameter is related to the registration times of the requests, and the second control means is responsive to said timing means.

37. The elevator system of claim **32** including timing means for timing the registration times of at least certain of the requests for elevator service, and means for indicating when a request has been registered for a predetermined period of time, and wherein the second parameter is related to requests which has been registered

for the predetermined period of time, and the second control means switches to its second predetermined condition when a predetermined number of requests have been registered for the predetermined period of time.

38. The elevator system of claim **32** including load responsive means for determining the load in at least certain of the elevator cars relative to their capacity, and wherein the second parameter is related to the magnitude of said load, and the second control means is responsive to said load responsive means.

39. The elevator system of claim **38** wherein the load responsive means includes means for indicating when the load in its associated elevator car reaches a predetermined magnitude, with the second control means operating in its second condition when a predetermined number of cars reach this predetermined load magnitude, and otherwise operating in its first condition.

40. The elevator system of claim **32** including means responsive to the first means, preventing the first means from generating a predetermined one of its signals for a predetermined period of time after switching to the opposite one of its signals.

41. The elevator system of claim **32** including means responsive to the first control means of each of the elevator cars, and to the status of each of the elevator cars, preventing a change in the signal generated by the first means from affecting the associated motive means until the elevator car has completed at least a predetermined portion of a run.

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