

June 13, 1933.

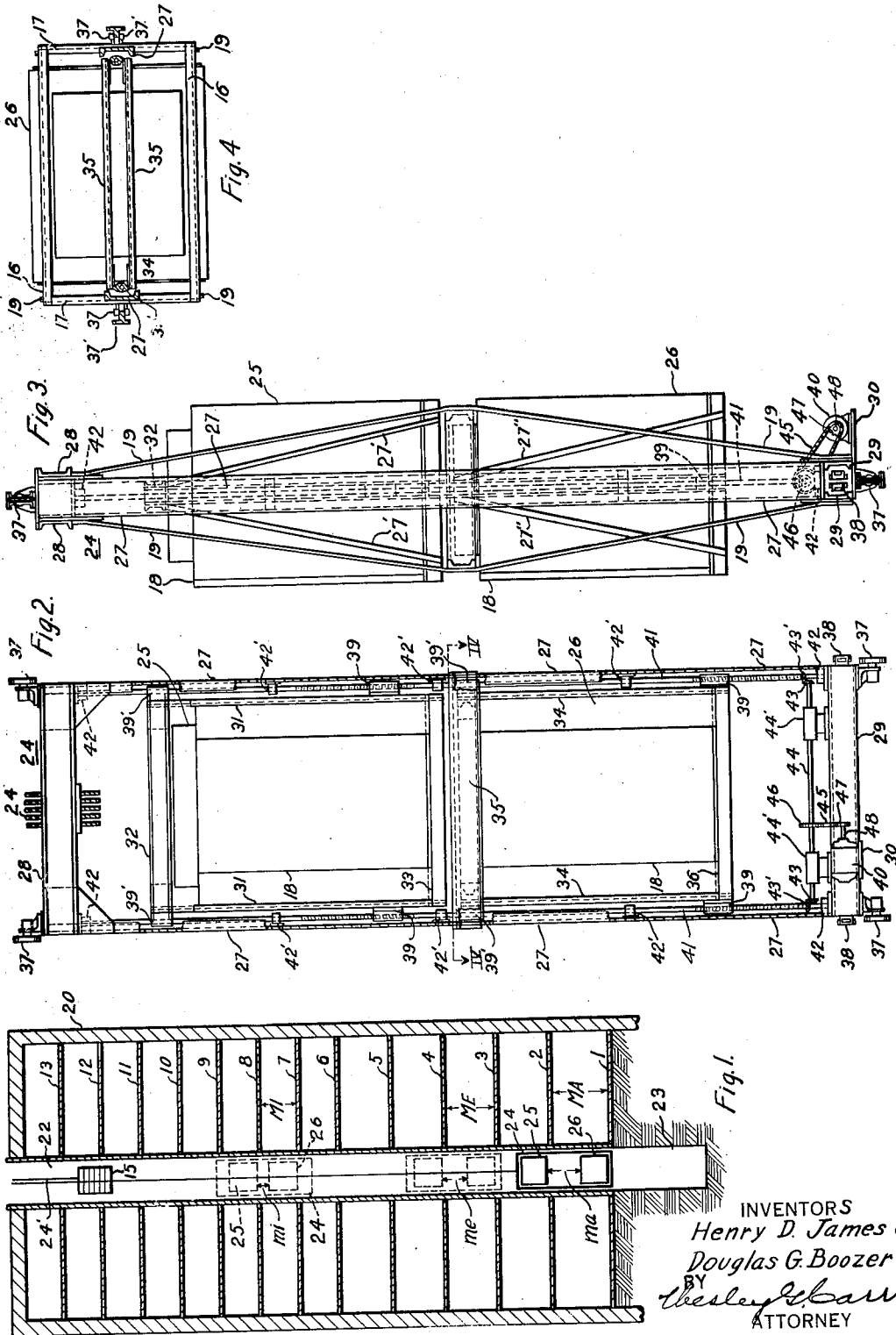
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MULTICAGE ELEVATOR

Filed Oct. 30, 1930

3 Sheets-Sheet 1



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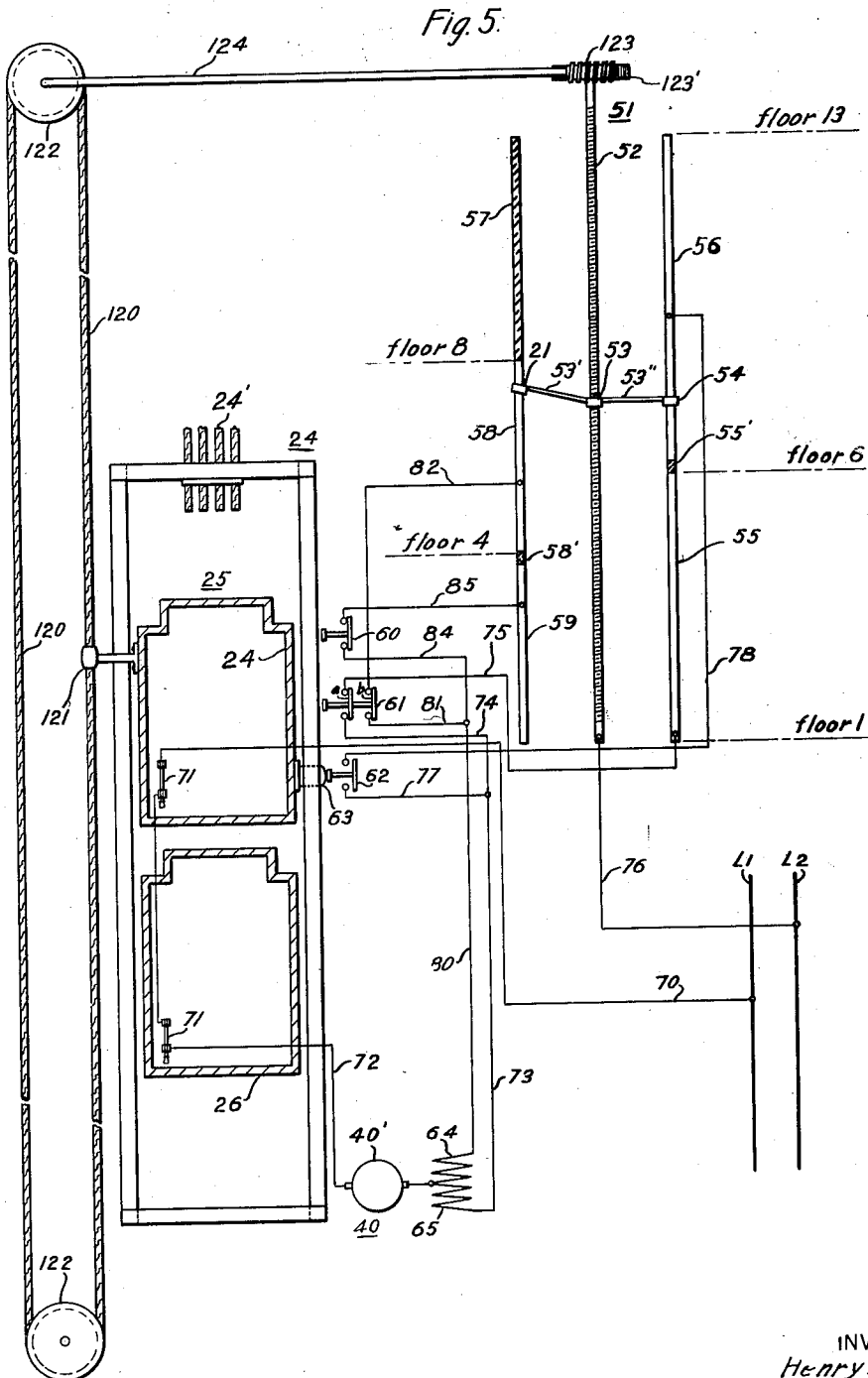
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3 Sheets-Sheet 2



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3 Sheets-Sheet 3

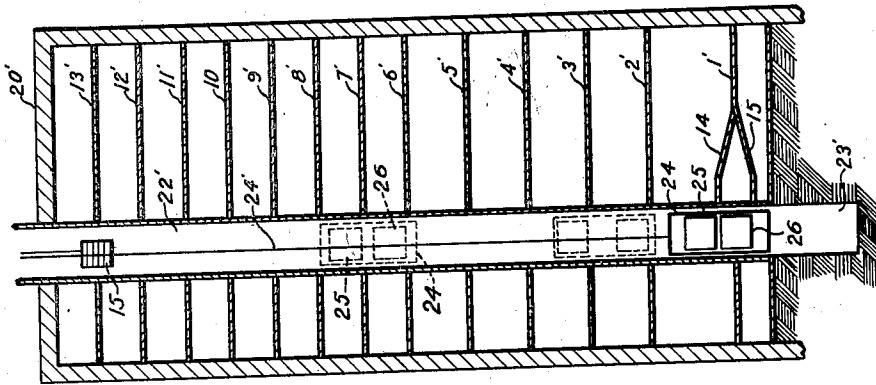
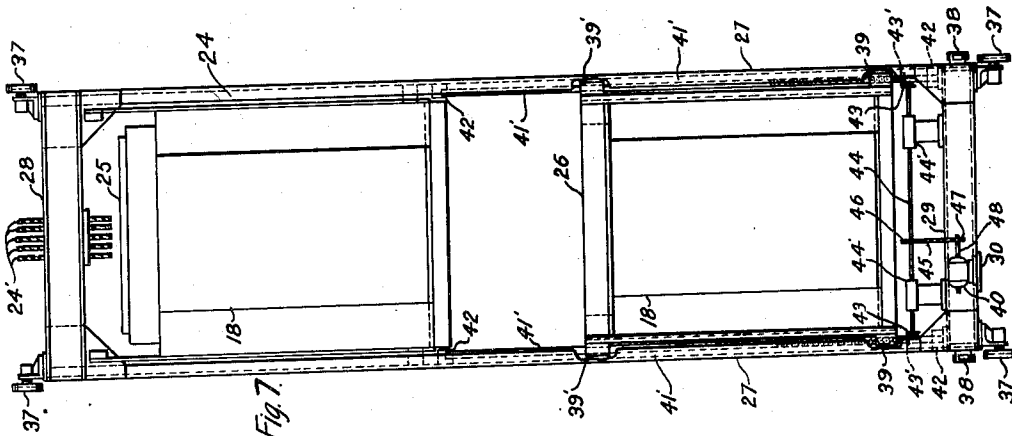


Fig. 8



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MULTICAGE ELEVATOR

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Our invention relates to elevator systems in which a plurality of cages are disposed in one hatchway and supported one above the other in a common carriage which moves all the cages simultaneously, and it has particular relation to multi-cage elevator systems of the type just mentioned in which the cages are automatically and simultaneously movable away from or toward each other, in their common carriage, during movement thereof through a hatchway in order to adjust the spacing between the cages.

The modern tall office building has presented a serious problem with respect to speed in transporting passengers from lower to higher levels, as well as to the conservation of floor space area necessary for the elevator hatchways.

As a solution of these two problems, elevator systems comprising a plurality of cages, supported one above the other in a common carriage, have been suggested. All the cages in their regular stopping positions are simultaneously aligned with adjacent floors. It will thus be understood that a multi-cage elevator system having two superimposed cages reduces the number of stopping positions necessary for one complete cycle of travel to one-half, and effects the transportation of twice as many people as does an elevator system having a single cage corresponding in size to each of the cages of the multi-cage elevator system.

In most office buildings the spacing between adjacent floors at various levels is not the same. That is, the distance between the first and second floors is usually much greater than the distance between two other floors at upper levels of the building. Ordinarily, the distance between two adjacent floors near the top of the building is less than the distance between two adjacent floors intermediate of the top and bottom of the building. Recognizing that for the practical application of a multi-cage elevator system to a building having different spacings between adjacent floors at various levels, the positions of the cages with respect to each other must of necessity be adjustable, it has been proposed to construct a common carriage for supporting two

cages, the lower cage being fixed with respect to the carriage, and the upper cage being movable with respect to the lower cage and the carriage. It has been proposed in an elevator of this type to provide a cable system and a motive means for the carriage and a separate cable system and motive means for the upper cage. Further, it has been proposed to have each of the motive means manually controllable from their respectively associated cages.

In systems of the type just described, it is necessary to level one of the cages with its stopping floor and then subsequently manually operate a control lever in the other cage to bring it to the level of its stopping floor. Obviously, such a control system is disadvantageous, both from the standpoint of depending upon the human element to level at least one of the cages, and the unnecessary waste of time and consequent inconvenience and delay to passengers resulting therefrom.

We propose to construct an elevator system of the multi-cage type in which the spacing between the cage is automatically adjusted during movement thereof through the hatchway, the adjusting being entirely completed when the cages stop so that no time need be wasted in adjustment. Furthermore, our invention for effecting this automatic adjustment of the two cages may be utilized in connection with elevator control systems of any type, although we prefer that it be employed in connection with an automatic elevator including all of the latest features of landing or levelling, as well as other features of automatically operated elevators. We prefer, also, the application of a control system to one of the cages to automatically effect the levelling of that cage with its stopping floor, and the automatic adjustment of the spacing between that cage so controlled and the other cage or cages by means of our invention, which effects the levelling of the cages, not so controlled, with their stopping floors.

It is, therefore, an object of our invention to automatically adjust the spacing between the superposed cages of a multi-cage elevator system during movement thereof.

It is another object of our invention to

movably support two or more cages in a common carriage, one cage counterbalancing another, whereby movement of the cages relative to the carriage is effected simultaneously.

5 It is another object of our invention to so construct the supporting carriage for a plurality of cages that the weight thereof is reduced without impairment in the strength thereof, and still permit the top of one cage to closely approach the bottom of another by the telescoping of the top of a cage through the frame comprising a support connecting the mid portions of the stiles of the supporting carriage.

15 It is another object of our invention to movably support a plurality of cages in a common carriage whereby a motive means for adjusting the spacing between the cages may be disposed on the carriage.

20 It is a further object of our invention to provide a control system for the cage-adjusting motive means for automatically effecting the operation thereof.

25 It is a still further object of our invention to provide a control system for the cage-adjusting motive means which comprises a selector switch movable in accordance with the movement of one of the cages.

30 Other objects of our invention will be readily understandable from the subsequent description of our invention and the attached drawings; wherein

35 Figure 1 is a diagrammatic view, in elevation, of the cross section of a building having a different spacing between adjacent floors of successive groups thereof and an elevator of the type described herein employed therewith;

40 Fig. 2 is an enlarged view, in front elevation, with parts broken away, of a preferred construction of an elevator carriage showing two superposed cages in their closest positions together and screw means for movably supporting them with one cage counterbalancing another, whereby movement of both cages relative to the carriage is effected simultaneously;

45 Fig. 3 is a view, in end elevation, corresponding to the structure shown in Fig. 2;

50 Fig. 4 is a view taken on line IV—IV of Fig. 2;

55 Fig. 5 is a diagram of the selector switch and associated control system for effecting the automatic adjustment of the spacing between the superposed cages;

60 Fig. 6 is a modification of Fig. 2 and shows a flexible member, such as a cable or chain, connecting the two superposed cages to effect the counterbalanced support in a carriage, of one by another;

65 Fig. 7 is a further modification of Fig. 2 and illustrates an elevator carriage having an upper cage fixed with respect thereto, and a lower cage movable with respect to the upper cage and the supporting carriage; and

Fig. 8 is a modification of Fig. 1 and illustrates a building having a different combination of spacing between successive floors and the method of utilizing our invention for use with the ramps at the lower terminal. 70

75 For the purpose of illustrating the method of adapting the multi-cage elevator system to a building, we have shown diagrammatically in Fig. 1 a view, in elevation, of the cross-section of a building 20, having a plurality of superposed floors numbered 1 to 13, upwardly from the bottom floor. Floors 1 and 2 are a maximum distance MA apart, adjacent floors from floors 2 to 6 are a medium distance ME apart, and adjacent floors from floors 6 to 13 are a minimum distance MI apart. 80

85 An elevator hatchway 22 extends from the bottom to the top of the building, past all of the floors, and also extends below floor 1 a short distance to constitute a well 23 for providing the necessary space for elevator operating equipment, such as safety stop bumpers.

90 A rectangular cage frame or carriage 24, in which an upper cage 25 and a lower cage 26 are movably supported in superposed relation, as will be hereinafter described, is adapted for movement up and down in the hatchway 22 by guide rail shoes 37 attached at the four corners thereof, the shoes being suitably disposed to engage guide rails 37' supported on the walls of the hatchway 22. 95

100 The carriage 24 comprises a pair of spaced apart upright channel members or stiles 27 rigidly connected together at the top by the channel members 28 and at the bottom by the channel members 29.

105 A horizontally disposed rectangular frame comprising a pair of structural channel members 16 connected at their ends by the transversely disposed channel members 17 which enclose an area smaller than the horizontal cross-sectional area of the lower portion of the cages is provided for imparting rigidity and mechanical strength to the carriage 24, as well as to permit a reduction in the size and weight of the vertically disposed stiles 27 of the carriage. 110

115 The upper portion or head room of the lower cage 26 is offset from and has a smaller horizontal cross-sectional area than the lower portion of the cage in order to allow it to pass through the horizontal rectangular frame, which connects the midpoints of the stiles 27 and is interposed between the bottom of the upper cage 25 and the lower portion of the lower cage 26, and closely approach the bottom of the upper cage 26. 120

125 The flanges of the channel members 16 and 17 are turned inwardly toward the area which they inclose, and those of the channel members 17 are cut away at points midway between the ends of the channel members to constitute a dovetail joint whereby the rec- 120

tangular frame is suitably fitted and attached to the stiles 27, as by welding.

A plurality of struts or cables 19 are provided for the purpose of aiding in maintaining the rigid perpendicular relation between the rectangular frame and the stiles 27. The cables are suitably attached to the four corners of the rectangular frame and extend upwardly and downwardly to the upper and lower ends of the stiles 27 to which they are attached by any suitable means.

It will thus be seen that, by means of the construction of the carriage just described, a maximum rigidity and strength, as well as a minimum weight thereof, is obtained while at the same time the cages are not prevented from approaching each other very closely.

Projecting outwardly from the ends of the bottom channel members 29 are the gripping members 38 of a safety brake of any suitable type.

Supporting cables 24' for the carriage 24 are attached to the central portion of the upper channels 28 and extend upwardly through the hatchway 22 and around the drum or sheaves of the elevator motor (not shown) to a suitable counterweight 15, for moving the carriage 24 up and down in the hatchway.

The upper cage 25 and the lower cage 26 are provided with suitable doors 18 and are disposed within the carriage 24 in counterbalanced relation to each other.

The cage 25 is attached to a rectangular frame comprising upright channel members 31 on each side thereof, rigidly connected together at their tops by channel members 32 and at their bottoms by channel members 33. Struts 27' extending at an angle to the vertical, outwardly from the tops of the upright channel members 31 to the corners of the cage 25, are provided for maintaining a rigid connection and relation of the cage 25 and the frame to which it is attached.

The lower cage 26 is also attached to a rectangular frame which comprises channel members 34 disposed on either side thereof and connected together at the top by channel members 35 and at the bottom by channel members 36 and having struts 27'' for serving a purpose corresponding to that of struts 27'.

The cages 25 and 26 are moved up or down in the carriage 24 simultaneously either toward or away from each other by a drive mechanism comprising a motor 40 and an associated counterbalancing screw and gear mechanism.

The motor 40 is suitably supported at the bottom of the carriage on a bracket arm 30 attached to the lower channel members 29.

The screw and gear mechanism comprises a pair of rods 41, disposed one on each side of the cages 25 and 26, closely adjacent and parallel to the stiles 27, and extending from the top to the bottom of the carriage 24.

Suitable double thrust bearing members 42, attached to the channel members 28 and 29, are provided for rotatably mounting the rods 41 on the carriage 24.

Other suitable bearing members 42' for engaging the smooth surface of the rods 41 and supporting them further to prevent their lateral displacement are provided at suitable intervals between the bearings 42 at opposite ends of the rods 41.

The lower portion of the upper half of each of the rods 41 is threaded in one direction and the lower portion of the lower half is threaded in an opposite direction. For example, the upper thread may be a right-hand one and the lower thread may be a left-hand one or vice versa. The length of the threading is slightly more than the distance which each cage moves relatively to the carriage 24.

The upper cage 25 is supported and guided by the upper half of the rods 41, and the lower cage 26 is supported and guided by the lower half of the rods 41.

Split-nut bearing members 39, attached to the bottom ends of the channel members 31 and 34 of the cages 25 and 26, respectively, engage the threaded portions of the rods 41. The split-nut construction of bearings 39 permits adjustment thereof on the rods 41, as well as a simple method of assembly of the cages in the carriage. The nuts 39 are screw threaded to cooperate with the threaded portions of the rods, so that simultaneous rotation of the rods 41 at the same speeds and in proper directions will effect a movement of the cages 25 and 26 with respect to the carriage 24. Furthermore, by reason of the fact that the upper and lower threaded portions are opposite, the two cages simultaneously move away from or toward each other.

Sliding guide or bearing members 39' for engaging the smooth surface of the rods 41 are suitably attached to the upper ends of each of the cage channel members 31 and 34, respectively. They provide a means additional to the split-nut bearings 39 for guiding the cages 25 and 26 for movement along the rods with respect to the carriage 24.

In order that the motor 40 may effect the simultaneous rotation of the rods 41 to move the cages with respect to the carriage, its armature shaft 48 has mounted upon it a sprocket wheel 47 that is connected by a chain 45 to a sprocket wheel 46 which is keyed to a shaft 44. The shaft 44 is rotatably supported in a pair of bearings 44' mounted on the channel members 29 and extends from one stile 27 to the opposite stile in parallel relation to the channel members 29. A beveled gear wheel 43 is keyed to one end of the shaft 44 and another gear wheel 43 is keyed to the opposite end in positions to engage respectively a cooperating gear wheel 43'.

keyed to the lower end of one of the rods 41 and a gear wheel 43' keyed to the lower end of the other rod 41 so that rotation of the shaft 44 by the motor 40, through the chain 45 and the sprocket wheels 46 and 47, will effect simultaneous rotation of the rods 41 at the same speeds.

Thus, it will be understood that the rotation of the motor 40 in one direction effects the movement of the two cages away from each other simultaneously and rotation of the motor in the opposite direction effects a movement of the two cages toward each other simultaneously.

It will also be clear that the interconnection of the two cages by the threaded rods 41 effects a counterbalance of one cage by the other. The weight of the upper cage acting downwardly tends to effect a rotation of the rods 41 in a direction which effects a lifting of the lower cage. The pitch of the threads on the rods 41 obviously determines the component of the weight of the upper cage effective to cause rotation of the rods 41. Similarly, the weight of the lower cage acting downwardly tends to raise the upper cage.

Assuming cages of equal weight, clearly a motor of sufficient power to overcome the unbalance of load in the two cages and the frictional forces is all that is required. Thus, one of the advantages of counterbalancing one cage by the other is that a motor of comparatively small dimensions and power may be used resulting in a minimum cost as well as a minimum weight of the carriage 24.

Another advantage resulting from the counterbalancing of one cage by another is that a motor of standard construction may be employed for effecting their adjustment in the carriage. It should be obvious that were a separate motor employed to move each cage individually, by means of a screw mechanism similar to that described herein comprising the threaded rods 41, without counterbalancing the cages in some manner, the power necessary to lift a cage would be more than that to lower it because in lifting a cage power necessary to overcome the weight of the cage would have to be provided and in lowering a cage this power is not only not required but the weight of the cage further detracts from the power necessary to overcome frictional forces. In order to permit a substantially constant speed of movement of the cage by the cage adjusting motor, regardless of whether the cage would be moving up or down, a motor of special design or having special compensating features would have to be provided. Assuming a constant load in the cages of a counterbalanced system, the power required to move them is constant and does not vary whether the cages are moving up or down. Thus, a motor of special design or having compensating features is not necessary and since a motor of standard construction may be employed

the cost of the elevator system is kept down to a minimum with respect to this item.

Referring to Fig. 1, it will be seen that the upper and the lower cages are spaced apart a maximum distance MA when they are at the level of floors 2 and 1, respectively. It will also be seen that the distance between the upper and the lower cages, when they are at a level, respectively, with floors 4 and 3 is less than the distance MA and that this distance is ME. It will be observed further that for another stopping position in which the upper and the lower cages are at the level, respectively, of floors 8 and 7, the distance between the cages is further decreased and is the distance MI.

It will thus be obvious that, by reason of the diminution in the spacing between successive up floors in the building, the cages must be adjusted from a maximum distance apart to a minimum distance apart in ascending from the bottom to the top of the building. It will be obvious also that in descending from the top to the bottom of the building the cages must move from a minimum distance to a maximum distance apart in accordance with the spacing of the floors at the various stopping positions.

Therefore, we have provided a means for effecting the automatic adjustment of the spacing between the cages during the movement of the carriage 24 between successive stops whereby the cages are properly spaced in accordance with the requirement of the spacing between the adjacent floors at which they respectively stop before their arrival thereat.

The means which we have provided for effecting this change of spacing between the cages comprises a control system for the cage adjusting motor 40. This control system is entirely separate from the control system for the hoisting motor (not shown) which moves the carriage 24 up and down in the hatchway, and is applicable to any of the elevator control systems known and in use today.

It should be understood that, since we provide an automatic means for adjusting the spacing between the cages of a multi-cage elevator system, an ordinary control system may be employed and applied to one of the cages only. It should further be understood that control push-buttons may be located in each of the cages for operation to register or effect stops desired.

It will also be obvious, since the minimum distance between successive stops of the cages is the distance between alternate floors, that a signal control system may be employed in which call push-buttons are located on adjacent floors and so connected as to effect the same stopping position of the carriage when the button at either floor is operated. Thus, if a call is registered on floor 8, the carriage 24 will be stopped so that the upper cage 25

is at the level of floor 8. If a call is registered at floor 7, the carriage will be stopped in the same position and the lower cage will be at the level of floor 7.

Inasmuch as any suitable control system may be employed for moving the carriage 24, a description thereof will be omitted.

The control system for the cage adjusting motor 40 comprises a selector switch 51 which is similar in construction and operation to the selector switches usually employed in elevator signalling and control systems. The selector switch 51 automatically establishes the proper electrical connections to the motor 40, whereby it is actuated at the proper times to effect the necessary adjustment of the cages 25 and 26. The selector switch comprises essentially (see Fig. 5) a threaded rod or shaft 52 suitably mounted (by means not shown) for rotation in accordance with the movement of one of the cages, for example, cage 25. An endless belt 120, attached at one point thereof by a suitable bracket 121 to the cage 25 and supported by pulleys 122 mounted at the top and bottom of the hatchway 22, is preferably utilized to transmit the movement of the cage to the shaft 52.

A worm gear 123, keyed to a shaft 124 to which one of the pulleys 122 is also keyed, engages a worm wheel 123' keyed to the threaded rod 52 and movement of the cage 25 is thus transmitted to the rod 52. Any other suitable gearing may be employed for transmitting the rotation of the pulleys to the rod 52.

A traveling nut 53 having the two arms 53' and 53'' projecting outwardly therefrom on opposite sides of the rod 52 moves in either direction along the rod 52 by rotation thereof in accordance with the movement of the cage 25. The two arms 53' and 53'' are disposed at an obtuse angle with respect to each other. The arm 53' has a contact member 21 at its free end for engaging conducting contact strips 58 and 59. The arm 53'' has a contact member 54 at the end thereof for engaging conducting strips 55 and 56.

The strips 55 and 56 are connected electrically to the motor 40 and the engagement of the contact member 54 therewith partially completes a circuit for causing the motor to rotate in a direction to move the cages toward each other, in the carriage 24.

The strips 58 and 59 are connected electrically to the motor 40 and the engagement of the contact member 21 therewith partially completes a circuit for causing the motor to rotate in a direction to move the cages away from each other in the carriage 24.

By reason of the angular relation of the arms 53' and 53'', and the friction between the threaded shaft 52 and the nut 53, the arms will be rocked to one extreme position when the cage starts upwardly and to the other extreme position when the cage starts

downwardly, so that when the car ascends, a contact member 54 on the arm 53'' will engage the strips 55 and 56 successively while a contact member 21 on the arm 53' will be disengaged and, when the cage descends, the contact member 21 will engage the contact strips 58 and 59 successively while the contact member 54 will be disengaged. Thus, in the travel of the nut 53 along the rod 52 in the direction corresponding to the upward movement of the cage 25, the contact member 54 engages the contact strip 55 from the time that the upper cage leaves the second floor until it arrives at floor 6. With the subsequent movement of the upper cage upwardly, the contact member 54 passes over a short insulating segment 55' and upon the contact strip 56 which it continues to engage until the upper cage reaches floor 13 and as long as it remains in that position.

Upon the descent of the carriage 24 and the descent of upper cage 25 from floor 13, the nut 53 is rocked into the position in which the contact member 21 engages the insulating strip 57. The contact member 21 continues to engage the strip 57 until the upper cage arrives at floor 8. Subsequently, upon the descent of the upper cage therefrom, the contact member 21 engages the strip 58 which it continues to engage until the upper cage 25 arrives at floor 4. Upon the further descent of the upper cage 25 the contact member 21 passes over a short insulating segment 58' and upon the strip 59 which it continues to engage until the upper cage arrives at floor 2.

Upon the reascent of the carriage 24 and that of the upper cage 25 from the floor 2, the nut 53 rocks into the position in which contact member 54 again engages the strip 55 and the cycle of operation is again repeated as before described for a complete cycle of travel from the bottom to the top of the building and down to the bottom again.

Limit switches 60, 61 and 62 are disposed one above the other, and suitably attached to one of the stiles 27 of the carriage 24. They are successively operable, in the order given, by a cam member 63 projecting from the side of the upper cage 25 in its movement toward the lower cage from a position in which it is a maximum distance therefrom. For opposite relative movement of the cage 25 and carriage 24 they are operable in the reserve order.

The limit switch 60 interrupts the control circuit of the motor 40 and stops the motor when the cages are a maximum distance *ma* apart.

The limit switch 61 interrupts the control circuit of the motor 40 when the cages are a medium distance *me* apart.

The limit switch 62 interrupts the control circuit of the motor 40 when the cages are a minimum distance *mi* apart.

A switch 71 of any suitable type is provided in one or both of the cages for the purpose of permanently interrupting the control circuit of the motor 40. It is desirable, at certain times, such as at night, when the passenger traffic is so reduced that only one cage is required, to stop the operation of the cage adjusting motor 40. A switch 71 on each cage provides a simple means for accomplishing this result.

While the cage adjusting motor 40 may be of any suitable type, we have shown it as a split-field motor having a field winding 64 wound in one direction, a field winding 65 wound in the opposite direction, and an armature 40'. The energization of the field winding 64 effects a rotation of the motor 40 in a direction such that the cages are moved toward each other. The energization of the field winding 65 effects a rotation of the motor 40 in the opposite direction which results in a movement of the cages away from each other.

The operation of our control system for effecting the adjustment of the relative positions of the cages 25 and 26 is best understood by assuming a hypothetical case. Let it be assumed that our invention is applied to an automatic elevator system of the latest type in which an operator merely presses push-buttons in the cage to record the stops desired by the passengers and in which the stopping of the cage is automatically effected both for the calls registered by the operator in the cage and for calls registered by operation of push buttons by passengers on the various floors. Let it be assumed, for the purpose of this analysis, that there is an operator in each of the cages 25 and 26; that the functions of the operator in the upper cage 25 are to operate the push buttons in the cage for effecting the automatic stopping of the cage at those stops desired by the passengers entering the upper cage, close the door of the cage and hatchway, and operate the control lever for initially starting the carriage 24 from rest; and that the functions of the operator in the lower cage 26 are to operate the push buttons for effecting the stops desired by passengers entering the lower cage and to close the lower cage and hatchway doors. Let it be assumed that the carriage 24 is positioned at the lower terminal of the building 20. In this position the cages 25 and 26 are spaced a maximum distance *ma* apart, the upper cage 25 being at the level of floor 2 and the lower cage 26 being at the level of floor 1. After the cages have been loaded with passengers and the cage and hatchway doors closed, the operator in the upper cage 25 moves the control lever therein (not shown) to effect the operation of the motor for moving the carriage 24 upwardly in the hatchway. The successive stopping positions of the carriage 24 are such that the upper cage 25 always

stops at even numbered floors, and the lower cage 26 always stops at odd numbered floors. The first stop possible, then, of the carriage 24 in its upward travel is such that the upper cage is at the level of floor 4 and the lower cage is at the level of floor 3. As indicated in Fig. 1 the distance between floor 3 and floor 4 is ME, which is less than the distance MA between floor 1 and floor 2, and, therefore, in order to permit the alignment of the two cages with their respective floors for this stopping position, it is necessary that the two cages be moved toward each other, into a closer space relation. We provide means for effecting this movement into a closer space relation during the movement of the carriage between the stopping positions, so that no time is lost in levelling the cages with their respective floors when they arrive thereat.

As the carriage 24 moves upwardly from the lower terminal position the contact member 54 of the selector switch 51 engages the strip 55 as previously described and it closes the circuit through winding 65 of the motor 40, so that the motor rotates in such direction as to effect a movement of the cages 25 and 26 toward each other, in a manner previously described, by means of the screw-and-gear mechanism. This circuit extends from supply conductor L—1, through conductor 70, switches 71, conductor 72, armature 40' of the motor 40, winding 65, conductors 73 and 74, contact members *a* of limit switch 61, conductor 75, strip 55, contact member 54, arm 53'', rod 52, and conductor 76 to supply conductor L—2. The motor is thus energized and rotates in such a direction to move the cages together. When they reach the distance *me* apart, the cam member 63 on the upper cage 25 engages the limit switch 61 and causes its contact members *a* and *b* to open. The control circuit, just traced, for the motor 40 is thus interrupted and the motor stops. This adjustment of the two cages is effected with such a speed that the proper spacing therebetween is attained before the upper cage 25 reaches floor 4.

If it is assumed that a stop call has been registered on either of the cages 25 and 26, or on floors 3 and 4, the carriage 24 will be caused to stop so that the cage 25 is level with floor 4 and cage 26 level with floor 3.

Let it be assumed that the next stopping position of the carriage 24 in its upward travel is such that the upper cage 25 is aligned with floor 8 and the lower cage 26 with floor 7 as indicated in Fig. 1. The distance between floors 7 and 8 is MI which is less than the distance ME between floors 3 and 4. Therefore, in order to permit the simultaneous alignment of the two cages with their respective stopping floors, it is necessary that they be moved still closer to each other.

As the upper cage 25 leaves floor 4, the contact member 54 runs off the strip 55, passes over an insulating segment 55' and engages the strip 56. This establishes a circuit through winding 65 of the motor 40, which extends from supply conductor L—1, through conductor 70, switches 71, conductor 72, armature 40' of the motor 40, winding 65, conductors 73 and 77, limit switch 62, conductor 78, strip 56, contact member 54, arm 53', rod 52, and conductor 76 to supply conductor L—2. The motor 40 is thus energized and moves the cages 25 and 26 closer together. When the two cages reach the distance *ma* apart, the cam member 63 on the upper cage 25 engages and opens the limit switch 62 causing the motor 40 to stop.

Since the spacing of the floors for successive stops of the carriage 24 in its upward travel above this level is the same as between floors 7 and 8, no further change in the spacing between the two cages is necessary in their movement to the top of the building.

Let it be assumed that the carriage 24 has ascended to the top of the building and starts to descend. The reversal of direction of movement of the carriage effects the rocking of the traveling-nut 53 to its other position in which the contact member 21, on the arm 53', engages the insulating strip 57, which it continues to do until the upper cage 25 descends from floor 8.

The cages are maintained in their same relative positions, therefore, until the upper cage descends below floor 8. The next stopping position of the cages below this point requires that they be a medium distance *me* apart.

As cage 25 moves downwardly from floor 8, the contact member 21 of the selector switch 51 engages the strip 58 thereby establishing a circuit through winding 64 of the motor 40, which extends from supply conductor L—1, through conductor 70, switches 71, conductor 72, armature 40' of the motor 40, winding 64, conductors 80 and 81, contact members *b* of the limit switch 61, conductor 82, strip 58, contact member 21, arm 53', rod 52 and conductor 76 to supply conductor L—2. The motor 40 is thus energized and rotates in a direction so as to move the two cages 25 and 26 apart. The two cages continue to move apart until the cam member 63 on the upper cage engages and opens the limit switch 61. The opening of the contact members *b* of the limit switch 61 opens the control circuit of the motor 40, previously traced, and stops the motor with the cages a medium distance *me* apart.

The medium spacing between the two cages is maintained until the upper cage 25 leaves floor 4 in a downward direction at which time a further movement of the two cages away from each other is effected in order to permit their simultaneous alignment with their respective floors, at the lower terminal. There-

fore, as the upper cage 25 leaves floor 4, the contact member 21 of the selector switch 51 passes over a short insulating segment 58' and engages the strip 59. A circuit for energizing the field winding 64 and the armature 40' of the motor 40, is thus established and extends from the supply conductor L—1, through conductor 70, switches 71, conductor 72, armature 40', winding 64, conductors 80 and 84, limit switch 60, conductor 85, strip 59, contact member 21, arm 53', rod 52, and conductor 76 to supply conductor L—2. The motor 40 is thus actuated and rotates in a direction so as to move the two cages farther apart. The cages continue to move apart until the cam member 63 on the upper cage 25 engages and opens the limit switch 60, thus opening the control circuit of the motor 40 and stopping it, with the cages the maximum distance *ma* apart.

Subsequently, upon the re-ascent of the carriage 24, the reversal of direction of rotation of the rod 52 of the selector switch 51 causes the traveling-nut 53 to rock into position so that the contact member 54 on the arm 53' engages the strip 55. The cycle of operation, previously described, is thus repeated.

In the operation above assumed, the travel of the carriage 24 was from the bottom to the top of the building and down to the bottom again. Obviously, this would not be the exact cycle of operation if the carriage 24 be stopped before it reaches the top and then caused to descend. However, the functions of the various elements of the selector switch would be the same, and would effect the proper operation of the motor 40 for the particular travel of the carriage 24.

While the control system for the motor 40, as previously described, is shown as applied to a building having floor spacings as illustrated in Fig. 1, it may be, obviously, readily applied to buildings having other combinations of floor spacing merely by the variation in the length of the strips similar to the strips 55, 56, 57, 58 and 59 to correspond to the particular requirements of the spacing between adjacent floors of the building.

A modification of Fig. 1 is illustrated in Fig. 8 wherein the spacing between successive floors is altered from that of Fig. 1. In Fig. 8, the building 20' has a plurality of superposed floors, numbered 1' to 13', upwardly from the bottom of the building. In department stores and office buildings, the distance between the first and second floors is sometimes two or three times the distance between upper floors. It would be impractical and of uneconomic construction in a building of this type, to have the carriage 24 long enough to allow the upper cage to be level with the second floor at the same time that the lower cage is level with the first floor. Therefore, as has been suggested, in prior art, we have provided a ramp 14 which extends upwardly

from the first floor the same distance as a ramp 15 extends downwardly from the first floor. In the terminal stopping position, the floor of the upper cage is at the level of the top of ramp 14 and the floor of the lower cage is at the level of the bottom of ramp 15, and thus access to both cages from a common floor is obtained. However, the cages of multi-cage elevator systems utilizing this method of loading were fixed with respect to each other and their supporting carriage at a distance apart necessary to effect the simultaneous alignment thereof, respectively with successive floors. Therefore, the ramps had to extend to a distance above or below the first floor, which was equivalent to one half the height of a cage plus half the distance between the two cages. In installations of multi-cage elevators in which the elevator cages were of a height equal to the distance between adjacent floors, the ramps had to extend to a height equal to one half the distance between the adjacent upper floors. Elevator cages of standard dimensions are used in our invention, and since the two cages may be moved very closely to each other in our invention, the height to which the ramps must extend, in the application thereof, above and below the terminal floor is substantially one half the height of the standard elevator cage. It will thus be clear that instead of requiring ramps to extend above and below the terminal floor a distance of at least six feet, that is, one half the average distance between floors, which is twelve feet, our invention requires that the ramps extend only to a distance of about four feet above and below the terminal floor, the four feet being approximately one half the height of a standard elevator cage. Therefore, our invention effects a reduction of at least two feet in the distance which it is required that the ramps extend above and below a common terminal floor.

The advantages of such a reduction in a height requirements of the ramps is obvious both from a psychological and an economical standpoint. Passengers have less objection and annoyance to walking up or down a ramp which extends only a distance of about four feet above or below a common floor, than they have if they are required to walk up or down a ramp which extends a distance of about six feet above or below a floor. As to the economical standpoint, a ramp extending to a height of four feet above or below a floor permits the same angle of inclination as may be used for a ramp extending to a height of six feet and with less floor space occupied by the ramp.

It should, therefore, be obvious that our invention is especially applicable to buildings having a lower floor terminal loading method in which ramps to the upper and lower cages are used.

The cycle of movement of the cages with respect to each other in the building illustrated in Fig. 8 obviously requires a modification of the strips of the selector switch 51 to effect the results desired. In traveling from their terminal position illustrated in solid lines to the next stopping position in their travel upward, illustrated in dotted lines, it is necessary for the cages to be moved to their maximum distance apart. Since the spacing between adjacent floors above floor 6' is less than the spacing below that floor, it is necessary that the cages be moved closer to each other, after the upper cage travels upwardly from floor 5'. This medium spacing between the cages is maintained in the subsequent upward travel thereof to the top of the building and down again until the upper cage leaves the floor 7'. It is necessary that the cages be spaced a maximum distance apart for the next stopping position after the upper cage leaves floor 7', in the downward direction. Furthermore, after the upper cage leaves the floor 3' in a downward direction it is necessary that the two cages be moved to a position in which they are a minimum distance apart in order to be in a position to be properly aligned with the ramps 14 and 15.

It has not been thought necessary to illustrate a control diagram for effecting the cycle of relative movement between the two cages, just previously described, since the control illustrated in Fig. 5 may be modified without invention to suit the particular requirements of this cycle by properly constructing the length of the contact strips of the selector switch 51 and properly connecting them to the windings 64 and 65 of the motor.

A modification of the mechanism for altering the relative position of the two cages 25 and 26 is illustrated in Fig. 6. The structure of the carriage 24 and the cages 25 and 26 is identical with that illustrated in Fig. 2. The modification consists in the counter-balancing of cage 25 by cage 26 by connecting the sides of the lower cage 26 at the top thereof to the top central portion of the upper cage 25 by cables or chains 100 which are supported by sprocket wheels 101 and 102 suitably mounted in bearing members attached to the channel members 28. Keyed to the same shaft as sprocket-wheels 101 are gear wheels 103 which are each engaged by a worm gear 104 keyed to the shaft 105 of the motor 40 which is suitably supported from the upper channels 28.

Suitable guide rails 150 for engaging guide shoes 152 on the cages, are disposed between the flanges of stiles 27 and are attached to the carriage at top and bottom by bracket members 151.

Rotation of the motor 40 in one direction causes the upper cage 25 to be raised and the lower cage 26 to be lowered simultaneously

with respect to the carriage 24. Rotation of the motor 40 in the opposite direction causes the upper cage 25 to be lowered and the lower cage 26 to be raised simultaneously with respect to the carriage 24.

The fundamental principle of counter-balancing one cage by another is utilized in both the structures illustrated in Figs. 2 and 6, respectively.

A further modification of the structure of the moving mechanism for adjusting the spacing between the two cages 25 and 26 is illustrated in Fig. 7. In this figure, the upper cage 25 is fixed with respect to the carriage 24, and only the cage 26 is movable with respect to the upper cage 25 and the carriage 24. An additional horizontally disposed frame for connecting the mid-points of stiles 27 is not provided in this modification since the bottom of cage 25 performs this function.

A screw and gear mechanism similar to that already described, is provided for supporting and moving the lower cage 26 with respect to the carriage 24. It comprises the threaded rods or pipes 41', vertically disposed one on each side of cage 26 and rotatably supported in the carriage 24 at their bottom ends by double thrust bearings 42 which are attached to the lower channels 29, and at their top ends by the bearings 42 attached to the stiles 27 at the level of the bottom of the top cage 25.

The rods 41' are threaded at the lower portion thereof for a distance slightly greater than the distance which the cage 26 moves relatively to the carriage 24.

Split-nut bearing members 39, and sliding bearing members 39' are provided for cage 26. They are attached thereto in a manner similar to that already described and they also serve corresponding functions. Bearings 39 support the cage 26 and move it upwardly or downwardly with respect to carriage 24 when the rods 41' are rotated simultaneously at the same speed in proper directions. Bearings 39' engage the smooth surface of the rods 41' and serve to additionally support and guide the movement of the cage 26.

The rods 41' are rotated simultaneously at the same speed in the proper directions by a drive mechanism identical with that already described for that of Fig. 2 so that it will not again be described here.

Thus, in this modification, it will be seen that rotation of motor 40 in one direction causes the cage 26 to be raised toward cage 25 and that rotation thereof in an opposite direction causes the cage 26 to be lowered away from cage 25.

The structure illustrated in Fig. 7 is provided for some installations where the carriage 24 moves at a slow speed or where the distance between the successive stops thereof

is greater than the distance between alternate floors. Assuming the same speed of movement of the cages in each case a longer time is required for the same variation in the spacing between the two cages with a mechanism which moves only one cage than with a mechanism such as previously described which moves both cages simultaneously. Therefore, in a high speed movement of the carriage 24, with stopping positions at alternate floors, an adjustment of but one cage would not insure a complete adjustment of the spacing between the two cages during the travel of the carriage 24 between successive stops. Therefore, for most installations, the counter-balancing method of supporting and moving the two cages 25 and 26, previously described, is preferred over this latter construction.

Therefore, it will be seen that we have disclosed a novel means for adjusting the spacing between the cages of a multi-cage elevator employed in buildings having different spacing between adjacent floors at different levels, and have disclosed a control system for automatically effecting the alteration of the spacing between the cages during movement thereof.

Although we have shown and described certain specific embodiments of our invention we are fully aware that many modifications thereof are possible. It should be understood, therefore, that our invention is not to be restricted except as is necessitated by the prior art and the spirit of the appended claims.

We claim as our invention:

1. In an elevator, a plurality of interconnected adjustably spaced cages simultaneously movable in a common hatchway, means, including a common motive means, for moving all of said cages in the hatchway, and means including a second motive means operable separately from said common motive means, for changing the relative positions of said cages.

2. In an elevator, a plurality of interconnected adjustably spaced cages simultaneously movable in a common hatchway, means, including motive means, for moving all of said cages in the hatchway, and means, including a second motive means operable separately from said motive means, for changing the relative positions of said cages during movement thereof in the hatchway.

3. In an elevator, a carriage movable in a hatchway, a plurality of cages, means for movably supporting said cages in said carriage for movement relative thereto and to each other, and a common motive means for moving all of said cages relative to said carriage and to each other.

4. In an elevator, a carriage movable in a hatchway, a plurality of cages, means for movably supporting said cages in said car-

riage for movement relative thereto and to each other, and motive means on said carriage for moving said cages relative to said carriage and to each other.

5 5. In an elevator, a carriage movable in a hatchway, a plurality of cages, means movably supporting said cages in said carriage for movement relative thereto and to each other, and common motive means on said
10 carriage for moving all of said cages relative to said carriage and to each other.

6. In an elevator, a carriage movable in a hatchway, a plurality of cages, and means for movably supporting and counterbalancing
15 said cages in said carriage for movement relative to said carriage and to each other.

7. In an elevator, a carriage movable in a hatchway, a plurality of cages, and means for movably supporting and counterbalancing
20 said cages in said carriage for simultaneous movement relative to said carriage and to each other.

8. In an elevator, a carriage movable in a hatchway, a plurality of cages, and means
25 for movably supporting said cages in said carriage and counterbalancing one cage by another.

9. In an elevator, a carriage comprising a vertically disposed quadrangular frame movable
30 in a hatchway, a plurality of cages, means movably supporting said cages in said quadrangular frame one above the other for movement relative thereto and to each other, the upper portion of a cage being offset
35 from the lower portion and having a smaller horizontal cross-sectional area than the horizontal cross-sectional area of the lower portion, and a horizontally disposed quadrangular frame, for connecting opposite
40 members of said vertically disposed quadrangular frame and imparting rigidity thereto, said horizontal frame enclosing an open area larger than the horizontal cross sectional
45 area of the said upper portion of a cage but smaller than the horizontal cross-sectional area of the lower portion of the cages and said upper portion of a cage being movable
50 through said horizontal frame to effect its close approach to the bottom of an immediately adjacent upper cage.

10. In an elevator, a carriage movable in a hatchway, a plurality of cages, and means for movably supporting said cages in said carriage and counterbalancing one cage by
55 another comprising a threaded shaft rotatably mounted in said carriage, motive means on said carriage for rotating said threaded shaft, and a nut on each of said cages cooperating with said threaded shaft whereby the
60 cages are moved relatively to said carriage upon rotation of the threaded shaft.

11. In an elevator, a carriage movable in a hatchway, a plurality of cages, and means for movably supporting said cages in said
65 carriage and counterbalancing one cage by

another comprising a supporting pulley rotatably mounted in said carriage, a flexible member engaging said pulley for supporting
said cages by connecting one cage to another, and motive means on said carriage for rotating
70 said pulley to simultaneously move said cages relatively to said carriage and to each other.

12. In an elevator, a carriage movable in a hatchway, a plurality of cages, means movably supporting said cages in said carriage
75 for movement relative thereto and to each other, and means for moving said cages relative to said carriage and to each other during movement of said carriage in the hatchway.
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13. In an elevator, a plurality of interconnected adjustably spaced cages simultaneously movable in a common hatchway, means, including motive means, for adjusting the
85 cages and changing their relative positions during movement of the cages in the hatchway, and control means for automatically causing said motive means to adjust the cages into any one of a plurality of predetermined
90 relative positions, said control means comprising means movable in accordance with the movement of one of the cages in the hatchway.

14. In an elevator, a carriage movable in
95 a hatchway, a plurality of cages movably supported in said carriage for relative movement with respect thereto and to each other, means including motive means, for changing the relative positions of said cages in said
100 carriage, and cooperating means on said carriage and on one of the cages operable at predetermined relative positions of the cages for controlling the operation of said motive means.
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15. In an elevator system for a building comprising a plurality of superposed landings having different spacings between adjacent landings at different levels and a hatchway extending past all of said landings,
110 a plurality of interconnected cages simultaneously movable in the hatchway and means for changing the relative positions of the cages during movement thereof in the hatchway in accordance with the spacing between
115 the landings at which they next stop, before their arrival thereat, whereby upon stopping they are simultaneously in alinement with adjacent landings.

16. In an elevator system for a building comprising a plurality of superposed landings having different spacings between adjacent landings at different levels and a hatchway extending past all of said landings, a
120 plurality of interconnected cages simultaneously movable in the hatchway, and means including means movable in accordance with the movement of one of the cages in the hatchway, for automatically changing the relative
125 positions of the cages a predetermined
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amount during movement thereof in the hatchway in accordance with the spacing between the landings at which they next stop before the arrival thereat, whereby upon
5 stopping they are simultaneously in alinement with adjacent landings.

17. In an elevator system, a building having a plurality of groups of landings therein, the distance between adjacent landings
10 of said groups being different and decreasing in steps from a maximum at the bottom to a minimum at the top of the building, a hatchway extending past all of said landings, a plurality of interconnected cages, simultaneously movable in said hatchway and adjustable relative to each other so that upon
15 stopping they may be in alinement with adjacent landings in any of the said groups, and means for reducing the distance between cages to a minimum in successive steps during movement thereof from the bottom to the top of the building and for increasing the distance between the cages to a maximum in successive steps during movement thereof
20 from the top to the bottom of the building.

18. In a building having a plurality of superposed landings, a hatchway extending past all of said landings and a ramp extending up from and a ramp extending down from
30 one of said landings, a pair of interconnected cages simultaneously movable in the hatchway and adjustable with respect to each other, whereby they may be simultaneously alined with said ramps or any two adjacent
35 landings, and means including means movable in accordance with the movement of one of the cages in the hatchway, for adjusting the positions of the cages relative to each other a predetermined amount in accordance
40 with the requirements of each stopping position, the adjustment being effected automatically by said movable means during movement of the cages through the hatchway prior to reaching each stopping position.

19. In an elevator, a carriage movable in a hatchway, a plurality of adjustably spaced cages supported by said carriage, and means including a motive means disposed on said carriage, for simultaneously adjusting all the
50 cages and thereby changing their relative positions.

20. In an elevator, a carriage movable in a hatchway, a plurality of adjustably spaced cages supported by said carriage, and means
55 including a motive means disposed on said carriage, for simultaneously adjusting all the cages and thereby changing their relative positions during movement of the carriage in the hatchway.

21. In an elevator, a plurality of interconnected adjustably spaced cages simultaneously movable in a common hatchway, means including motive means for adjusting the cages and changing their relative positions,
65 and control means for said motive means in-

cluding means movable in accordance with the movement of one of the cages in the hatchway for automatically causing said motive means to adjust the cages into any one of a plurality of predetermined relative positions and stop
70 them thereat during movement of the cages in the hatchway.

22. In an elevator, a plurality of interconnected adjustably spaced cages simultaneously movable in a common hatchway, motive means for moving all of said cages simultaneously in said hatchway, means including a second motive means operable independently of said first motive means to simultaneously adjust all of said cages and change
80 their positions relative to each other, and control means for said motive means including means movable in accordance with the movement of one of the cages in the hatchway for automatically causing said second motive means to adjust the cages into any one of a plurality of predetermined relative positions and stop them thereat during the movement of the cages in the hatchway.

23. In a carriage for supporting a plurality of superposed elevator cages, a vertically disposed quadrangular frame, a horizontally disposed quadrangular frame disposed to connect portions of said vertically disposed frame intermediate the upper and lower ends thereof and impart rigidity to the vertically disposed frame, said horizontally disposed frame being adapted to permit a portion of one of said cages to move therethrough and closely approach another of said cages.
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24. In an elevator system for a building having a plurality of variably spaced superposed landings and a hatchway extending past all of said landings, a plurality of adjustably spaced interconnected cages simultaneously movable in the hatchway, motive means for adjusting said cages, and control means for said motive means including means movable in accordance with the movement of one of the cages for automatically causing
110 said motive means to adjust the cages into any one of a plurality of predetermined relative positions in accordance with the requirements of a stopping position before the arrival of the cages thereat and during the
115 movement of the cages in the hatchway.

In testimony whereof, we have hereunto subscribed our names this 28th day of October, 1930.

HENRY D. JAMES.
DOUGLAS G. BOOZER.
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