

Variable Speed Passenger Transit Device

The present invention relates to passenger transit devices, such as escalators, and may be used to enable
5 an escalator to operate at more than one speed and change speed and direction while under passenger load.

Although the invention will be described hereinafter with particular reference to escalators, it will be appreciated that the invention is not limited to this particular
10 field of use and may be utilized for other continuous passenger conveyors, such as moving walkways or travolators^(ATM).

In the past escalators have been driven by single speed AC motors, by two speed AC motors, by variable speed DC motors and by variable speed commutator motors.

15 While it is usual for escalators to be provided with mechanical speed governors to limit maximum speed for safety purposes, motors driving escalators are not speed regulated at their nominal operating speed and in the case of variable speed motors typically vary from a nominal
20 speed selected according to load.

Moreover, in no case has the escalator control system been suited to starting or stopping escalators loaded with passengers, the jerk and rates of acceleration and deceleration being considered to be unsuitable and unsafe.

25 Thus while conveyors have been known to operate at variable speeds, they have not previously provided speed regulation at any selected speed, independently from load, or controlled acceleration and deceleration between selected speeds, or the combination of those features.

According to the invention there is provided passenger conveyance means comprising:

a continuous passenger conveyor driven by a variable speed electric motor;

5 means for regulating the speed of the motor at a selected first speed or at a selected second speed; and

means for changing said motor speed from said selected first regulated speed to said selected second regulated speed at a predetermined rate of change irrespective of the load carried by said conveyor, whereby said conveyor may be accelerated or decelerated at a controlled rate from one regulated speed to another; said means for regulating the motor speed comprising means for producing
10 a first signal representative of the speed of said motor,

means for producing a reference signal indicative of a desired speed,

means for comparing said first signal with said reference signal for producing a difference signal,

20 means for producing a second signal responsive to change in the load driven by said motor, and

means for controlling the motor speed in response to said difference signal and said second signal.

Thus the invention provides a continuous passenger conveyor of which the speed is not only selectable but is
25 regulated at a selected speed, and in which the acceleration or deceleration from one selected speed to another may be controlled at a rate which is independent of passenger load so that the speed of the conveyor may be altered safely
30 while the conveyor is carrying passengers.

According to preferred embodiments of the invention there is provided a conveyor which may be decelerated from a first speed to zero speed and then accelerated to a second speed, but in the opposite direction without undue
35 discomfort to passengers carried.

Various embodiments according to the invention have a number of advantages over prior passenger conveyors.

Because the escalator speed is not only selectable but is regulated at the selected speed, the escalator may
5 be used with particular advantage in locations requiring traffic control when it is desired to predetermine a maximum rate of delivery of passengers from one area to another. More importantly, the ability to accelerate or decelerate the escalator from one selected speed to
10 another while conveying passengers enables the rate of delivery to be altered on a more or less continuous basis in response to traffic density monitors.

Another advantage is that escalators according to the invention may for example, be set to operate at two speeds, one being an idle speed and the other a rapid transit speed to which the escalator safely and rapidly accelerates upon detecting the presence of a passenger. Once the passenger has traversed the escalator, the system may automatically return itself to the idle speed, with associated savings on power and wear.

It may also be advantageous in cases of emergency, for example of fire at one conveyor destination, or of bomb scare, or civil commotion, or the like, to be able to decelerate the escalator in a controlled manner to zero speed and then reverse direction and accelerate in a controlled manner in the opposite sense without significant passenger discomfort.

An embodiment of the invention will now be described by way of example only and with reference to the accompanying drawings, in which

Figure 1 is a diagrammatic illustration of a variable speed passenger transit device control system according to the invention; and

Figure 2 illustrates in Figures (i) to (vi) three sets of set speed reference signals and their associated control speed reference signals.

Referring to Figure 1 of the drawings, the escalator (not shown) is driven by a motor 1 which may be a separately excited DC shunt wound motor. The motor is mechanically coupled to a high accuracy, low ripple DC voltage velocity feedback transducer or tacho-generator 2.

The armature of the motor 1 is connected to a 4 quadrant, solid state AC to DC controlled converter 3. The converter is of the three phase, fully controlled, anti-parallel Thyristor type, capable of supplying power to

the DC motor (rectification) when the motor is motoring and capable of receiving power from the DC motor (inversion) when the motor is regenerating. Protection devices, such as instantaneous overcurrent trip, circuit breakers, etc., are provided with the converter to shut the converter off in the event of overload or excessive current levels. The operating mode of the converter, either rectification or inversion, depends on whether the Forward or Reverse bridge is switched on. The current level passed by the converter depends upon the period of time for which the Thyristors are switched on or fired.

A firing circuit 4 generates low energy pulses whose phasing is a function of a DC control voltage. The firing circuit shapes the pulses, and amplifies the pulse power to a value suitable for driving the Thyristors (silicon control rectifiers) and distributes the pulses to the appropriate Thyristors.

The DC control voltage for the firing circuits 4 is supplied by a current regulator 5. The current regulator output (c) controls the current passed by the converter and, hence, motor speed by comparing the converter current (a) with an input reference (b) to the regulator. Motor current limit and current rate limit controls are applied by the current regulator input reference (b) from a voltage (speed) regulator 6. The speed regulator 6 compares the signal (e) from the tacho-generator 2 with a required speed reference input (d) and adjusts its output accordingly. When the motor load torque changes and, hence, tacho-generator output changes, the output of the speed regulator 6 changes to provide a new current reference (b) corresponding to the motor torque required to balance the new load torque and to maintain constant speed for a constant speed reference input (d).

Should the speed reference input (d) change, the voltage regulator inputs (d & e) are unbalanced, thereby resulting in a change in output (b), resulting in a change

in current regulator output (c). This change in current regulator output causes a change in timing of the trigger pulses applied by the firing circuits 4 to the converter Thyristors, resulting in a change of motor current and, hence, motor speed, until the output of the tacho-generator 2 matches the new speed reference (d). A switching logic circuit 7 determines the direction of current called for by inspection of the current reference and inhibits either the Forward or Reverse bridge in the converter 3.

10 In order to provide a speed change of predetermined characteristics so as to avoid passenger discomfort, the speed reference input (d) to the speed regulator 6 is supplied by a speed reference unit 9 via a ramp unit 8. The speed reference unit 9 accepts various input commands and, depending upon the selection made, sets the appropriate reference (f) which is then fed to the ramp unit 8.

15 The ramp unit 8 provides adjustable acceleration and deceleration rates set to give the desired escalator velocity profile. It has been found that a rate of acceleration or deceleration of $.375 \text{ m/sec}^2$ is suitable for avoiding discomfort to passengers. Examples of velocity profiles (d) resulting from various set speed reference signals (f) are shown in the three pairs of corresponding signals illustrated in Figure 2(i) and (ii); 2(iii) and (iv); 20 2(v) and (vi).

25 The set speed reference signal shown in Figure 2(i) represents a selected change from zero to high speed and then a return to zero after a predetermined time has elapsed. If this set speed reference signal (f) were presented directly to the speed regulator 6 at (d), it would result in unacceptably high acceleration and deceleration rates for normal escalator starting and stopping with passenger load. The ramp unit 8 modifies the shape of the signal on input (f) to an acceptable acceleration and deceleration profile by utilizing, in this example, an Integrator Time Constant to modify the profile as shown

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in Figure 2(ii). This signal is then supplied to the speed regulator in place of the set speed reference (f). The time intervals (t_1 and t_2) are adjustable acceleration and deceleration times, set to give the required acceleration and deceleration rates. Clearly, the ramp unit speed-change output need not be linear in form, since any suitable curve could be used. For normal stops the decelerating function of the ramp unit 8 is operative, but for emergency stops the unit is bypassed. Fig. 2 (iii) shows another sequence of change in value of a set speed reference signal (f) and Fig. 2(iv) the corresponding change in voltage regulator reference and escalator velocity profile and Fig. 2 (vi) shows the respective corresponding output voltage regulator reference signal profile (d) and velocity profile of the escalator for a third sequence of changes in set speed reference signal (f) shown in Fig. 2 (v).

As mentioned above, it is desirable for the escalator to be able to move automatically between high and low speeds upon detection of a passenger. To provide for this preferred function, a passenger presence detector 11 is used to initiate the process. The detector may be located at the entrance or approach to the escalator and may take any convenient form, such as a light ray, ultrasonic beam or pressure pad. The signal received from the passenger presence detector 11 will then cause the control system to accelerate the escalator automatically to its preselected high speed at the rate preset on the ramp unit. In order to reset the system to adopt the low speed mode once the passenger has left the escalator, a passenger transit simulator 10 is provided to simulate passenger progress along the escalator and provide a signal to change the speed reference state from high to low upon expiry of the Passenger Transit Time which may be set at, say, 1.2 times the escalator transit time.

If, during the progress of the first passenger along the escalator, the passenger presence detector senses a further passenger, the transit simulator is again reset so that it will not change the speed reference state from high to low until the predetermined passenger transit time has elapsed from the last actuation of the passenger presence detector.

The transit simulator may take the form of a pulse generator and preset counter, or the Time Integral of the tacho-generator signal and a comparator, or other suitable device. On start-up, with or without passengers, the transit simulator is automatically reset and the escalator accelerates at its preset rate to either its preset running or idle speed, as the case may be.

Various overriding controls are preferably incorporated into the system. For example, a tacho-ramp comparator unit 12 compares the speed feedback signal from the tacho-generator 2 with the output of the ramp unit and initiates a stop should the tacho-generator signal fail. An electronic overspeed governor 13 may also be provided to stop the escalator in cases of overspeed and nonselected escalator motion direction reversal. A zero speed switch may also be incorporated to facilitate brake application at zero speed prior to removing motor power.

The velocity and acceleration/deceleration regulating system may be analog or digital in form. Similarly, any suitable power system may be used, such as a variable voltage, both double bridge (anti-parallel) or single bridge (armature reversal) type or variable frequency type, in order to achieve the variable speed. The mode may be AC or DC to accommodate AC or DC motors. The ramp unit may also be analog, digital or hybrid in form, but in a completely digital system a computer unit 14 would control the firing circuits directly, itself containing the ramp rate information. A fluid or magnetic coupling or fluidic motor with associated controls could

alternatively be used to provide controlled acceleration or deceleration.

In an extension of the system, traffic flow can be optimized by sensing the escalator load and speed by any suitable means. This information is then fed into the computer unit 14 either singly or together with similar information from other escalators or transportation devices. The computer 14 would then output a speed command as the new speed reference to each escalator or other passenger transit device. Hence, the speeds of the various transit devices can be varied to prevent bottlenecks and ensure controlled traffic flow. Escalator speeds could also be automatically set by time measurement means to meet expected high traffic flows, for example, by train arrivals at known times.

Although the invention has been described with reference to a specific example, it will be appreciated by those skilled in the art that the invention may be embodied in many other forms without departing from the scope of the inventive concept, ^{defined in the claims}

CLAIMS

1. Passenger conveyance means comprising:
a continuous passenger conveyor driven by a
variable speed electric motor;

5 means for regulating the speed of the motor
at a selected first speed or at a selected second speed;
and

means for changing said motor speed from said
selected first regulated speed to said selected second
10 regulated speed at a predetermined rate of change irrespec-
tive of the load carried by said conveyor, whereby said
conveyor may be accelerated or decelerated at a controlled
rate from one regulated speed to another; said means for
regulating the motor speed comprising means for producing
15 a first signal representative of the speed of said motor,

means for producing a reference signal
indicative of a desired speed,

means for comparing said first signal with said
reference signal for producing a difference signal,

20 means for producing a second signal responsive
to change in the load driven by said motor, and

means for controlling the motor speed in response
to said difference signal and said second signal.

2. Apparatus according to claim 1 further
25 comprising passenger detecting means and wherein said
means for changing the motor speed is responsive to said
detecting means whereby a change in said motor speed is
initiated by the presence or absence of passengers to be
conveyed.

30 3. Apparatus according to claim 2 wherein said
detecting means is responsive to a passenger approaching
said conveyor.



4. Apparatus according to claim 1, 2 or 3 further comprising time measurement means and wherein said means for changing the motor speed is responsive to said time measurement means, whereby a change in motor speed
5 may be initiated at a predetermined time.

5. Apparatus according to any preceding claim wherein said motor is a DC shunt wound motor and said regulating means includes an AC to DC controlled converter.

10 6. Apparatus according to any preceding claim wherein said means for changing the motor speed comprises means for changing a value of said reference signal from a first value to a second value as a predetermined function of time.

15 7. Apparatus according to claim 6 wherein said means for changing the motor speed comprises a signal ramp circuit adapted to receive an input reference signal including a substantially instantaneous change from one value to another value of a parameter thereof and to
20 produce an output signal having a parameter which alters over a predetermined time interval from a first value to a second value.

25 8. Apparatus according to any one of the preceding claims wherein said motor is reversible, and comprising:

means for regulating the speed of the motor at a selected regulated first speed in one direction,

means for decreasing said first speed to zero speed at a predetermined rate of deceleration, and



means for increasing said speed to a selected regulated second speed in the other direction at a pre-determined rate of acceleration.

5 9. Passenger conveyance means substantially as herein described with reference to the accompanying drawings.

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