

CONTROL APPARATUS FOR PASSENGER CONVEYOR

1 The present invention relates to a control apparatus for a passenger conveyor.

 Once driven, a passenger conveyor usually runs continuously at a predetermined speed for the whole
5 day. Therefore, a three-phase induction motor is suitable to drive such a passenger conveyor, as described, for example, in U.S. Patent No. 3,658,166 and U.S. Patent No. 3,896,925. In these patents, an induction motor having a capacity determined by the rated load torque
10 of the conveyor is driven in the form of delta-connection.

 On the other hand, a passenger conveyor seldom conveys passengers corresponding to its rated maximum torque but it is usually driven with a several per cent of the full transportation load or sometimes
15 with no load. In other words, in most of the operations the motor is used to drive the conveyor with a lower load factor with respect to its capacity and with a low efficiency.

 In order to raise the efficiency, there has
20 recently been employed a system wherein the existence of a passenger or passengers is detected to selectively stop or start the conveyor based on the result of detection. In the system, since the conveyor may stop when there is no passengers on it, the power consumption
25 may be saved for the stopped period of time. However,

if there is even one passenger on the conveyor, the conveyor has to run as in the conventional system. The efficiency is still low in such a system which often conveys a few passengers. In addition, in such a system, in the case where the conveyor happens to come to a stop because of absence of passengers therefor, subsequent passengers who are about to ride thereon might wrongly take it to be out of service. For such a reason, in a building such as a department store which is available for a large number of non-specific persons and which therefore takes a serious view of serviceability, the conveyor can not stop even if there is no passenger. Thus, the conveyor must be operated continuously as in the conventional system.

Therefore, it is desirable to provide a control apparatus for a passenger conveyor in which power consumption may be reduced.

According to the present invention there is provided a control apparatus for a passenger conveyor having step plates interlinked to one another in an endless form to transport passengers thereon, the control apparatus comprising a three-phase induction motor arranged to drive said step plates and capable of being changed over between star- and delta-connection modes,

transportation demand detecting means arranged to detect transportation demand for said passenger conveyor on the basis of at least one of current and electric power supplied to said three-phase motor; and

change-over means arranged to switch the winding connection of said induction motor into the delta-connection mode when the transportation demand exceeds a first predetermined value and to switch the winding connection of said induction motor into the star-connection mode when the transportation demand is below a second predetermined value.

Conveniently, a passenger conveyor utilising the control apparatus of the present invention, will provide a smooth, comfortable safe riding condition

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

5 Fig. 1 is a schematic perspective view of an embodiment of a passenger conveyor incorporating a control apparatus of the present invention;

Fig. 2 is a main circuit diagram of a passenger conveyor incorporating the control apparatus of the present invention;

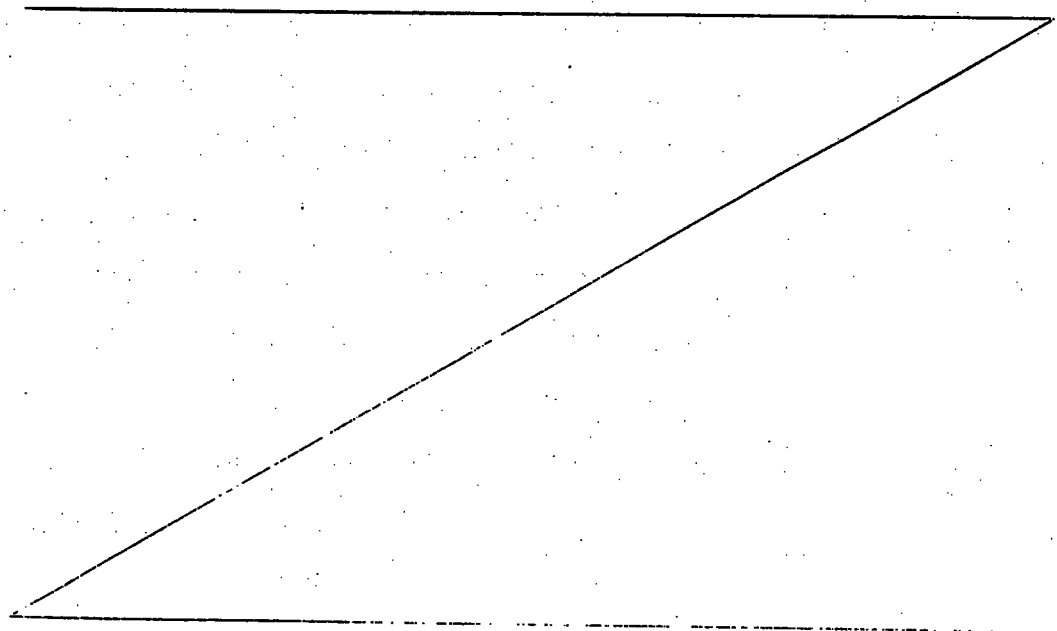
10 Fig. 3 is a characteristic diagram showing the relationship between the efficiency/input power and the output of the conveyor, for explanation of the principle of the present invention;

Fig. 4 is a characteristic diagram showing the relationship between the input current and the output, for explanation of the principle of operation of the present invention;

15 Fig. 5 is a circuit diagram of an embodiment of a load detector which constitutes a transportation demand detector of a control apparatus according to the present invention;

20 Fig. 6 is a circuit diagram of an embodiment of a passenger conveyor control circuit of control apparatus according to the present invention; and

Figs. 7A and 7B show measurement results of noise suppression effects of control apparatus according to the present



1 invention.

Three types may be considered as a transportation demand detector for a passenger conveyor, as follows:

5 (1) A detector of a first type in which passengers are directly detected;

(2) A detector of a second type in which passengers are indirectly detected; and

10 (3) A detector of a third type in which passengers are detected based on an estimate.

As the first type detector, the "apparatus for detecting the number of objects" disclosed in U.S. Patent No. 4,023,135 and U.S. Patent No. 4,112,419 is available. The apparatus is based on the fact that if ultrasonic
15 waves are directed toward passengers the intensity of the waves reflected therefrom are proportional to the number of passengers. Therefore, this type of detector can be used to detect the quantity of passengers with accuracy sufficient to embody the present invention.

20 The second type detector is based on the fact that the load of a motor for driving a passenger conveyor varies depending upon the quantity of passengers. In the detector, accordingly, the current or power of the motor is detected to measure the passenger
25 quantity. The detector of this type will be detailed later in connection with an embodiment of the present invention.

According to the third type detector (3), the

- 5 -

1 time range or ranges where passengers on the conveyor
increase are detected, for example, by means of a
timer. In the event that the conveyor is installed in
such a place where passengers on the conveyor increase
5 only in such specific time ranges as office-going/leaving
hours and lunch time, the transportation demand for the
conveyor can easily be estimated only by setting the
specific time ranges in the timer mentioned above.

The following explanation will be made
10 with respect to an embodiment of the present invention
in which the second type detector mentioned above is
utilized. _____

15 Referring now to Fig. 1, there is shown a
schematic perspective view of a passenger conveyor,
_____ partly in section
at its upper and lower ends to illustrate its internal
structures. As illustrated in the figure, step plates
20 1 are interconnected to each other in an endless form
substantially along a length of the conveyor and
driven by an endless chain 4 which is hung between
sprockets 2 and 3 to pass therearound. On the both
sides of the step plates 1, disposed are upright supports
25 or balusters 5 each of which has a length corresponding
to the total length of the step plates 1. Each of the
balusters 5 supports at its top a hand rail 7 which
is moved in synchronism with the step plates by a hand

1 rail driver 6. The step plates 1 can be moved upward
or downward through a reduction gear box 8 and the
chain 4 by a three-phase induction motor IM which is
selectively switchable between star- and delta-connection
5 modes. EC designates a controller for the conveyor.
The controller EC provides a feature of the present
invention, and will be explained in detail later. These
components constituting the conveyor are supported by
a frame 9 and installed between floors in the building.

10 Fig. 2 is a main circuit diagram of the
passenger conveyor. _____

_____ As shown in Fig. 2, phase terminals R, S and T of
a three-phase a.c. power source 3 ϕ are connected
respectively to input terminals u, v, and w of a three-
15 phase induction motor IM, through a main circuit breaker
FFB, an electromagnetic contactor 111 for upward move-
ment or an electromagnetic contactor 121 for downward
movement, and an electromagnetic contactor 101 for
operation start. As shown in Fig. 2, the terminals X,
20 Y and Z of the motor IM are connected respectively to
an electromagnetic contactor DR_1 for a delta-connection
mode and an electromagnetic contactor YR_1 for a star-
connection mode. The contactors DR_1 and YR_1 function
to selectively put the motor IM in a delta-connection
25 mode or a star-connection mode under control by a control
circuit of Fig. 6. An overcurrent relay 14 is provided
to protect the power source 3 ϕ from being short-
circuited in the case where the contactors DR_1 and YR_1

DH

1 are both closed. More specifically, the relay 14
includes a current detecting coil 14A and a relay 14A₁.
As soon as the detection coil 14A senses an excess
current, the relay 14A₁ is opened to cut off the star-
5 connection of the motor. A load detection circuit
LDA is the second type detector mentioned above, and
is used to detect the transportation demand for the
conveyor. The load detection circuit LDA receives
across its terminals a and b a phase voltage between
10 the phases R and S, and at its terminals c to f a phase
current of the phase S detected by current detectors CT₁
and CT₂.

Now, for the better understanding of the
present invention, the operational principle of this
15 embodiment will be explained with reference to Figs. 3 and
4. Fig. 3 is a diagram illustrating the characteristic
of the three-phase induction motor IM including the
efficiency characteristic of the reduction gear box 8.
In particular, the diagram shows the relationship be-
20 tween the efficiency EF and the output P of the gear
box 8 linked to the motor IM and the relationship
between the input voltage W and the output P. In the
figure, a curve (1) indicates the efficiency charac-
teristic in the case where the motor is wired in the
25 star-connection mode, a curve (2) indicates the efficiency
characteristic in the case where the motor is wired in
the delta-connection mode, a curve (3) indicates the
power consumption characteristic in the case where the

1 motor is wired in the star-connection mode and a curve
④ indicates the power consumption characteristic in
the case where the motor is wired in the delta-con-
nection mode.

5 As seen from the figure, the star-connection
configuration is higher in efficiency and less in power
consumption than the delta-connection one, within the
range where the output P is below about 50% of the
rated value. The relationship between the efficiency
10 and power consumption as mentioned above is reversed
and the efficiency in the star-connection arrangement
abruptly drops if the output power P exceeds a value
slightly higher than 50% of the rated value, resulting
in a status where satisfactory torque can not be obtain-
15 ed.

In view of this point, in the embodiment of
the present invention, the connection of the motor IM
is changed over between star- and delta connections
depending on the transportation demand for the conveyor
20 so that the motor IM is operated with high efficiency,
thereby minimizing the power consumption.

In this embodiment, the load condition of the
motor IM is detected by measuring the input power W
and the motor connection is changed over between the
25 star- and delta-connections in accordance with the
magnitude of the detected input power W.

In this case, however, if the change-over is
effected merely depending on the magnitude of detected

1 input power W, the change-over operations would be
very frequently undesiredly repeated due to the
fluctuations in the power W in the vicinity of the
value thereof at which the change-over be effected.

5 In order to avoid this, in this embodiment,
different switching values are set to a first power
level (nearly at 40% level of the output P) for change-
over from the star- to delta-connection and to a second
power level (nearly at 30% level of the output P) for
10 change-over from the delta- to star-connection, so that
after switching to the delta-connection has been
completed at a point (a), a switching operation to the
star-connection is inhibited until the power W drops
below a point (c) for stable control, as it will be
15 clear from the figure.

In this way, the load condition of the motor
IM has been detected in the form of power in order to
avoid adverse effect resulting from voltage fluctuations
in the power source 3 ϕ . However, in the case where
20 the voltage of the power source 3 ϕ does not so fluctuates,
the change-over of connections may be effected by using
only the input current of the motor IM.

Fig. 4 is a characteristic diagram showing
the relationship between the input current I and the
25 output P of the motor IM together with the reduction
gear box 8. In the figure, curves (5) and (6) indicate
input currents in the case of the star-connection and
delta-connection arrangements, respectively. As known

1 well, if the voltage of the power source 3 ϕ is
maintained constant, the magnitude of a load for the
motor IM is proportional to the magnitude of the input
current I. In this embodiment, a current detector is
5 provided as a backup of the power detector, so that in
the case where a change-over to the delta-connection
mode by the power detector fails to be effected, the
backup detector (i.e. the current detector) will cause
a forcible change-over to the delta-connection mode
10 when the fact is detected that the current I reaches
a value corresponding to about 50% level of the output
P at a point (e) on the curve (5).

Figs. 5 and 6 show embodiments of means for
controlling the passenger conveyor based on the opera-
15 tional principle as mentioned above.

Fig. 5 shows an embodiment of the load detec-
tion circuit shown in Fig. 2. As shown in Fig. 2, the
phase terminals R and S of the power source 3 ϕ are
connected across a primary winding TW_1 of a transformer
20 T so that a secondary winding TW_2 thereof produces a
fixed d.c. voltage E_{ZD} via diodes D_1 and D_2 , a resistor
 R_3 and a Zener diode ZD_1 .

A well-known power detector PWD is provided
to detect the load of the induction motor IM. As illust-
25 rated in Fig. 5, secondary windings TW_3 and TW_4 of the
transformer T produce voltages proportional to the
phase voltage between the phase lines R and S. The
voltages produced across the respective secondary

1 windings are then combined with a voltage which appears
across a detection resistor R_{11} and which is proportional
to the R-phase current detected by the detector CT_1 .
The combined voltage are rectified by full-wave rectifying
5 bridge circuits SR_1 and SR_2 and then applied to output
resistors R_1 and R_2 . A voltage appearing across each of the
output resistors R_1 and R_2 is proportional to the input
power W shown in Fig. 3. The input power W assumes a
positive or a negative value depending upon the running
10 direction (upward or downward) of the passenger conveyor.
A voltage proportional to the absolute value of the
input power W is supplied to resistors R_4 and R_5 through
full-wave current bridge circuit SR_3 . As a result, a
voltage appearing across the variable resistor R_5 is
15 proportional to the power consumed by the motor IM.

The load detection circuit of Fig. 5 further
includes transistors TR_1 to TR_3 , an auxiliary relay
coil A for star-delta change-over, a relay coil AX for
star-delta change-over command, and a relay coil AQ for
20 star change-over command. Resistors R_6 and R_7 are
selected to be $R_6 > R_7$.

In operation, first, a power switch PSW is
turned on to energize the load detection circuit of
Fig. 5. This causes the transistors TR_2 and TR_3 to
25 receive base voltages respectively through the resistor
 R_6 and a resistor R_8 and through the resistor R_6 and a
resistor R_{10} . Thus, the transistors TR_2 and TR_3 are
made conductive. When the transistor TR_3 is made

1 conductive, the auxiliary relay A is energized so that
 a contact A_1 is closed to energize or excite the
 star- delta change-over command relay coil AX. The
 contacts of the relay coil AX are inserted in the
 5 conveyor control circuit of Fig. 6 so that the induction
 motor IM is put into the star-connection mode when
 the relay coil AX is excited and into the delta-connec-
 tion mode when the relay coil AX is deenergized. Under
 this condition, contacts $14A_2$ and AQ_1 are closed, as
 10 will be described later.

In this way, as soon as the power switch PSW
 is turned on, the change-over command relay coil AX
 is energized and the induction motor is operated in the
 star-connection mode. In this mode, a terminal voltage

15 E_B appearing across a bias resistor R_9 is $E_{ZD} \cdot \frac{R_9}{R_7 + R_9}$.

On the other hand, the transistor TR_1 is
 supplied at its base terminal with a voltage properly
 divided by the variable resistor R_5 . The base voltage
 is proportional to the input power of the motor IM, as
 20 has been explained earlier. Therefore, if passengers
 to be carried by the conveyor so increase in number
 that the input power of the motor IM correspondingly
 increases and that the base voltage of the transistor
 TR_1 exceeds the bias voltage E_B across the resistor R_9 ,
 25 the transistor TR_1 is made conductive. Upon the
 conduction of the transistors TR_1 , the transistors TR_2
 and TR_3 are turned off because the respective base

- 1 voltages of the transistors TR_2 and TR_3 are lowered.
This causes the auxiliary relay coil A and the relay
coil AX to be both deenergized, whereby a command is
issued from the relay coil AX so as to put the motor
5 IM into the delta-connection mode.

More specifically, the bias voltage $E_B =$
 $E_{ZD} \cdot \frac{R_9}{R_7 + R_9}$ is set at a level corresponding to the
point (a) in Fig. 3 so that as soon as the output P
exceeds 40% level of the rated value, the change-over
10 into the delta-connection mode can be automatically
effected.

In the delta-connection mode, the bias voltage
 E_B appearing across the resistor R_9 changes to the
value $E_{ZD} \cdot \frac{R_9}{R_6 + R_9}$. Since the resistors R_6 and R_7
15 are selected to be $R_6 > R_7$ as has been explained, the
bias voltage E_B is lowered. The bias voltage $E_B =$
 $E_{ZD} \cdot \frac{R_9}{R_6 + R_9}$ is set at a level corresponding to the
point (c) in Fig. 3 so that once the star-connection mode
has been established, a change-over operation into the
20 star-connection mode can not be effected until the
input power W drops to a level less than that at the
point (c). As soon as the input power W so drops that
the base voltage of the transistor TR_1 is lowered to
a level below the above-mentioned value $E_B = E_{ZD} \cdot \frac{R_9}{R_6 + R_9}$,

1 the transistor TR_1 is turned off, whereby the detection circuit of Fig. 5 is returned to the initial state so that the change-over command relay AX is energized to put the motor into the star-connection mode.

5 In this way, the detection circuit of Fig. 5 functions to generate a command to effect a selective change-over between the star- and delta-connection modes according to the input power of the motor IM and therefore according to the quantity of passengers on the
10 conveyor.

On the other hand, the current detector CT_2 is provided as a backup. The output of the current detector CT_2 is supplied to a resistor R_{12} and a voltage appearing across the resistor R_{12} is proportional to the S-phase
15 current. When the relay coil AX is energized, the voltage across the resistor R_{12} is supplied to a resistor R_{15} via a smoothing circuit which comprises a full-wave rectification bridge circuit SR_4 , a resistor R_{13} and a capacitor C_1 . The voltage thus applied to
20 the resistor R_{15} is proportional to the current I shown in Fig. 4. A Zener diode ZD_2 is set at a level corresponding to the value at the point (e) (corresponding to 50% level of the rated output P) in Fig. 4 so that a transistor TR_4 is turned on when the current I on the
25 U-phase line of the motor IM exceeds the point (e), whereby the delta-connection change-over command relay coil AQ is energized to deenergize the star-delta change-over command relay coil AX because the contact AQ_1 of

- 1 the relay AQ is opened.

In this way, the delta-connection change-over relay coil AQ acts to forcibly switch the motor into the delta-connection mode as soon as the output P exceeds the 50% level of the rated value thereof, in spite of the fact that the star-delta change-over command relay coil AX is maintained energized and the conveyor is operated in the star-connection mode. If the circuit on the side of the power detector PWD is normal, the relay coil AX is deenergized at a point where the output P exceeds its 40% level to thus open the contact AX₁ of the relay AX. Therefore the delta-connection command relay coil AQ can never be energized. Once the relay coil AQ is energized, the delta-connection mode is held for the purpose of safe conveyor operation so long as a reset switch RS is not released.

Fig. 6 shows a control circuit for the passenger conveyor. In Fig. 6, the symbol UPS denotes an upward run command switch for upward operation of the conveyor and the symbol DNS denotes a downward run command switch for downward operation of the conveyor.

Now, explanation will be directed to the upward operation of the conveyor. When the upward command switch UPS is turned on, an auxiliary relay coil 11X for upward operation is excited so that a contact 11X₁ thereof is closed to hold the relay 11X in the self-sustained state and a contact 11X₂ thereof is opened to interlock an auxiliary relay coil 12X for

1 downward operation to prevent its excitation. A normally
closed stop switch STS is turned off to open the self-
sustained circuit thereof when the conveyor is stopped.

When a contact $11X_3$ of the relay $11X$ is
5 closed, a relay coil 11 for upward operation is
energized thereby opening a contact 11_4 of the relay
 11 to cause a relay coil 12 for downward operation to
be interlocked.

Under this condition, the star-delta change-
10 over command relay coil AX in Fig. 5 is energized. As a
result, contacts $11X_4$ and AX_2 are closed to energize an
operation relay coil 10 and keep the relay 10 in the
self-sustained state by means of a contact 10_2 of the
relay 10 . At the same time, a contact 10_3 of the
15 relay 10 is closed and a normally-open contact AX_3 of the
relay AX is closed to energize a relay coil YR for
star-connection. When the relay YR is energized, its
contact YR_4 is opened to interlock a relay coil DR for
delta-connection.

20 In this way, when the upward operation relay
coil 11 , the operation relay coil 10 and the star-con-
nection relay coil YR are energized, the upward operation
contactor 11_1 , the operation contactor 10_1 and the star-
connection contactor YR_1 are closed in Fig. 2, so that
25 the induction motor IM is driven in the star-connection
mode to move the conveyor upward.

Upon starting the induction motor IM , a
starting current may temporarily increase the power

1 consumption, and therefore the star- delta-connection
change-over auxiliary relay coil A and the delta-
connection change-over relay coil AS may be temporarily
deenergized so as to temporarily deenergize the star-
5 delta change-over command relay coil AX, whereby the
motor might unwantedly be switched into the delta-
connection mode. In order to avoid such change-over
operation into the delta-connection mode at the time
of starting the motor, a timing relay coil 50T is
10 provided in Fig. 6 so that its contact $50T_1$ (see Fig. 5)
is closed for a desired period of time after the motor
has been started, to allow energization of the change-
over command relay coil AX regardless of the states
of the contacts A_1 and AQ_1 .

15 With the arrangement as described above, as
soon as passengers to be carried by the conveyor
increase in number in its upward operation so that the
output P of the motor IM exceeds 40% level (correspond-
ing to the point (a) in Fig. 3) of the rated output,
20 the star-delta change-over command relay coil AX is
deenergized, as has been explained earlier. The de-
energization of the relay coil AX causes the normally-
open side of the contact AX_3 in Fig. 6 to be opened and
a normally-closed side of the same contact AX_3 to be
25 closed, so that the star-connection relay coil YR
is deenergized while the delta-connection relay coil DR
is energized. As a result, the contactor YR_1 is opened
and the contactor DR_1 is closed in Fig. 2 to allow a

- 1 generation of torque enough to drive a large load from
the induction motor IM, so that the conveyor can be
efficiently operated by the motor in the delta-connec-
tion mode, because the delta-connection mode is higher
5 in efficiency than the star-connection mode.

In this way, the star-connection contactor YR_1
and the delta-connection contactor DR_1 in Fig. 2 are
selectively switched according to the load torque of
the motor, i.e., the quantity of riders on the conveyor.

- 10 If the switching time is so longer, however, correspond-
ing fluctuations in the torque would provide uncomfort-
able shock to the passengers. Therefore, it is preferable
to shorten the switching time as possible. However,
arc may take place between contact pairs when alive
15 contactors are opened. At this time, because the
contactor is momentarily electrically linked or closed
for a short time due to the arc phenomenon between
contact pairs even if mechanically opened, there is
a possibility that a momentary and undesirable short-
20 circuit is caused between lines. If such a momentary
short-circuit phenomenon occurs between lines, a
large short-circuit current would cause all or some
contact pairs in the contactor DR_1 or YR_1 to be melted
into their permanently closed condition, so that the
25 power source 3ϕ is permanently short-circuited and
the main circuit breaker FFB is tripped to thus stop
the conveyor, disabling the conveying operation thereof.
In order to avoid such situation, the overcurrent

1 relay 14 is provided in Fig. 2. The overcurrent relay
14 may operate prior to the breaker FFB. More
specifically, as soon as the relay 14 detects a large
short-circuit current resulting from a short-circuited
5 power source, the relay 14 opens its contact $14A_1$ to
forcibly cut off the star-connection circuit. At the
same time, the relay 14 opens also its contact $14A_2$
(Fig. 5) to maintain the delta-connection contactor DR_1
closed, so that the conveyor operation can be maintained
10 to secure its service even in the case where the
contactor YR_1 or DR_1 is melted to thus make contact
pairs closed permanently. It will be readily understood
that the overcurrent relay 14 may be provided on the
side of the delta-connection contactor DR_1 . In this case
15 the conveyor can be continuously operated in the star-
connection mode in case where either one of the
contactors is melted at its contacts. However, the
former embodiment is superior in operational safety
to the latter, when it is taken into the consideration
20 the case where the conveyor may carry an increased
number of passengers.

A malfunction indication lamp PL shown in
Fig. 6 is used to indicate a faulty condition of the
conveyor for repair. When the overcurrent relay 14
25 is actuated, its contact $14A_3$ is closed and the fault
indication lamp PL is lit up or illuminated. Even
in the event where the output P from the motor IM

1 exceeds 40% level (corresponding to the point (a) in
Fig. 3) of the rated output for some reasons but the
change-over to the delta-connection mode has been
performed by the relay coil AQ, as has been explained
5 in connection with Fig. 5, the contact AQ₂ of the
relay AQ is closed to thereby light up the faulty indica-
tion lamp PL.

Although the above explanation has been made
in the case of the upward operation of the conveyor,
10 it will be easily appreciated that the same can be
true for the downward operation thereof. Further, the
load detection circuit of Fig. 5 has been used as a
transportation demand detecting circuit in the illust-
rated embodiment, but the present invention is not
15 limited to this embodiment and a detector of the first
or third type as explained earlier may be employed.

That is, in the case where the first type
detector is employed, the output voltage of the apparatus
for detecting the number of objects or passengers on
20 the conveyor is proportional to the number of passengers.
In this connection, change-over between the delta- and
star-connection modes can be carried out according to
the quantity of passengers in exactly the same manner
as in the embodiment by applying across the variable
25 resistor R₅ the output voltage of the detection apparatus
in place of the power detector PWD in Fig. 5. Moreover,
since the detection apparatus can also detect the
presence or absence of passengers who are going to

ride on the conveyor, the present invention may be designed so that in the presence of passengers the upward or downward operation switch UPS or DNS is turned on, while in the absence of passengers the stop switch STS is turned off. This arrangement can allow not only minimization of power consumed by the motor during operation of the conveyor by selectively switching between delta- and star-connection modes depending on the quantity of passengers, but also saving of power during the stopping period of time of the conveyor by stopping the conveyor in the absence of passengers. In department store applications, however, it is favorable to continuously efficiently drive the conveyor in the star-connection mode even in the absence of passengers for the major purpose of its serviceability.

According to the present invention, not only the power can be saved by driving the induction motor IM in the star-connection mode during period of less transportation demand of the conveyor, but noises resulting from the conveyor can also be suppressed.

Figs. 7A and 7B show measuring results of noise when the conveyor is operated in the star-connection mode and in the delta-connection mode, respectively. In each of Figs. 7A and 7B, the ordinate denotes the acoustic pressure level and the abscissa denotes the frequency. It will be readily seen from the measuring results in Figs. 7A and 7B that the noise higher than 40 dB level in the star-connection mode is less than that

in the delta-connection mode and especially the peak noise level at the vicinity of 600 Hz in the star-connection mode can be reduced by about 3 dB when compared with that in the delta-connection mode. Such

5 noise from the conveyor causes a problem especially when a less number of passengers are on the conveyor and when the noise level from the vicinity of the conveyor is relatively low. According to the present invention, however, since the conveyor is driven in the star-

10 connection mode when it is in such a relatively low noise environment or surroundings, the noise level issued from the conveyor itself can be advantageously made lower.



- 23 -

CLAIMS:

1. A control apparatus for a passenger conveyor having step plates interlinked to one another in an endless form to transport passengers thereon, the control apparatus comprising a three-phase induction motor arranged to drive said step plates and capable of being changed over between star- and delta-connection modes,
5 transportation demand detecting means arranged to detect transportation demand for said passenger conveyor on the basis of at least one of current and electric power supplied to said three-phase
10 motor; and
change-over means arranged to switch the winding connection of said induction motor into the delta-connection mode when the transportation demand exceeds a first predetermined value and to switch the winding connection of said induction motor into the star- connection
15 mode when the transportation demand is below a second predetermined value.
2. A control apparatus as claimed in Claim 1, wherein said second predetermined value is set to be smaller than said first predetermined
20 value.
3. A control apparatus as claimed in Claim 1, wherein said change-over means includes means for maintaining said motor in the star-connection mode, regardless of the output of said transportation demand
25 detecting means, for a predetermined period of time after said conveyor has been started.
4. A control apparatus as claimed in Claim 1, wherein said transportation demand detecting means includes means for detecting the
30 electric power supplied to said induction motor.
5. A control apparatus as claimed in Claim 4, wherein said transportation demand detecting means further includes means for detecting the current supplied to said induction motor.



- 24 -

6. A control apparatus as claimed in Claim 5, wherein said change-over means includes means arranged to change said motor into the delta-connection mode when the output of said current detecting means exceeds a third pre-determined value.

7. A control apparatus as claimed in Claim 6, wherein the value of transportation demand represented by said third predetermined value of the output of said current detecting means is set to be larger than the value of transportation demand represented by said first predetermined value of the output of said power detecting means.

8. A control apparatus as claimed in Claim 1, wherein said apparatus further comprises overcurrent detecting means arranged to detect when the current supplied to said induction motor has exceeded a third predetermined value, and means arranged to cut off _____ the star-connection _____ of said motor in response to the output of said overcurrent detecting means.

9. A control apparatus as claimed in Claim 8, further comprising means arranged to maintain the other of said star-connection and delta-connection that has not been cut off by said cutting-off means in response to said overcurrent detecting means.

10. A control apparatus as claimed in Claim 8 or 9, wherein said cutting-off means includes an electro-magnetic contactor connected to one of the star-connection and the delta-connection of said induction motor.

11. A control apparatus as claimed in Claim 8, 9 or 10, further comprising an abnormal condition indication lamp arranged to light up in response to the detection of overcurrent by said overcurrent detecting means.



12. A control apparatus substantially as hereinbefore described with reference to, and as illustrated in Figs. 1 to 6 and 7A and 7B of the accompanying drawings.
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