Systems employed by Various Companies in Japan

Following articles cover 6 systems which were picked up from the K-J authorized companies. The articles are in the order of arrival of data from these companies. In the description of each system, explanations which are duplicates of other systems are omitted. Therefore, there should be no concern regarding the quality of the system if the description be longer or shorter.

a) HITACHI SYSTEM

Hitachi is one of the earliest Japanese companies which succeeded in developing the AC feedback control elevator. The other companies belonging to the earlier group are Mitsubishi, Nihon Elevator Seizo and Fujitech. They were put on sale from 1972. Nippon Otis and Toshiba came into the picture a few years later.

Total installations of Hitachi equipment had reached several thousand units by the middle of 1976, when they developed a revised system. The old system is called “Thyristronic Control Type DB” and the new one is “One-Unit SCR-SR Bridge.” The new system was employed only for the middle class speeds, such as 45 mpm (150 fpm) and 60 mpm (200 fpm). The old system still remains to be used for the higher speed classes such as 30 mpm (300 fpm) and 105 mpm (350 fpm). The reason for the continued use of the old system for the higher speed elevators is, according to the Hitachi Review, that it established a good history of reliability on the already installed thousands of units.

The major difference between the old and new systems is that, compared with the former which employs notch resistance starting, the latter employs a thyristor controlled stepless acceleration method. In both, deceleration is feedback controlled by using a reference speed pattern. The braking torque is obtained from the DC dynamic braking method. In all systems a 2-speed AC induction motor is used, and the second-speed winding is used for dynamic braking as well as for slow-speed inspection running of elevator.

Fig. 6.1 shows the block diagram of the Thyristronic DB system. Starting is achieved by using starting resistance exactly the same as the old conventional AC-2 elevators. By closing contacts S1 and S3, the motor is connected to the power line through starting resistance R and the motor is accelerated by removing the resistance R, step by step, by means of contractors S2. The operation of S2 is time controlled. When the elevator reaches the point of retardation, S3 contacts are open. At the same time, contacts S4 are closed to switch over the connection of motor from 6-pole to 24-pole. To this 24 pole side, the DC dynamic braking current is provided through the deceleration controller. The thyristors control the amount of dynamic braking current by receiving necessary signals from the phase shifter, compares the speed of the motor and the actual speed of the car, dispatching necessary signals either to increase or to decrease the dynamic braking current. If the motor speed is in excess of the reference speed (pattern speed), the DC current is increased. The reference pattern is controlled to correlate with the exact position of the car. That is why it is called a “distance domain” pattern.

This conventional thyristronic DB control system has been satisfactory so far as the control of deceleration is concerned. However, the acceleration control, though usable as it is in quality, left some room to be technically improved because: (1) periodic maintenance is necessary as contractors are used for the control of acceleration, (2) there is inefficient utilization of thyristors which are used only for the control of deceleration and not acceleration control, and (3) a part of the starting input current is wasted as heat generated in the starting resistance.

In the new system developed in 1976, both acceleration and retardation can be controlled steplessly with a pair of thyristors. The basic principle is to bring the torque characteristic curves of both motoring and braking as near to the ideal torque characteristics as possible.

In Figure 6.2, the solid line represents the actual torque characteristic of the 2-speed induction motor for elevator. The upper line shows 3-phase motoring torque and the lower line shows the dynamic braking torque. If the motor is properly designed to have the motoring torque as shown, it will be easily understood that such torque can be used as it is except the starting point, which is controlled by varying the gate angle of thyristors to obtain the stepless torque curve as shown in Fig. 6.3 by the two-dot line. Control for only about 0.5 second is required until the motor reaches the middle of acceleration. After that, the thyristor gate is fully open and the motor is driven by its own motoring torque and soon reaches the normal speed running point.

Figure 6.2 Actual and ideal torque diagram. Illustrated are actual motor torque characteristics and torque characteristics for obtaining the ideal acceleration and deceleration characteristics of the elevator.
The characterstic feature of this system is to start the motor with the single-phase torque which has zero torque at the beginning of the start and then, gradually, increase the thyristor firing angle to bridge the single-phase torque to the 3-phase torque by controlling the thyristor firing angle. The braking torque can be controlled by increasing or decreasing the dynamic current.

When we climb a steep mountain, descent is more difficult and dangerous than ascent. The same is true in controlling the elevator motor torque. Retardation control requires more skill than acceleration control. That is why the control system for deceleration should be much more sophisticated. As will be seen in Fig. 6.3, the dynamic braking torque characteristic is vastly different from the ideal torque curve. Therefore, the whole range of travel must be controlled by feedback control (closed loop control). The deceleration feedback control method employed in this new system is the same as used in the old system (conventional thyristric DB control).

Fig. 6.5 shows the time chart of various contactors. The elevator dispatching signals close the main circuit contactors S1 and S3. The contactors S3 connect two phases of the motor input terminals to the power source (though not illustrated in Fig. 6.4) and at the same time S3 short-circuits the diode arm side of the thyristor unit, which has two SCRs in a state of inverse parallel connection. The connection of the inverse parallel element to the single phase of the motor makes it possible to form an acceleration circuit by single-phase voltage control. Also, at the same time, phase-line switch Sa is closed, and the synchronizing voltage or the same phase voltage of the inverse-parallel connected thyristors is given to the phase shifter. The (1) side of the phase-shifter input relay Sr is closed and the speed pattern circuit is connected to the phase shifter. The acceleration signal is given to the phase shifter directly from the speed pattern circuit. Then the main circuit thyristor increases continually the torque from the single-phase condition of the zero angle of conduction, i.e., zero starting torque and about 0.5 second later, the thyristor gate angle is fully open. After that, the elevator is accelerated by the motor's own 3-phase motoring torque characteristic to achieve normal running speed.

Quick response of the control system to the speed pattern circuit provides satisfactory acceleration performance without the aid of feedback control, therefore, the control circuit is simplified to eliminate sophisticated adjustment.

When the elevator reaches the point to begin deceleration, a deceleration signal is dispatched by means of the position detector fixed on the car. Main contacts S1 are closed and S4 turns on. As a result, the one-unit of thyristors forms a controlled rectified circuit, supplying a dynamic current to the slow-speed winding of the induction motor. Sa is opened and the synchronizing power is given to the rectifier through the line voltage between two phases. At the same time, relay Sr is connected to the (2) side to
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form a speed feedback control loop and the elevator decelerates gradually by the dynamic braking torque occurring in the induction motor. The magnitude of the braking torque is controlled corresponding with the position of the car. The control is made via the thyristor unit, by the thyristor firing signal in proportion to operation results of the speed pattern signal voltage made in correspondence with the car position and the output voltage made in correspondence with the car position and the output voltage of tacho-generator (P.G.). The speed pattern circuit voltage at deceleration control is decreased corresponding to the actual position of the car and it becomes zero when the car has arrived at the desired floor level. Now, the zero-speed checker issues a stop signal to open the main contractors S1, and the magnetic brake is applied to hold the car securely by mechanical force. At this time, the magnetic brake is used, not for decelerating the car, but only to hold it after stopping. The creeping time, which was about 26% of the total flight time, is entirely eliminated. No wear of the brake shoe lining occurs. Wasteful heat generation does not occur in the starting because the starting resistance is eliminated.

In summary, Fig. 6.6 shows graphically how the sequence of controls occurs throughout the intervals of acceleration, normal speed running, and deceleration.

Figure 6.6 Sequence of control of one-unit SCR SR bridge elevator.