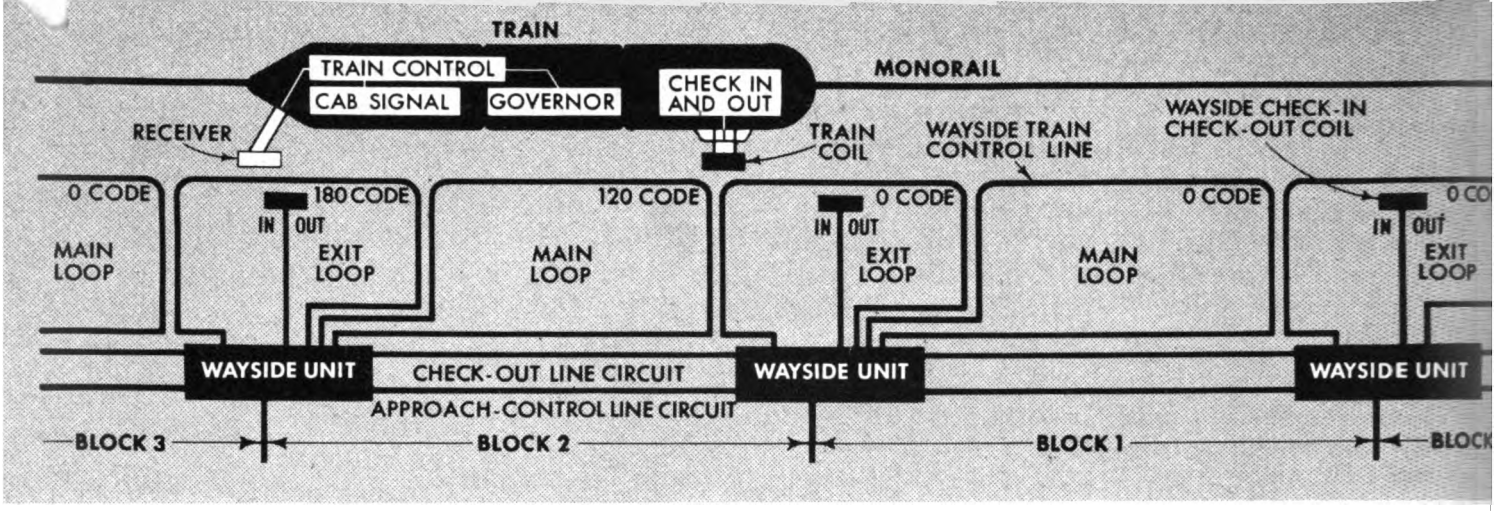


Figure 1. A simplified diagram illustrating the operating principles of the Disneyland Monorail signal system.

Monorail Is Signaled Electronically

General Railway Signal Co., has developed a solution to the problem of providing a fail safe signal system for the one-rail train. Train control and signals on the Disneyland Monorail work on the check-in check-out principle.

THE DISNEYLAND Monorail comprises approximately 4,000 ft of monorail forming one continuous loop, with a single station for loading and unloading of passengers. There is one switch leading to a descent onto the service or set-out track.

Two trains are operated simultaneously. While one train is unloading and loading at the station, the second train travels counterclockwise around the loop. The normal maximum speed is 20 mph.

Briefly, the signal system (1) provides a visual display, in the cab of the train, of the allowable speed in each section of the train's route, thus reflecting traffic conditions ahead, and (2) senses the actual train speed to provide a means of controlling the speed to that specified for the signal displayed in the cab. Safety of operation is assured by the use of fail-safe circuitry.

Operating Principles

Fig. 1 is a simplified diagram that illustrates the operating principles of the cab signal and train control system. The right-of-way is divided into five sections, or blocks. These blocks are spaced to provide the operation desired, consideration being given to suitable braking distances.

Non-contact electronic means are used to determine a train's entry into a block and its exit from a block. This check-in check-out system includes an inert coil on the train which couples inductively with a wayside coil. This action operates relays associated with each block, so that the system can accurately determine, and memorize as required, that a train has entered a block and likewise that it has departed from that block. The check-in check-out feature is an essential part of the system as it, in effect, reaches out in advance of the train at each check point to detect occupancy of the block ahead, and, if clear, permits the train to proceed. At the same time, it protects the rear of the train by providing that a stop indication will be given a following train entering the block behind.

The cab signal system, by means of electronic equipment and relays, continuously obtains information from the wayside through a train-carried receiver. This is inductively coupled to a signal wire installed along the right-of-way, but insulated from the monorail structure. The wire forms one side of a continuous loop. The information obtained is then displayed in the cab signal and reflects conditions observed and recorded by the check-in check-out system. The function of the relatively short exit loops at each check point will be explained later.

The wayside check-in check-out system provides the train with information of block conditions ahead by means of electric current in the wayside loops. The coding of the current is of a distinctive nature and dependent upon the information to be conveyed. This information is received and read out by the train-carried equipment. The coding is started by entry into a block and exists only in the block being traversed. The receiver is mounted on the head-end car and the train coil is mounted on the rear car. The check-out coil being on the last car insures that all cars have left the block.

Sequence of Events

Consider the train shown in Fig. 1 as just having checked into block 2. This automatically applies current in the wayside main and exit loops of block. 2. This current is interrupted at the rate of 120 times per minute in the main loop and 180 times per minute in the exit loop. At the same instant, current is removed from the wayside train control loops in block 1. When the train checks out of block 2 and into block 3, block 1 will be conditioned to be able to apply current to the train control loops as a following train checks into block 1. Block 2, however, will be a Stop block, as train control code would be removed.

The check-in of a train in a block behind an occupied block does not

apply code to the main and exit loops, as it would if the block ahead were unoccupied. Hence the train is required to come to a stop before it can proceed at slow speed. The circuitry of the train-carried equipment is such that a proceed signal cannot be acted upon (following a period of 0 code) unless a short period of 180-rate code is detected. Therefore the second train in an occupied block receives, but cannot act upon, the same proceed signal being transmitted to the first train. Thus the spacing between the two trains becomes a safe value, since the second train must travel at slow speed until it passes over an exit loop having a 180-rate code.

Fig. 2 shows in block-diagram form the organization of the cab signal and train control equipment carried on the train. The receiver is mounted on the train in close proximity to the wayside signal wire. The receiver consists of a laminated core of electrical type sheet steel on which is mounted a rubber encased coil. Voltages are developed in the coil by electro-magnetic induction from the coded currents in the loops.

The signal from the receiver is passed through an electrical filter to ensure that only the code information from the signal wire will be received. The voltage pulses are then amplified by a transistorized amplifier, the output of which drives a "code responsive" CR relay. This relay pulses at the code rate being received from the loops.

Under coding conditions, the CR relay provides energy to the decoders, one of which is tuned to each of the code rates. Each decoder has an associated relay which picks up when the code rate is at the tuned frequency of that decoder.

Permanent Speed Restriction

Since there is a permanent speed restriction upon entering the station, a speed of 10 mph will be enforced at that point. This section will have a 75 rate of coding. Therefore, the 75-rate decoder will select the proper filter in the speed governor and, through the control relay group, apply the brakes automatically if the allowable speed is exceeded. This speed control feature can also be applied to the maximum speed of the trains, although it is not provided at present.

The speed governor includes a frequency generator, which is driven by the train's motive power in such a manner that it produces an ac voltage with a frequency proportional to the speed. The output of the generator is amplified, then applied to a high-pass filter, further amplified, and applied to the output relay. The filter is selected by the 75-rate decoder so that the allowable speed is proper for the code being received from the wayside loop. This speed governor incorporates an oscillator checking means so that about once per second the oscillator, filters, amplifiers, and relays are checked for proper operation. The governor output relays act on the control relays. The control relays actuate the brakes as determined by the conditioning of the decoder relay and governor output relays.

The decoders and relays operated by the pulsing of the CR relay also determine the aspect of the cab signal. If 180- or 120-rate is received, the aspect will be green. If 75-rate code is received in the restricted speed zone entering the station, the aspect will be yellow and, with no code present, the signal will be red.

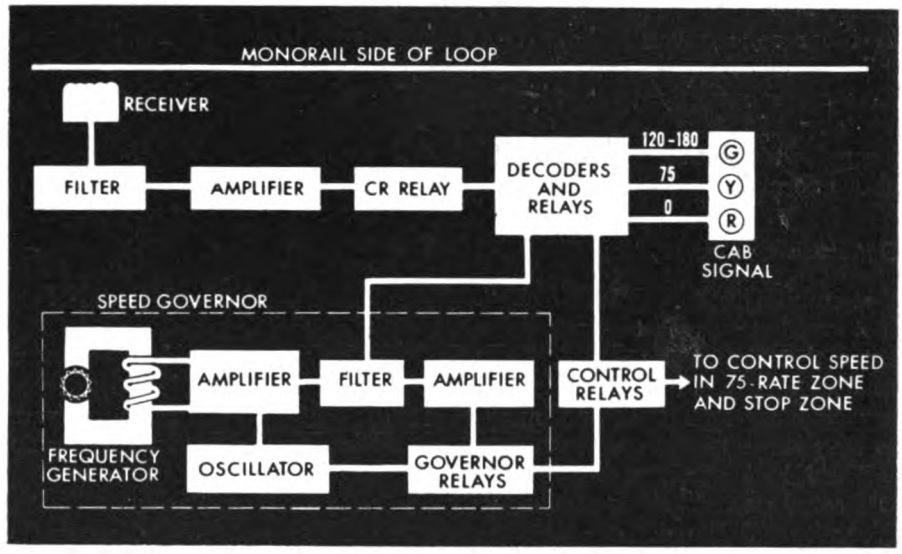
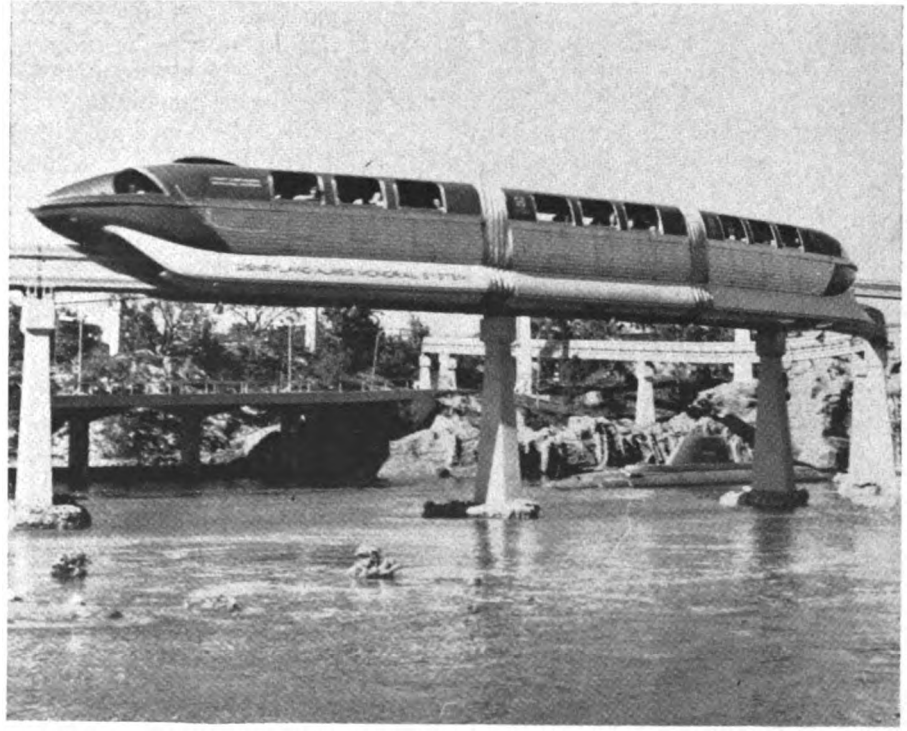


Figure 2. A block diagram of the train carried signal equipment.



Disneyland Monorail utilizes new principles to provide fail safe signaling.