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Semiautomatic Operation for Upgrading Intermediate-Sized Hump Yards

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A simplified control-system concept is described that may be applied to older manual hump yards to improve operating efficiencies, car handling, and volume and allow semiautomatic operation with one operator where two or three may have been needed for manual operation. The system provides automatic routing of cars based on manual handling of the entry of cars onto tracks during humping or on use of a switch list received in advance directly from a host computer. It offers speed control with a closed-loop radar system and manual inputs that allow the operator to specify a group-retarder exit speed for each individual classification track. These exit speeds are modified automatically according to car weight as determined by a conventional weight rail. No rolling-resistance calculations are made. The effect of track fullness is compensated for manually by the operator, but another option offers automatic fullness compensation based on cars counted into each classification track. Corrections for the effects of misroutes or stalls need manual intervention. Although this approach is not fully automatic, it is much more cost effective for lower-volume yards than a fully automatic system. This has been proven in two yards handling volumes of 1,000 to 1,500 cars per 24-hr day.

There are many older hump yards in the United States that still use manual retarder operation and manual switching of cars from a lever-type operator console. Depending on size, many of these yards employ several retarder operators in addition to the person who routes the cars to their destination tracks. These yards typically process between 500 and 1,500 cars per 24-hr day and have from 24 to 48 classification tracks--truly the middle-sized classification yard.

The control system described in this paper is a method of greatly improving the efficiency of such a yard without going to the expense of a completely automatic yard. It consolidates control in one operator, who monitors both retardation and routing; it improves the reliability of switching; it improves the speed control with resulting reduction in damage; and it raises the overall operating efficiency of the yard. This system has been installed in two yards of the Consolidated Rail Corporation (Conrail) and has provided outstanding results.

In general design concept, the system is two systems in one package: a switching or route-control system using microprocessor logic and manual pushbutton entry and a semiautomatic speed-control system with individually selectable exit speeds for each track. The speed control uses radar speed monitoring with a closed-loop control that drives the retarder to reduce the speed of each car to the value called for by the microprocessor. Speeds called for are values entered by the operator, modified slightly according to car weight and ambient temperature. An optional enhancement also provides automatic compensation for track fullness, which will be discussed later. Another optional enhancement, to be discussed later, is direct entry of the switch list from a host computer, eliminating the operator pushbutton entry other than corrections as needed. The system also provides a full operator's console permitting manual override of any automatic function and a test and simulation panel employed in maintenance and system testing.

AUTOMATIC SWITCH OPERATION

In the automatic switching portion of the system, new data are entered in one of two modes, selected by the pushbuttons marked TRACK SELECT and DEFAULT SELECT. Following system clearout, the system will automatically revert to DEFAULT SELECT. In this mode, the DEFAULT SELECT button lights and a two-digit number entered on the keyboard will appear in the DEFAULT display window. That number track will subsequently be used as a destination track for any car humped without an entry for destination. The default track selection will remain in effect and the number will remain in the window until it is changed by the entry of a new number. The system will not accept an invalid number as a default track and will respond to such a request by issuing an INVALID TRACK alarm.

To enter the track-select mode the TRACK SELECT button must be pushed. It will then light and remain lighted, and the DEFAULT SELECT light will go out. In the track-select mode, track entries are made as two-digit numbers from the number keyboard. Track numbers 1 through 9 are entered with a leading zero. The first two digits entered will appear in the CUT 1 display window, each digit appearing as it is entered. This is the destination track for the first cut. The next two digits entered will appear in the CUT 2 display window, representing the destination track for the second cut. Subsequent entries may be made for the third and fourth cuts; the numbers appear in the CUT 3 and CUT 4 windows. If an invalid track number is entered, it will not appear in the CUT window, and an invalid-track alarm will be issued. If a valid track number already entered must be deleted or changed, this is done with the CUT CANCEL button. Pushing this button cancels the last full track number entered and removes it from the cut display window. A second push of this button cancels the next prior track number entered, and so forth. For example, if four track numbers are entered and the operator wishes to change the number displayed for cut 2, he must push the CUT CANCEL button three times, cancelling in turn cuts 4, 3, and 2. He then reenters the numbers, beginning with cut 2. As each cut enters the master retarder, its number is dropped from the CUT 1 display and all following cuts advance one position, allowing a new number to be entered for cut 4. Any numbers entered while all cut displays are filled will be disregarded.

As a cut enters the master retarder, its destination track in the CUT 1 display can no longer be changed, and all switches leading from the crest to the destination track are positioned, unless any of the required switches are awaiting an earlier cut. Progress of the cut is tracked by the computer by using both retarder-wheel detectors and switch-presence detectors (PDs). The computer always attempts to position as many switches as possible ahead of each cut without affecting earlier cuts. If a switch fails to achieve the requested position within approximately 0.9 sec after the request, it will be restored to its previous position (unless its PD has been occupied), and a switch-failure alarm will be issued.

MANUAL SWITCH OPERATION

On the console there is a control level for each switch with three rotary positions: left, right, and automatic. In the automatic position, the switch is controlled by the computer as described previously. In the left or right position, the computer will not attempt to control the switch but still monitors its position. In the left or right position, the switch will remain in the requested position and the position will be displayed continuously by the appropriate white light on the console and the test panel. Cuts can be routed automatically through a switch in manual mode as long as a change of position is not required. If a destination-track number is entered for a track and it cannot be reached because of a switch manually positioned for other than the required route, the track number will not be accepted, and a ROUTE BLOCKED alarm will be issued. If a track is to be protected or "blue flagged," the switch-control lever is placed in the protecting manual position and pulled up; a blocking collar is slipped under the knob to hold it in the up position. This provides the additional protection of opening the circuit to the control relays and lighting the blue light alongside the switch on the control panel to indicate that the switch is blocked. Automatic operation makes no distinction between a blocked switch and one that is simply in manual operation; it cannot control it in either case. As in automatic operation, if a switch fails to achieve the requested position within approximately 0.9 sec after the request, it will return to its previous position.

Pushing of the TRIM button deactivates data input from the keyboard and weigh-rail PD to prevent default track selection by the automatic routing when manual switching is used. The TRIM pushbutton is lighted to indicate that the system is in the trim mode. Routes stored in the computer before the trim mode is selected are unaffected and continue to be processed by the computer. Manual route selection can be performed by manual operation of the switches in each selected route. The trim mode is cancelled by pushing the lighted TRIM button.

SPEED CONTROL

The speed-control portion of the system begins with a weight measurement on each cut. The weight of each cut being humped is classified on a weigh rail installed just below the crest of the hump. The weigh rail uses microswitches to transfer contacts based on rail-head deflection. Weight categories represented by the contacts are light, medium, heavy, and extra heavy. Actual weights applying to each category are adjustable within limits at the time of installation. Because rail-head deflection occurs only when a wheel is centered over the deflection point, a separate reading is made for each wheel. These momentary outputs from the microswitches are stored during the time that the PD at the weigh rail is occupied. The measurement is progressive in that the greatest weight recorded for any one wheel during passage of a cut is stored and used as the weight for that cut. Cut weight and track circuit occupancy are indicated in lights on the console and on the test panel while the weighing takes place. The finally determined weight is delivered to the computer for transfer to the retarders when the PD becomes vacant. If for any reason no weight is obtained, the system will default to the category of heavy.

Actual speed of each cut as it moves through each retarder is measured by the Doppler radar unit. The radar antenna is enclosed in a heavy sheet-metal housing with a nonmetallic front panel. The antenna assembly is mounted on a foundation consisting of two rectangles made up of galvanized steel angle stock. Light-duty bolts are used to mount the antenna to provide break-away protection in the event that an antenna is struck by dragging equipment. The antenna unit is mounted approximately 15 ft upstream from the top of the retarder and just outside the ends of the ties. A light cable from each antenna unit will terminate in a bootleg junction box adjacent to the antenna, which is also mounted with the break-away principle.

A card cage in the control bungalow contains a logic card for each antenna unit. A rack-mounted power supply provides the power for the radar. Inputs to the logic card are the audio signal from the antenna, with frequency proportional to measured speed; track occupancy taken from the wheel detectors in each retarder; and requested speed from the computer. Outputs from the logic card are analog voltages to drive meters on the test panel that indicate actual speed, target speed, and deviation from target speed as well as contact closures that represent radio-frequency (RF) failure (to operate warning lights on both the console and the test panel), close retarder (when speed is above target), and open retarder (when speed is at or below target). Each of these outputs will be displayed in lights on both the console and the test panel. These contact closures drive relays in a network that also uses weight data from the computer and provides for manual override from the console. In automatic operation, the selection of which pressure to apply to the retarder is based on weight, and the decision to close or open is based on radar output. The resting position of all retarders in this mode is the weight category of heavy. For the master and intermediate retarders, target speed input to the logic card is an analog voltage from a speed-selection potentiometer. For all group retarders, a 6-bit digital signal is supplied from the computer.

To assure that the retarder units are only operating when a car is in the retarder, a wheel-detector count-in, count-out scheme is used in each retarder. Some types of retarders could be used with track circuits, but the wheel-detector approach is adaptable to any retarder. Wheel detectors are bolted to the base of the rail, one at the upper end and one at the lower end of each retarder. A separate count is maintained for each retarder; all counting is done in a microprocessor control unit.

Each time the upper detector is actuated, the count is increased by 1. Each time the lower detector is actuated, the count is decreased by 1. Any count greater than zero is interpreted as an occupied retarder. A count of less than zero, for whatever reason, is ignored. When occupancy is detected in this way, the counter control unit drives a relay the contacts of which key on the radar antenna, operate lights on the console and the test panel, and notify the computer when the retarder is occupied by a car so that the proper weight and speed information may be obtained. The computer relays the appropriate weight information continuously as long as the occupancy is indicated. A time-out feature is used to recover from the possibility of a miscount on one of the wheel detectors.

Exit speed from the master and intermediate retarders is selected by rotary potentiometers for each retarder on the operator's console and is the same for all cuts regardless of their destination. Markings on the panel, along with a pointer on the speed-select knob, indicate the approximate speed chosen within the range of 5 to 12 mph. Exit speeds from the group retarders will vary with destination track, and the operator will assign a specific retarder exit speed to each of the classification yard tracks. Once assigned, the exit speed will apply to all cuts destined for that track until changed by the operator. A small cathode-ray tube (CRT) is provided to continuously display a list of all destination tracks in the yard and the exit speeds assigned to each track. This is a ready reference for the operator that allows him to easily check the current speed assignments at any time.

To change a speed assignment or enter a new one, the operator pushes the SPEED-SELECT button. This takes the system out of the track-select or default-select mode, whichever it was in previously. While the system is in the speed-select mode, the SPEED SELECT pushbutton is lighted. In the speed-select mode, the operator uses his number keyboard on the console to select track numbers and make the speed assignments. For each speed entry, he must first enter the two-digit track number in the same manner as for track selection; leading zeros are required for tracks 0 through 9. If an invalid track number is entered, an invalid-track alarm will be issued. If the two digits entered represent a valid track number, the system will then accept the next two digits entered as the new exit speed for that track, in integral miles per hour. Speeds under 10 mph must be entered with leading zeros in the same way as the single-digit track numbers. As the new speed is entered, it will replace the previously stored speed, if any, both in the computer storage and on the CRT display. Speeds selected must be within a permissible range that is set from the terminal device adjacent to the computer, inaccessible to the operator. The range of permissible speeds would typically be 3 to 12 mph. If speeds are being entered for more than one track, the operator will continue to use the number keyboard; after a speed has been entered, the next two digits represent the next track number, followed by two digits for its speed assignment, and so on until all speed assignments have been made. When speed assignments are complete, the operator returns to either the default-select or the track-select mode by using the appropriate pushbutton. Any track for which no exit speed has been assigned will use a default speed of 6 mph. Default speed may also be changed from the computer maintenance terminal. In place of making rolling-resistance measurements, a speed offset of 0.6 mph for medium-weight cars and 1.2 mph for lightweight cars is automatically added to the selected track speeds to compensate for the inherent poorer rollability of the lighter-weight cars. Changing of speed offset for lighter-weight cars is done from the computer maintenance terminal. An additional offset is provided via the summer/winter switch, which adds a fixed speed differential in the winter position only.

The console is equipped with a linear-motion lever for each independent retarder section. Most retarders have independent upper and lower sections. Because there is only one radar per retarder, both sections operate together in automatic, but either section can be taken out of automatic and operated manually, independent of the other section. The retarder levers have five positions: open, light, medium, heavy, and automatic. A pushbutton is provided adjacent to each pair of levers, which may be used when either lever of the pair is in the heavy position to increase the pressure to extra heavy (XH). The XH pressure will be applied only as long as the XH button is held down. When it is released, the pressure will revert to heavy.

Because of the relatively short distance from the weigh rail to the master retarder and because weight information on each cut must be determined before the lead wheel reaches the master retarder, weight is generally based on measurement of the first two trucks of a cut. On longer cuts, the weight of the first car is generally used as the weight of the cut, and retardation pressure will be applied accordingly. For this reason, multiple-car cuts of mixed weights may require manual retardation control.

Additional functions provided on the operator's console are various operational alarms, a hump signal stop control, indications of actual hump signal aspect, control of the warning siren, a dimmer control for the console indication lamp, a switch-status control that causes the positions of all switches to be displayed on the console, and an indicator showing when the test panel is operating in either the monitor or the control mode.

The test panel, located in the remote bungalow or equipment room, presents a track diagram of the hump area containing various controls and indicators. These include switches for simulating occupancy of all track circuits, PDs, and wheel detectors; indications of switch positions, retarder positions, track circuit and PD occupancy, and hump signal aspects; and speed meters indicating actual speed, target speed, and variance from target speed with a selector switch allowing the meter set to be used on any selected radar unit. Also on the test panel are a set of data entry pushbuttons allowing the entry of destination tracks for test purposes and a set of lighted pushbuttons duplicating the alarm indications presented on the operator's console. A key-lock switch on the test panel selects one of three modes for the test panel. These are the off mode; the monitor mode, in which all indications are presented on the test panel but control and simulation inputs are disabled; and the control mode, in which control is taken away from the operator console and transferred to the test panel. Indications and alarms are presented on the operator's console at all times, regardless of the status of the test panel.

ALARMS

An assortment of different alarms is provided. In each case the alarm is indicated by flashing a lighted pushbutton bearing a legend to identify the alarm and requiring the operator to push the button to acknowledge the alarm. Where a function needs further identification, such as a switch number or track number, this number will appear in a digital display in the alarm window.

The alarm for invalid track entry is produced when the operator inputs a two-digit number for either a destination-track or default-track assignment that is not an existing track number accessible to the automatic switching. When an invalid number is detected, the INVALID TRACK light goes on, the invalid number is posted in the alarm display window, and a single-stroke bell is sounded. The INVALID TRACK light and track-number display will remain on until acknowledged.

The switch-fail alarm is generated when a switch in automatic mode fails to achieve the requested position within approximately 0.9 sec. With this alarm the SWITCH FAIL light goes on, the number of the failed switch is displayed in the alarm window, and the single-stroke bell is sounded. The light and number display will remain on until acknowledged.

The route-blocked alarm is generated when the operator enters a destination track that cannot be reached because one or more switches in the route to that track are in the manual mode, positioned for other than the required route. The alarm consists of the ROUTE BLOCKED light, display of the requested track number in the alarm window, and the single-stroke bell. The light and number display will remain on until acknowledged.

The power-off alarm responds to contacts on a power-off relay provided by the railroad and contacts of two power-off relays in the control bungalow. The power-off indication will be a steady light that uses battery energy.

The radar-fail alarm is generated when the antenna of one of the radar units is not transmitting properly. The alarm consists of a flashing RADAR FAIL light, the single-stroke bell, and the red warning light adjacent to the appropriate retarder on the console and test panel track diagrams. The operator is required to acknowledge by pressing the RADAR FAIL light. The light on the track diagram will remain on as long as the condition exists.

The overspeed alarm is generated when a cut passes through a retarder without having been brought down to the desired exit speed. If at any time during retardation the cut reaches the desired speed and the retarder is opened, the alarm is preempted for that cut. The alarm consists of a flashing OVERSPEED light, a flashing red warning light adjacent to the retarder involved on the operator's console and test panel track diagrams, and the single-stroke bell. The lights will go out when the operator acknowledges the alarm with the OVERSPEED button. The alarm is operative only when the retarder control lever is in the automatic position.

Any alarm described in the preceding list may be logged in coded form on the maintenance terminal adjacent to the computer for reference by maintenance people.

OPTIONS

Several enhancements are available as options to this system that are not part of the existing installations. One of these is an automatic speed compensation for track fullness. The operator assigns a clear-track speed for each track, which applies to the first cuts entering when the track is empty. The system then counts the number of cuts it switches into each track and reduces the entrance speed automatically as the number of cars increases. A typical value of compensation might be 1 mph for each eight cars, but this would be selectable individually for each track. The operator has the ability to override the calculated speed with a manually entered speed at any time, and future reductions for fullness will then start from the manually entered value. When a track has been pulled clear, the operator reports this information and the speed automatically reverts to clear-track speed.

Another available option is direct entry of switch lists from a host computer rather than manual entry as defined earlier. In this configuration the system can store up to 30 trains of 200 cars each, with a car initial and number and a classification code for each car. Lists may be called up for editing on a CRT before humping. During humping the system permits operator corrections to add a car, delete a car, or reverse the order of a block of cars. It also provides for track swings as needed. When a given list is complete, the operator is asked to make any corrections for cars that did not go as intended, and the as-switched information is then added to a classification yard inventory. This inventory is subject to manual adjustments as necessary to account for errors or trimming. When classification tracks are pulled to make up outbound trains, the appropriate inventories are then combined into an outbound file for transmission back to the host computer.

New technology and the elimination of many high-level refinements makes it possible to install a system such as this in a moderate-sized yard for a fraction of the cost of a fully automatic system. It is unsuitable for a major terminal handling 3,000 cars a day, but there are many yards that could benefit from this straightforward, no-frills concept.