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Informal Note #1

GENERIC DESCRIPTION OF CONVENTIONAL RETARDER CONTROL SYSTEM

Background

We shall attempt herein to describe the basic building blocks of a conventional retarder control system from a generic-functional viewpoint. Although each installation is different, such a generic description will provide a common reference point from which to analyze and compare different systems. Furthermore, this generic description will provide a framework which will allow us to focus on parts of the system and determine its effect on the whole.

Block Diagram

Figure 1 shows a block diagram of the major functions in a conventional retarder control system; this description is independent from how the functions are organized from a hardware viewpoint.

We see that the central function is what I call "speed control management" (SCM). The SCM takes inputs from the following functions: weight determination, rollability prediction, weather modification, distance-to-couple measurement, and operator override to give instructions to the master-retarder control function and group-retarder control function.

It should be remarked that Figure 1 is a top-level overview of the major functions in a conventional retarder speed control system. Each of the "boxes" and functions can be further expanded into a more detailed diagram.

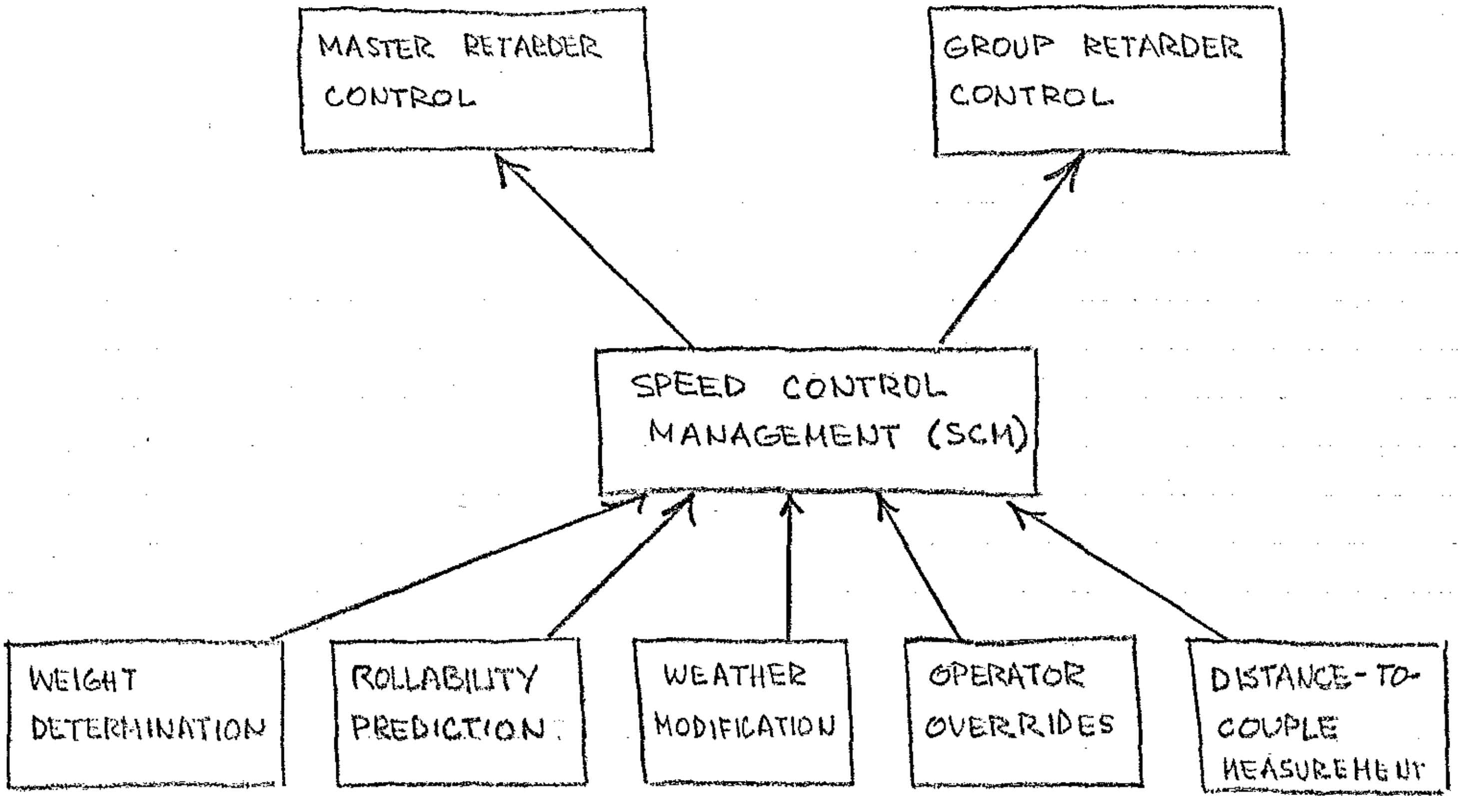

FIGURE 1: BLOCK DIAGRAM MAJOR FUNCTIONS OF CONVENTIONAL RETARDER SYSTEM.

Weight Determination

This can be accomplished by a complex scale arrangement to measure actual weight or a simple weigh-rail which would classify cars into discrete weight classes such as: light, medium, heavy.

This function is normally performed ahead of the master retarder.

Rollability Prediction

Car rolling resistance varies with car speed, weather conditions, and the distance the car has rolled from the hump. The latter effect reflects the fact that after sitting in the receiving yard the car begins to roll easier as the lubrication heats up due to the car's roll. Furthermore, the older journal bearing cars roll harder than the newer roller bearing cars. Also, rolling resistance is smaller on straight (tangent) track as compared to curved track.

Traditionally, a rollability measurement is obtained on a carefully calibrated concrete pad prior to the master retarder. More sophisticated schemes would measure rolling resistance at several points in the yard.

The rollability values for a car are used to determine the proper exit velocity at both the master and group retarder. The calculation of the exit velocity from the group retarder to insure proper coupling on the class track is particularly sensitive to rollability estimates for the car.

Schemes for predicting rollability from velocity measurements can be simple or sophisticated (e.g., least squares estimation procedures[*]).

Weather Modification

Some speed control systems allow the user to set parameters according to the weather conditions. For example, the operator can indicate if the weather conditions make the rolling behavior of the cars: FAST, NORMAL, or SLOW. In some systems, weather conditions (e.g., wind) are automatically fed into the systems.

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[*] "Rollability Prediction System," by Peter J. Wong, Dale W. Ross, and Kenneth W. Gardiner, Patent No. 3,690,788, September 5, 1972. (The patent was assigned to Southern Pacific; to my knowledge there exists no commercial implementation of the patent.)

Operator Overrides

Most systems allow the user to override the speed control system, i.e., to control the retarders manually. This may be necessary if certain cars require special handling, e.g., extra heavy car, extra wide load, extra long car, explosives, etc.

Distance-To-Couple Measurements

In order to calculate the proper exit velocity from the group retarder, the "distance-to-couple" (i.e., the length of roll before coupling) must be known. There exist several types of systems from simple to sophisticated. A simple system would estimate whether the class track is empty, 1/4 full, 1/2 full, 3/4 full, or full based on the car counts into the track (i.e., assumes average car length). Another system would use track circuits to determine the position of the last car into the track. A sophisticated system might measure coupling performance (e.g., stop short, over-speed impacts) and "adaptively" adjust parameters in the speed control to insure proper coupling performance based on the prevailing conditions.[**]

An example equation used by WABCO to calculate exit velocity of the group retarder based on the distance-to-couple and other parameters is as follows:[*]

$$V_{exit} = V_{couple}^2 + 2g \quad L \quad (G-R)$$

where:

V_{exit} = exit velocity of group retarder

V_{couple} = desired coupling velocity

R = car rolling resistance

G = gradient of classification track

L = distance to be covered

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[*] "Calculation of Target Speed by Computer at Sotterville Yard," Railway Gazette International, November 1974.

[**] I do not know whether such a system is commercially available; although some railroad have experimented with "adaptive" logic.

Speed Control Management (SCM)

The SCM essentially takes sensor information such as weight, rollability, weather, and distance-to-couple to instruct the master and group retarders on the desired exit velocity.

Most conventional systems base speed control management philosophy strictly on the attributes of the car to be controlled. In particular, WABCO's "Magic X"[*] (see Figure 2) defines retarder control for a normal car, i.e., a normal car will enter the master retarder at a normal entering speed ($V_{NORMAL\ ENTER}$) and the retarder will retard the car to a normal exit speed ($V_{NORMAL\ EXIT}$). Faster rolling cars are identified by entering the retarder at speeds greater than $V_{NORMAL\ ENTER}$ and will be retarded to exit speeds less than $V_{NORMAL\ EXIT}$ based on a "straightline proportional logic" shown in Figure 2. The slower rolling cars are identified by entering the retarder at speeds less than $V_{NORMAL\ ENTER}$ and will be retarded (or left unretarded) to an exit speed greater than $V_{NORMAL\ EXIT}$ based on the "straightline-proportional logic" shown in Figure 2.

A system control management philosophy which takes into account only the car attributes of the car being controlled is rather primitive. Ideally, one would like to control the headway between consecutive cars. This would entail a system control management philosophy in which the car attributes of the car to be controlled and the attributes of the car immediately ahead and behind are taken into account.[**]

A sophisticated system control management philosophy should be "self-adapting." In particular, control parameters should be adjusted based on the current performance of the system, such systems which "learn" or "correct" themselves have been studied in feedback control theory.

Master/Group Retarder Control

The "sevo-loop" which actually controls the retarder to achieve the desired exit velocity commanded by the SCM can be simple or sophisticated. A simple control logic would apply constant retarder pressure until the car reaches the desired exit velocity at which time the retarder

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[*] "Typical Classyards," WABCO, Bulletin 818.

[**] I do not know whether such a system is commercially available.

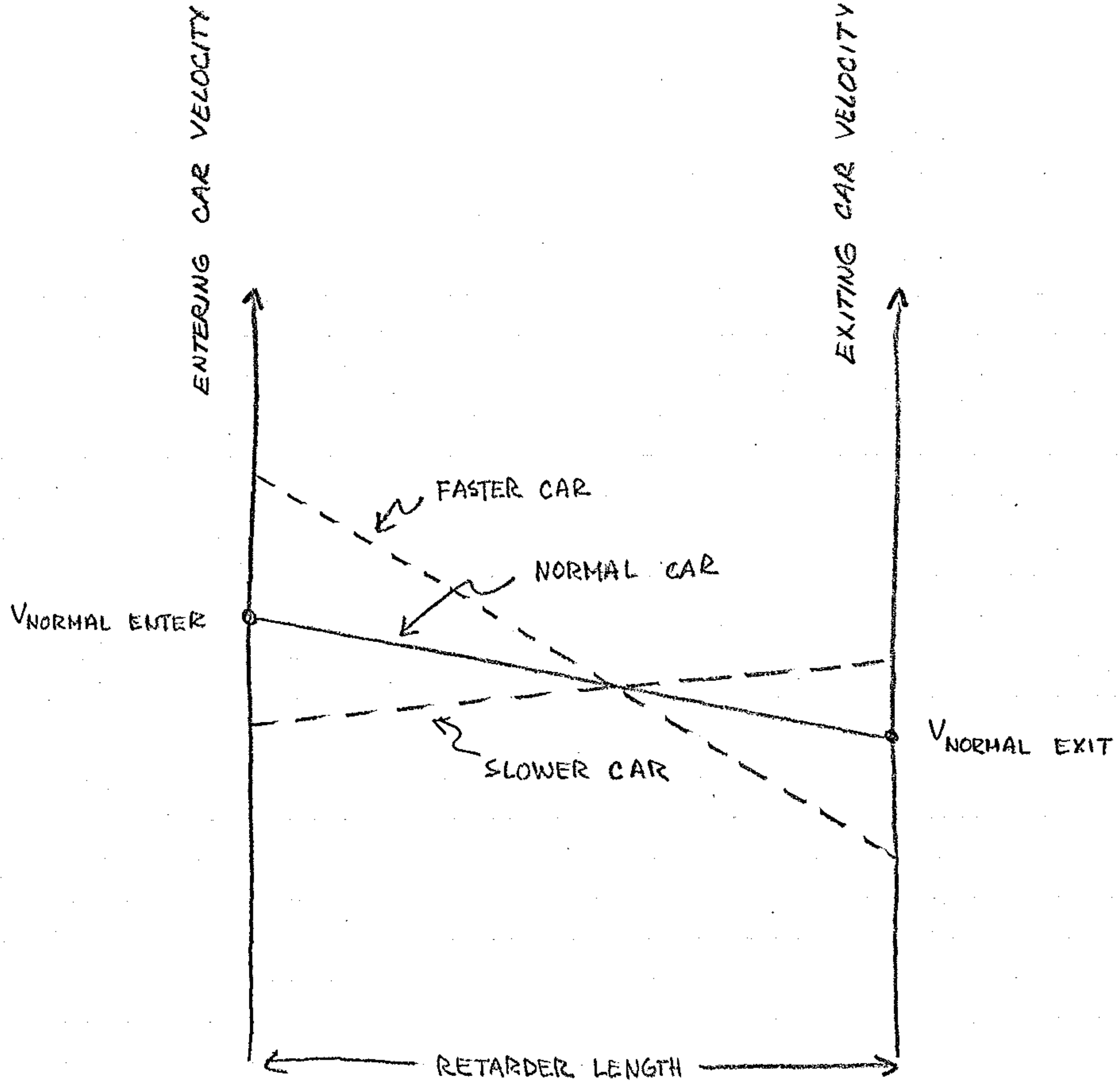

FIGURE 2: WABCO'S MAGIC "X" METHOD

beams open, i.e., retardation occurs in the front portion of the retarder in most situations (see Figure 3). A more sophisticated control logic would smoothly decelerate the car throughout the entire length of the retarder, achieving the desired exit velocity as the car leaves the retarder (see Figure 3).* Such a control logic produces more even wear of the retarder and, therefore, less maintenance, faster time through the retarder, (i.e., average velocity in retarder is higher) and less retarder noise.**

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*"Hump Yard Retarder Control System," by Peter J. Wong and Robert S. Ratner, Patent No. 3, 745, 33, July 10, 1973. (This patent was assigned to Southern Pacific; to my knowledge this patent has not been exploited commercially.)

**"Retarder Noise," R. Cass, et al, presented at Winter Annual Meeting of Rail Transportation Division of ASME, New York, NY, November 17-22, 1974 (Paper #74-WA/RT-7).

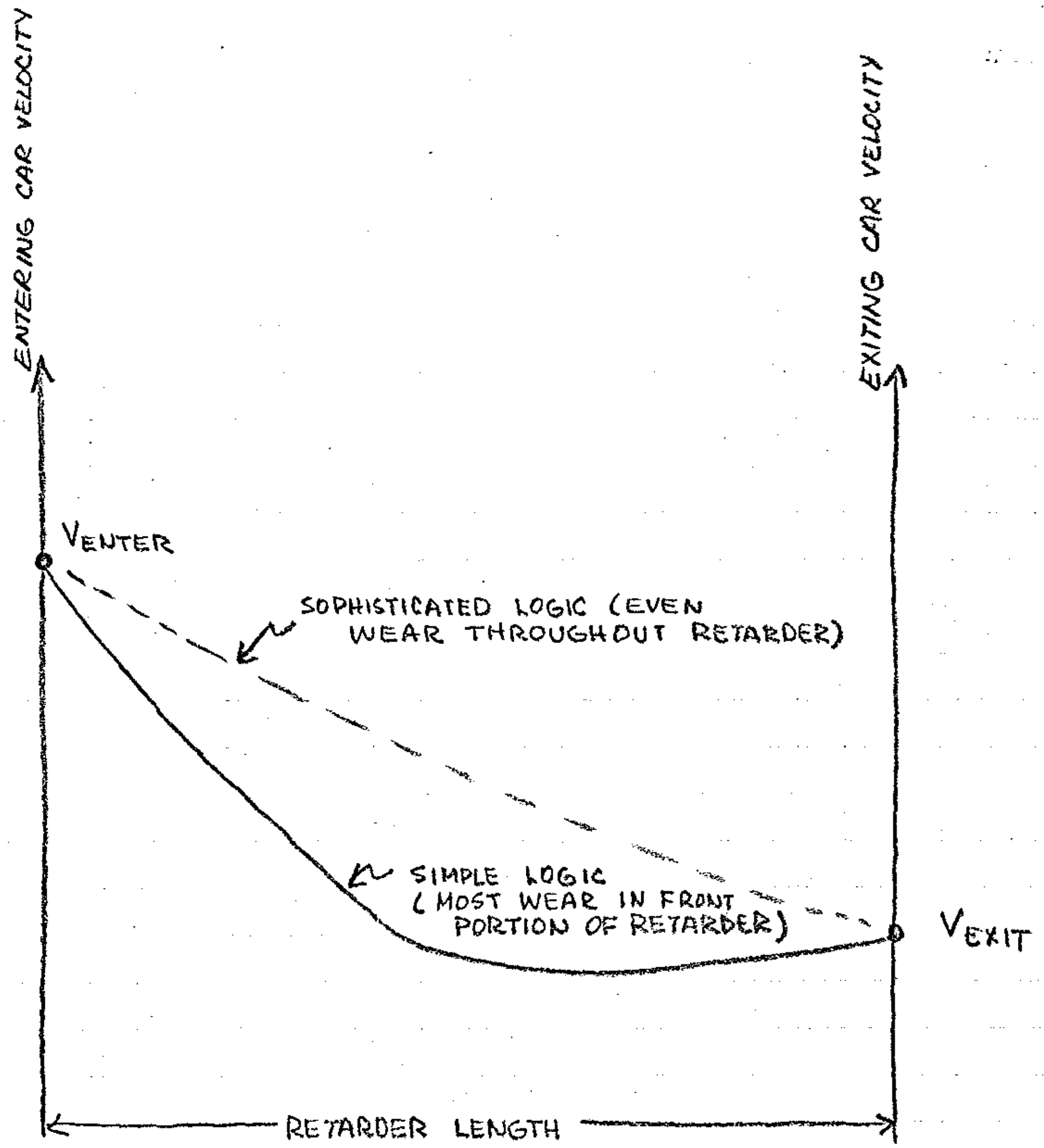

FIGURE 3: VELOCITY VS. DISTANCE PROFILES FOR TWO RETARDER CONTROL LOOP LOGICS