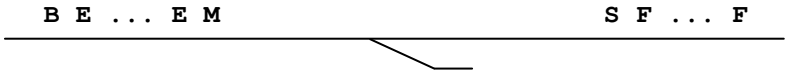
An ultimate railway shunting problem (after Dudeney)

There are a number of classic railway shunting problems on the general theme that two trains have to pass each other on a single line and the passing loop is too short to allow one to pull up while the other goes through. The following version may perhaps have some original features.

We are on a branch line railway leading from the main line to a mine:



A main-line locomotive M is bringing up a train of empty wagons plus a brake van, the mine shunter S is bringing up a string of full wagons, and the task is to interchange these, forming a train of full wagons plus the brake van ready to go to the main line and putting the shunter at the head of a string of empty wagons for the mine. The siding can hold only a single wagon, or the brake van, or the mine shunter, but not the main-line locomotive (though this can push a vehicle into the siding or pull one out), and safety regulations forbid the pushing of more than one vehicle at a time though each engine can pull as many vehucles as required.

Solution

- S stops far enough short of the points to allow the main-line train to pull up to it without fouling them, M stops far enough short to allow S to come down to it.
- S detaches and goes into the siding, M pulls E...E above the points leaving B behind, and S emerges. We now have B and S below the points and E...EM / F...F above them (M need not connect to F...F).
- S detaches the lowest E, pushes it into the siding, and pulls the remaining E...E below the points, M extracts the E from the siding and pushes it up to F...F (it need not connect to them, but it must go far enough for the whole string MBE...E eventually to be fitted in without fouling the points). This gives B / SE...E below the points and ME / F...F above them.
- M pulls all but one of E...E above the points leaving the lowest E with S, S parks this E in the siding and pulls the remaining E...E below the points, M extracts the E from the siding and pushes it up to join the first E. This is repeated for each of the remaining E...E in turn, eventually giving B / S alone below the points and ME...E / F...F above them.
- S goes into the siding, M pulls B above the points, S emerges and puts B into the siding, S and M come below the points, and M extracts B from the siding and pushes it up to join E...E. We now have S alone below the points and MBE...E / F...F above them.
- S goes into the siding, M pulls BE...E below the points, S emerges and couples to the lowest F. We now have MBE...E below the points and SF...F above them.
- S puts the lowest F into the siding and pulls BE...E above the points, M extracts the F from the siding and pushes it up to join BE...E. We now have nothing below the points and MFBE...ES / F...F above them.
- M pulls FBE...E below the points, S puts the next F into the siding and pulls FBE...E above the points, M extracts the F from the siding and pushes it up to join the F at the bottom of the string. This is repeated for each of F...F in turn, eventually giving MF...FBE...ES above the points.
- The trains divide above the brake van and go their separate ways.

Each wagon visits the siding once, as does the brake van.

History

Problems of this general kind have been around for a long time, and the provision only of a dead-end siding restricted to holding a single vehicle was done by Dudeney (problem 374 in Martin Gardner's 1967 edition *536 Puzzles and Curious Problems*). The elements in the present version that may be original are the setting of the task on a branch leading from the main line to a mine, and the restriction that only one vehicle may be pushed at a time. I posted the puzzle in this form in November 2015, with an invitation to readers to tell me of any previous appearance. None has yet done so.

JDB, 2 May 2018