Experiments in Controlling a Steam Locomotive by Radio

— by Ralph Brewer

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Last Issue I published two articles that gave some history and background to Julian Malec's Atlantic, which had previously been in the care and ownership of Ralph Brewer. Although Radio Control is perhaps now taken somewhat for granted, its use to control live steam engines was not so usual in 198X, especially in Gauge '3'. I feel therefore that Ralph's description of how he approached this subject is still of relevance and interest to us today.

Introduction

The main problems in controlling a model steam locomotive by radio are mechanical ones. In essence, they are the problems of matching the mechanical outputs of a radio system to the mechanical inputs, i.e. the controls of the locomotive. These inputs, such as the regulator and the reversing gear, are the same as when the locomotive is being controlled manually by a driver; but the absences of:

(a) the driver's weight;

(b) the power of the driver's fingers;

(c) the driver's continuous assessment of the moving situation mean that the control functions have to be considered differently when operated remotely by radio.

My account is that of a single, personal experience; it does not constitute the "received wisdom" which would follow from studying a range of practices.

Background

The locomotive, which I bought in a partly-finished state, is an Atlantic version of FAYETTE. It had no tender; but this I have built, as well as doing a good deal of other work in bringing the engine up to a reasonably good finished state. It has been run several times at Leatherhead and Eastbourne.

At the start of the project, I decided that the locomotive should still be capable of normal manual driving and passenger-hauling. It was also decided that the engine and tender must be easily separable for the ordinary purposes of transportation, preparation and maintenance. In other words, control by radio was not to be a permanent change in the operating method. The radio is a 2-channel Futaba system bought several years ago for another purpose. It consists of a small transmitter with a telescopic aerial; and, at the receiving end, the radio receiver and aerial, two servos and a battery.

<u>Functions considered for control</u>

The number and kind of functions that are candidates for control by radio are governed by the motion and power of the servos, which are the mechanical output of the system. The Futaba servos are small rectangular units housing an electric motor which, through a worm gear, moves the output shaft back and forth through an arc of about 80 degrees. The system can be set so that the position at rest can be either at one end of the arc, or at the centre point, giving about 40 degrees of movement in either direction. The radio receiver is also encapsulated in a rectangular plastic case. I should mention that a much more powerful servo is available; but at a price of £40, I decided to use the units to hand.

The obvious first candidates for radio control are:

(a) Direction of travel

(b) Speed

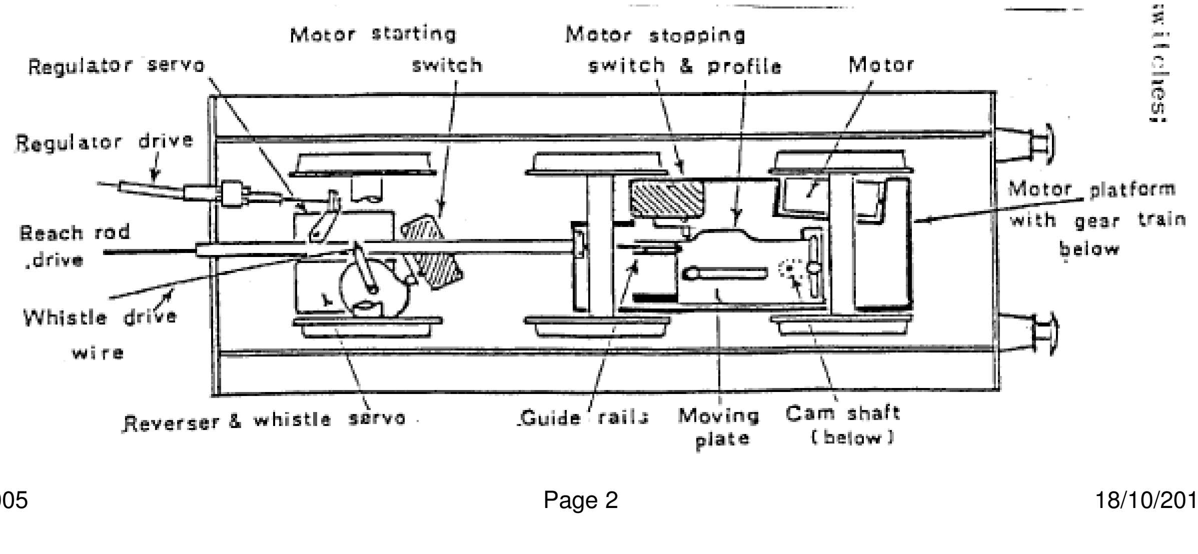
(c) Whistle

A fourth function - the blower - was considered; but I foresaw no easy solution to the problems likely to arise, particularly in view of the demands made by the three prior functions.

At the outset, I differentiated between functions which must be adjustable to any point in the range of control, and those which are either on or off.In the first category are the regulator and blower (if the latter was to be attempted); and in the second category are the direction (forward/ backward) the whistle (on/off), and other possible functions such as coupling/uncoupling a train. This analysis constituted the first design principle.,

The second design principle stemmed from the recognition that having got an electrical system on board, it could be extended to provide additional mechanical power. These two principles are used in the design of the three functional controls as follows.

FIGURE 1.



Direction of Travel

The force required to move the reach-rod is beyond the capabilities of the servo. I therefore decided to use a small electric motor working through a reduction gear-train to operate a cam, the follower of which is linked to a lever connected to the reach-rod. The linkage includes a stiff but flexible steel wire in a semi-flexible tube running along the centre axis of the engine and tender. A total movement of about one inch is made by the cam follower, which provides a force of about 1.5 lb. The cam follower is a plate moving along guide rails. It takes about six seconds to run from end to end.

The moving plate carries an edge profile which engages with the actuator of a micro-switch. This switches power from a 3 volt battery to the motor. The profile causes the switch to open at either end of the plate's travel; but as soon as it moves away from an end position, the switch closes and the motor runs until the opposite end is reached, when it automatically stops.

The job of the servo is therefore to do no more than get the running sequence started - the second battery and motor do the real work of moving the reach rod. The initiating action is taken by a second micro-switch in parallel with the first, this second switch being actuated by a cam on one of the servos which is normally in the centre position. The operational sequence is therefore as follows: The transmitter joystick is moved from the centre position to one side; then, at about two seconds, it is released to return to its normal centre position. This two-second movement of the servo is sufficient for the motor to have moved the plate, which in turn trips the micro-switch which keeps the system running until the other end is reached. The switch then goes off, the reach rod having moved correspondingly. It will be seen that the control cannot be marked "forward" or "backward", but simply "change direction".

Before describing the regulator control, it is worth listing the extra items to be taken on board:

(a) one radio aerial;

(b) one radio receiver;

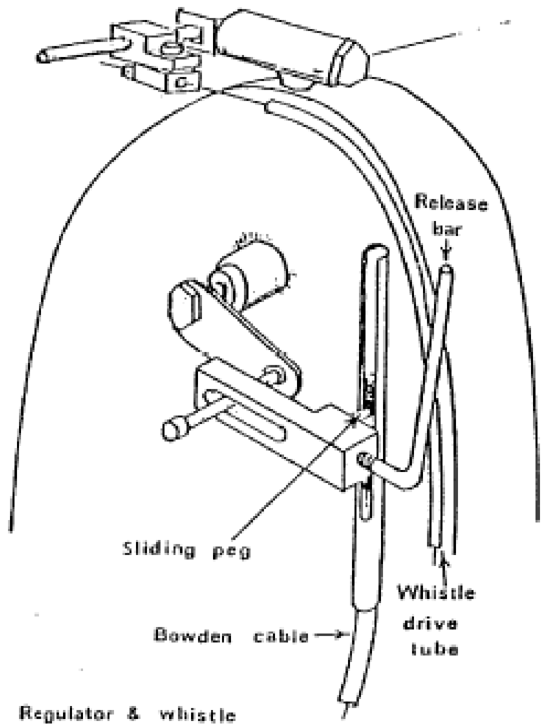
(c) two servos;

(d) two sets of batteries and switches

(e) one electric motor

(f) various rods, levers and cables for mechanical and electrical connections.

Many of these items are incompatible with heat and water; furthermore, they will be subjected to vibration and changes in their relative positions due to the movement on curved track. Given this environment, I decided that nearly everything must fit on the tender, principally under the baseplate with additional space being provided in a partitioned-off section of the water tank. Figure 1 shows the arrangement under the tender. We can now go back to the regulator control, remembering that this is by direct drive from the servo on the tender. A Bowden wire running in a flexible metal tube transmits the rotary movement of the servo to a corresponding vertical movement of a sliding peg in the vicinity of the regulator. The sliding peg carries a slotted bar, which engages with another peg on the regulator arm. Thus vertical movement of the sliding peg turns the regulator shaft through an arc of about 30 degrees. See figure 2.



Regulator & whistle controls

The Bowden wire is connected to the servo by a clip arrangement, so as to facilitate the easy separation of engine and tender. At the other end, there is a quick-release bar which enables the servo drive to be disconnected from the regulator lever; see figure 2. This is necessary for safety reasons, because it is impossible to move the servo from the regulator end of the drive wire. If, for any reason, the servo is unable to close the regulator, it is essential that they can be separated quickly so that the regulator can be closed manually.

The release bar enables this to be done, but the remote "driver" may have to move fast!

<u>Whistle</u>

This is operated on the same channel and via the some servo as the direction-changer, but with the servo moving in the opposite direction. (Remember that the normal or rest position of this servo is at the centre.) A thin steel wire is attached to a short lever on the servo shaft; and, after passing through a copper tube on the firebox end, terminates on the whistle lever. A touch on the appropriate joystick of the transmitter is sufficient to sound the whistle. The reverser, although on the same channel is not affected.

Regulator

This has proved to be the most difficult function to control smoothly, partly due to the design of the regulator valve itself, this being a screw-down type with limited movement.

At an early stage, I had established that the servo was powerful enough to move the regulator, but over a very limited range of opening. At the same time, it was noted that, in the absence of the load provided by a driver, a reasonably good speed could be obtained with a small opening of the regulator. These initial trials were made by pumping up the boiler with air.

These trials also showed that the full range of the servo's movement was required, so the normal on/off position of the transmitter control was changed from the usual centre point to one end.

Practical Results

Preliminary steam trials on relatively short lengths of straight and curved track are promising, but I have yet to discover how long a run can be obtained on one firing. The fact that the regulator is only slightly opened helps.

An experiment on the distance over which the control is effective was interesting. Originally the receiving aerial wire was threaded along the tender coal rails. In this position, control was lost at about 25 yards. On advice from a local model shop, the aerial was raised about half an inch on non-metallic supports, with dramatic results. The range is now about 100 yards.

Acknowledgements

My thanks are due to George Beesley for his help and encouragement over several years, which has enabled me to bring the model up to its present state. Thanks are due also to Solent Models of Southampton, for advice on the radio aerial and other associated matters.