Linear Traction Motor

A SIMPLE form of linear induction motor with possible applications in electric traction is being developed for the British Transport Commission by Dr. E. R. Laithwaite of Manchester University in conjunction with Dr. F. T. Barwell of the Commission's research organisation. An experimental linear motor fitted to a rail trolley was demonstrated last week at British Railways' Gorton Locomotive works. Essentially the motor consists of a three-phase winding in open slots in a flat, laminated core (Fig. 1) which is fitted to the trolley, and a continuous metal plate (aluminium in this instance) which is fixed vertically midway between the rails along the whole length of track. The winding is equivalent to the stator of an ordinary induction motor cut along an axial slot and flattened out. The metal plate is equivalent to the "rotor"; with this arrangement, when the winding is energised currents are induced by transformer action in the plate. Reaction between the currents in the winding and those in the conductor or reaction plate results in a force (analogous to the torque in an induction motor) which propels the winding and the trolley along the track.

At the demonstration last week Dr. Barwell described the project as a scientific experiment designed to evaluate the possibilities of the linear induction motor in the field of traction.

The outstanding advantages are that the tractive effort and conversely the dynamic braking that can be obtained from this system are absolutely independent of adhesion. The linear induction motor is a simple device and this simplicity is retained in dynamic braking (and in reversing the direction of motion) which is effected simply by reversing one of the three phases in the supply to the winding. But the fact that the power supply to the motor must be three-phase introduces some complication. Centrifugal force, which can limit the peripheral speed of a rotor, does not apply to the linear motor. Indeed the higher the speed the more attractive the linear motor as a propulsive unit: above about 120 m.p.h. the advantage, compared with orthodox motors, becomes paramount. Power limitations are relaxed because cooling is simpler than in an ordinary motor: the conductor plate presents few problems because the winding meets cold plate and the heated plate is left behind. On the other hand the cost of the conductor plate along the whole length of track will be considerable. In addition it may be difficult to mount the plate without interfering with other rolling stock and to provide clearance at points and crossings.

The main objects of the present experimental work are to elucidate certain technical performance factors to provide a basis for an economic appraisal of the system. Attention is being concentrated on the material, dimensions and form of the central conducting plate; the minimum air gap attainable between the winding and the conductor plate; power consumption; and the method of attaching the winding to the trolley to allow for vertical and horizontal displacement of the vehicle.

The present arrangement is illustrated here. Because the conductor plate (unlike the "rotor" which it simulates) requires no magnetic circuit the winding can be duplicated, the two parts being mounted one on each side of the conductor plate. Duplicating of the winding improves the

Winding of linear induction motor and the continuous metal strip in which currents are induced to provide the propulsion reaction.

power/weight ratio and the performance. To maintain the air gap ($\frac{3}{16}$ in on each side of the plate) whilst allowing for vertical and transverse movement of the trolley the two windings are mounted in a carrier which "floats" with respect to the trolley. The carrier is fitted with guide wheels which run on the conductor plate and maintain the air gap. Wheels on roller bearings at the front and rear of the winding carrier bear on machined surfaces on the trolley (Figs. 2 and 3) and transmit the tractive and braking forces while allowing relative movement vertically and transversely between the trolley and the windings.

In the present form, illustrated here, the trolley weighs 1 140 lb and the linear motor produces a thrust of 1 000 lb with an average consumption of 60kW with peak currents (line) of 190A at 400V. The current density in the aluminium plate is estimated to be about 16 000A/in².

On the existing track at Gorton the trolley is accelerated to 34 m.p.h. in about 2·8 seconds, balanced at full speed for 3 seconds and then stopped by reverse current braking in about 3 seconds. There are no controls on the trolley itself. Control of the system is by varying the power supply voltage and reversing one phase for braking. The three phase trolley wires and pick-up can be seen in the illustrations.

The current programme of experimental work is expected to define more closely the development potential of the linear motor particularly in relation to high-speed passenger traffic. Immediate though less spectacular applications are envisaged for the linear motor as a booster accelerator in moving heavy trains from rest or up starting inclines, or for duties such as hump shunting in marshalling yards. The application of linear induction motors to conveyors has been examined in a paper by Laithwaite, Tipping and Hesmondhalgh (*Proc. I.E.E.*, Vol. 107A, paper No. 3225U, 1960).

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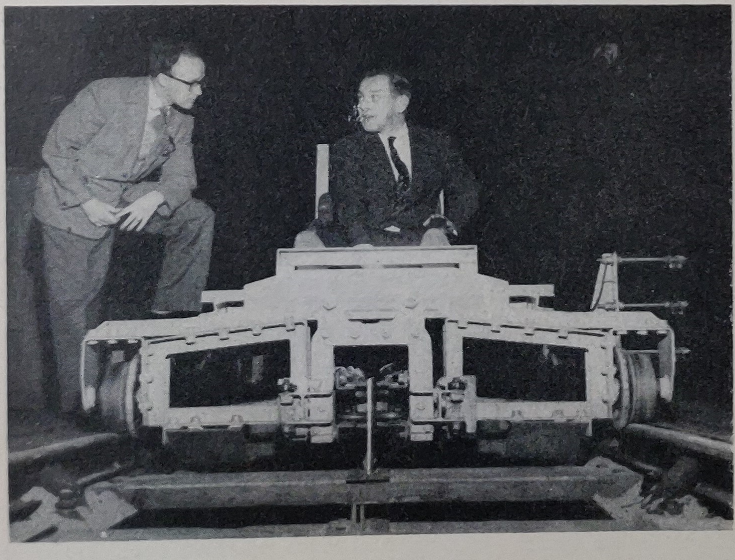

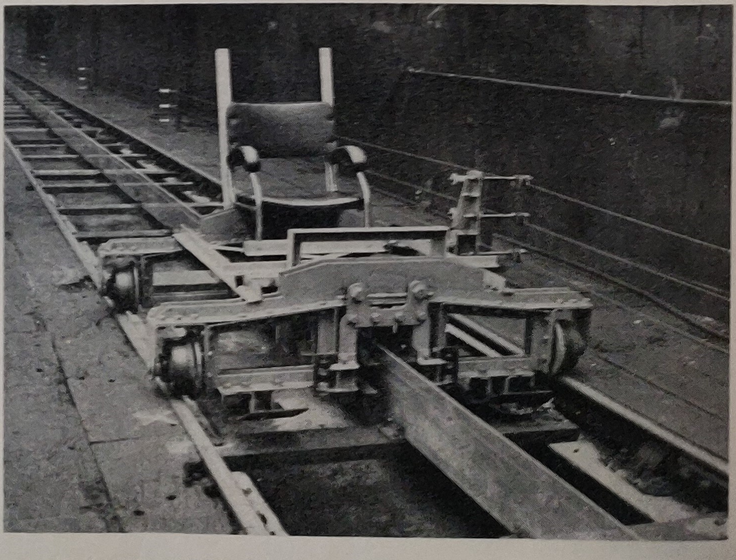

Dr. Laithwaite, seated, demonstrating an experimental trolley fitted with linear induction motor.