VARIOUS POINTS IN THE DESIGN OF LOCOMOTIVE BRAKES.

Paper read before the Institution by J. H. HAIGH, Member, Horwich, on 18th January, 1924, in Manchester.

PAPER No. 164.

In designing a locomotive the engineer first pays attention to the cylinder and wheel dimensions in order to get a required tractive effort, then to the frames and boiler, and finally as an afterthought to the brakes. Under these circumstances the brake work and brake blocks have to be accommodated in the only remaining spaces within loading gauge limits, with the inevitable result that they are ill-designed and inefficient.

As a rule, brake blocks are applied to the driving wheels only, so that in the case of eight or ten-wheeled engines only a small part of the total weight can be employed in braking.

Again, owing to lack of space, single blocks may be fitted in front of the leading and behind the trailing wheels, and when any play in the horns or axleboxes occurs, the application of the brake shortens the centres of the driving wheels and imposes unnecessary stresses on the coupling rods, etc.

The low brake power of a locomotive is demonstrated as a passenger train is coming to rest, when the train stops first and the engine is drawn back to it by the action of the drawbar springs.

It is unusual to find all engine brake blocks entirely clear of the wheels when the brake is off, either the top or bottom edges being in light contact and taking up some of the power and retarding acceleration. This point is given careful attention in electric vehicles where rapid acceleration is a feature.

The position of the brake block with respect to the height of the wheel centre is of importance if engine height and spring and cylinder adjustments are to remain constant,

bearing in mind that tank engines are expected to run with equal usefulness in either direction.

For the purpose of discussion the following three questions are put forward :—

(1) Can the brake power of a locomotive be regarded as sufficient?

(2) What is the proper position of the blocks, on the centre line, above or below it?

(3) Should driving wheels be braked on both sides, and should bogie and other than driving wheels be braked?

DISCUSSION.

Mr. E. M. Gass: Mr. Haigh remarks that in the design of a locomotive, the boiler, cylinder and wheels are the main features considered, and the brake the last to receive consideration. But there is another aspect to this, *i.e.*, the question of curves. The engine having frequently to negotiate curves of sharp radii, the designer is compelled, particularly with engines of the multiple coupled-wheel type, to crowd the driving wheels as close as possible, leaving very little room for fixing the brake hangers and blocks, and consequently the blocks are often much below the horizontal centre line of the wheel. The best position for a brake block is just below the horizontal centre line.

As regards brake power, it would appear that engines are very often insufficiently braked. There are main line engines running with only 45 per cent. brake power of the wheels braked, or 25 per cent. of the weight of the engine. It would be interesting to know what should be the maximum block pressure; should this be 60 per cent. of the weight braked, or 60 per cent. of the weight of the engine?

I am not in favour of brakes on bogie wheels, for the reason that flexible connections are required to the cylinders, resulting in high maintenance, and there is also the danger of the bogie wheels being "picked up."

The skidding of engine wheels when the brake is applied is probably due to the great variation in the coefficient of adhesion between the wheel and rail. With a very dry rail the adhesion per ton of load is as high as 600 lbs.; in frosty weather as low as 200 lbs.

Mr. J. N. Gresham: The Author has raised some most interesting points in connection with the braking arrangements of locomotives. Should he or any other member be anxious to investigate these questions fully, much interesting matter will be found in three papers read by Capt. Douglas

Galton on "Railway Brakes" in the Proceedings of the Institution of Mechanical Engineers in 1878 and 1879. A paper read before the Institution of Civil Engineers by Mr. Rendell in November, 1922, also throws further light on this subject.

With regard to the amount of clearance between the blocks and the wheels, this is largely a question of the type of service for which the stock is designed. For electric traction, where the maximum acceleration and deceleration is required, brake block clearances are reduced to a minimum, consistent with removing the blocks from the wheels. This is, of course, done with a view to reducing the amount of idle piston stroke with its attendant loss of power before the brake becomes effective.

In general the coefficient of friction decreases with the increase of speed, being at 60 m.p.h. .074 and at 10 m.p.h. .242, showing that since the brake power increases as the train is brought to rest, the brakes should be eased off to prevent skidding. This is, of course, essential, since the coefficient of sliding friction is far less than that of rolling friction, the maximum braking power being obtained when sufficient power is applied to just not skid the wheels. The length of time for which the brake is applied tends to reduce the coefficient of friction, but the reduction due to this heating effect is not so rapid as the increase due to the fall of speed.

With regard to the position of the brake blocks, these should undoubtedly be placed slightly below the centre line of the wheels, so that the line of reaction between the brake block and the wheel may pass through the centre line of the wheel.

With regard to the braking of locomotives, there is a tendency among foreign locomotive engineers to brake the engine as a separate unit from the train, relying for ordinary purposes upon the stock for braking the train, keeping the engine brake as an emergency or reserve one.

Mr. J. W. Smith: Mr. Gresham referred to applying the brakes at 60 m.p.h. without damage, where the braking power was high. On coaching stock with, say, 90 per cent. of the weight on the wheels, the same thing will apply at higher speeds without any shock taking place, but if the same brake application was used to stop a train from a speed of 20 m.p.h. it would probably lead to the breaking of couplings between the coaches. This difference is no doubt due to the fact that in high speeds, part of the brake power is absorbed in checking the rotation of the mass of wheels themselves and to the coefficient of friction being

less at the higher speeds between the brake block and the tyre.

Mr. Gresham: With regard to the braking of engines, I consider that the percentage brake power should be based on the weight that is carried by the coupled wheels, not on the gross weight of the engine as a whole.

Mr. A. E. Kyffin: If I remember correctly, the earliest electric trains in service were braked up to 120 per cent., the brakes being applied by rapid action valves when the trains were travelling at relatively high speeds and gradually released as the train slowed down.

Mr. H. D. Atkinson: With regard to the question of coupled wheels "picking up," it is more acute on those engines having large diameter driving wheels.

In regard to the fitting of brake blocks on the bogie wheels, I have never seen bogie wheels "pick up," and although I am not altogether in favour of a bogie being braked, it is possible that by so doing the brake power of the engine is considerably increased, and so minimising the brake power required on the coupled wheels.

With regard to the position of the brake blocks, I think these should be below the centre line of the wheel, as the stress will not be so great on the horns.

With regard to the tender brakes, most tender brake blocks are put on the rear side of the wheels, resulting in an upward thrust on the hangers when the brake is applied. In some cases the brake blocks are placed on the front of the tender wheels, so that there is a downward pull on the brake hanger and therefore less liability for the brake blocks to jar in the hangers.