HOLD YOUR HORSES

TRUCK TECH: **JACOBS ENGINE BRAKE**

The very best inventions are borne out of adversity, so it's no surprise that engine pioneer Clessie Cummins became obsessed by the idea of an engine brake after a near-miss with a train

On the up: ERF tipper operators were among those to benefit from the Jacobs Brake

WORDS: BOB BEECH

Commercial Motor An effective auxiliary braking system is a key feature of any modern commercial vehicle when powered by a conventional diesel engine. To most operators this means an effective exhaust brake/compression engine brake, or either a hydrodynamic (hydraulic) or electromagnetic retarder. All work independently of a vehicle's conventional braking system, providing a totally separate means of reducing the speed of the laden truck on a descent or even on the flat.

Used effectively, any of these systems reduce foundation brake wear tremendously – and most importantly, are a vital safety feature. But drivers have to understand how to use an engine brake or retarder properly in order to enjoy the full benefit from these devices. Unfortunately, certain driver trainers and misguided vehicle operators fail to understand how these systems work, and some fleets discourage drivers from making full use of the technology in the belief that it increases fuel use.

Turn it on: The Jake Brake switch can be seen in this ERF 7MW cab above the guage nearest the camera (left). The switch and three-stage setting is also pictured (inset)

Images supplied by Richard Stanier

SAVING GRACE

We find this situation unbelievable – and have had some serious disagreements with misinformed individuals who fail to understand the basic working principles of the compression ignition diesel engine. Often they seem fixated by the stream of inaccurate information some less-effective vehicle telemetry systems produce. The idea that any increase in engine revolutions is indicative of increased fuel use only holds good if fuel is injected and the engine is actually firing. Once a diesel engine is either on the overrun, or working as a compressor when the exhaust/engine brake is in operation, there is no fuel entering the cylinders no matter how high the rpm level rises.

Clessie Cummins, the founder of Cummins engines and one of the great diesel pioneers of the previous century, would no doubt be exasperated by this failure to understand the basics – particularly as it is the 60th anniversary of another of his inventions, the Jacobs Engine Brake, or 'Jake Brake'. It was the first really effective compression brake developed for a diesel engine, which worked by modifying the engine's valve actuation to turn it into a compressor, creating braking torque fed back through the driveline. This slowed the laden vehicle on downgrades.

While he designed the system to fit a Cummins engine some years after he left the company in the 1950s, legend has it that it was an incident almost 30 years earlier that set him thinking about an engine-based braking system that worked independently of the wheel brakes on long descents.

Back in 1931, Clessie and two colleagues were engaged in a frantic coast-to-coast dash across the US to highlight the speed, reliability and fuel efficiency of early Cummins diesel engines. The epic trip, completed in 97 hours of driving, saw them at one point descending the Cajon Pass on Route 66 in California. Brake fade due to overheating meant their Cummins-powered Indiana truck was involved in a very near miss with a train at a railway crossing when they couldn't stop.

DIVINE INTERVENTION

This near-death experience remained with Cummins for the rest of his life and it is said that he was determined to develop some type of independent braking system that utilised the in-built compression of a diesel engine to slow the vehicle.

When time allowed that is exactly what he did. The compression cycle in a diesel engine compresses air to between 35-70 bar (500-1,000psi) when fuel is injected. When combustion takes place, the pressure increases to around 105bar (1,500psi), creating the force for the power stroke forcing the piston down.

Hearts and minds: Operators of Cummins-engined vehicles across Europe were won over by Jake Brakes in the 1970s

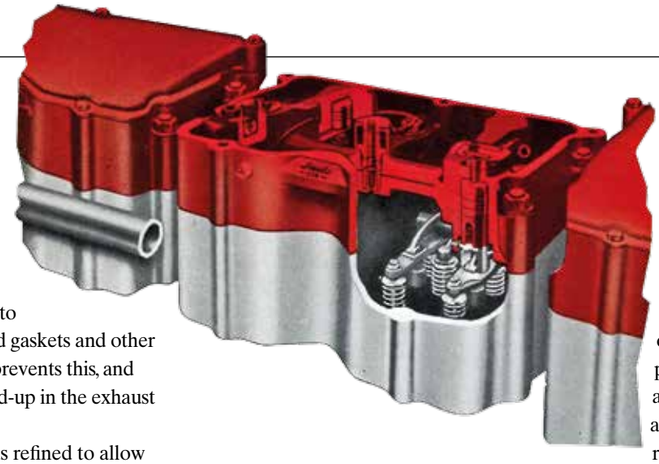
The returning upward motion pushes the exhaust gases out of the cylinder via the exhaust valve(s) and completes the cycle.

The Jake Brake modifies this by opening the exhaust valve just before combustion, allowing the compressed air to escape, removing the downward shove upon the piston. It's controlled by a master switch and is activated when the throttle pedal is released, shutting off the supply of fuel to prevent the engine from firing. The retarding effect of compressing the air acts as braking torque through the driveline, slowing the vehicle. The system is operated by a slave piston acting upon the exhaust valve and operated via a solenoid/control valve which initiates the flow of engine oil used as the fluid to activate the operating piston. The precise timing and control of the piston opens the exhaust valve just before the engine piston reaches TDC (Top Dead Centre), allowing the compressed air in the cylinder to be released.

The system also has the added advantage of retaining heat in both the cooling system and exhaust. Typically there is huge temperature fluctuation in the cooling system when climbing and then descending hills, where the engine is pulling hard and then has little load. This causes coolant temperature to plunge, and puts strain upon head gaskets and other components. The retained heat prevents this, and also helps to prevent carbon build-up in the exhaust system itself.

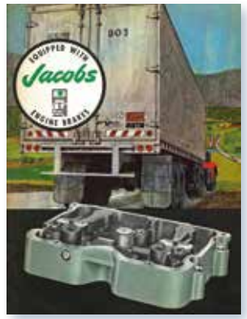
Over the years the system was refined to allow up to three stages of braking power. The system was far more powerful than any previous system of butterfly or sliding-gate exhaust brake that operated further downstream from the cylinders at the outlet side of the exhaust manifold. While the system was designed originally for use with Cummins engines in the US, it was later adapted to fit Caterpillar and Mack engines, along with Detroit Diesel two-strokes.

The name Jacobs, or Jake for short, comes from the company that Cummins worked with to take his invention into production. The Jacobs Manufacturing Company of Bloomfield, Connecticut, was better known for its production of machine tools, particularly the adjustable drill chucks on all types of drills. Older readers may recall seeing the company badge on some hand drills.



The name game: The Jacobs (or Jake) Brake gets its name from the Jacobs Manufacturing Company of Bloomfield, Connecticut

Jacobs formed a separate Vehicle Equipment Division division to promote the Jake Brake product line in 1961, when it went on sale in the US. Drivers found the new device a real boon on long mountain passes, since brake fade was a big problem on the very long descents in the Rockies and other mountain ranges. The powerful Jake Brake enabled laden trucks to tackle the steep gradients at far higher speeds in complete safety. Operators found that brake maintenance costs were reduced dramatically. Initial misgivings about putting the engine under greater strain proved to be groundless – after all, the system was designed by someone who had an innate understanding of engine design.



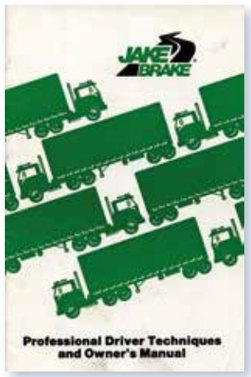
On the road: The ERF NGC was offered with a Jake Brake and 14-litre Cummins engine

NOISE ANNOYS

One of the drawbacks of the system, particularly with early vehicles with just a basic upright exhaust – or in some cases just a straight pipe system – was the distinctive rattle when the brake was engaged, caused by the highly pressurised air being released from the cylinders. Older ones are definitely loud, but as with all mechanical systems, later versions became much quieter if working with a suitable exhaust system. But some US operators liked to advertise their arrival, and ensured the engine note and the sound of the Jake Brake would reaches as many people as possible! This led to opposition in built-up areas, with signs telling drivers not to use their engine brakes. This is understandable, as nobody likes to be woken up in the middle of the night, but all things considered, if I lived at the foot of a long mountain pass, I think I would exchange a bit of noise for the danger of the bonnet of brakeless

Kenworth crashing through the house!

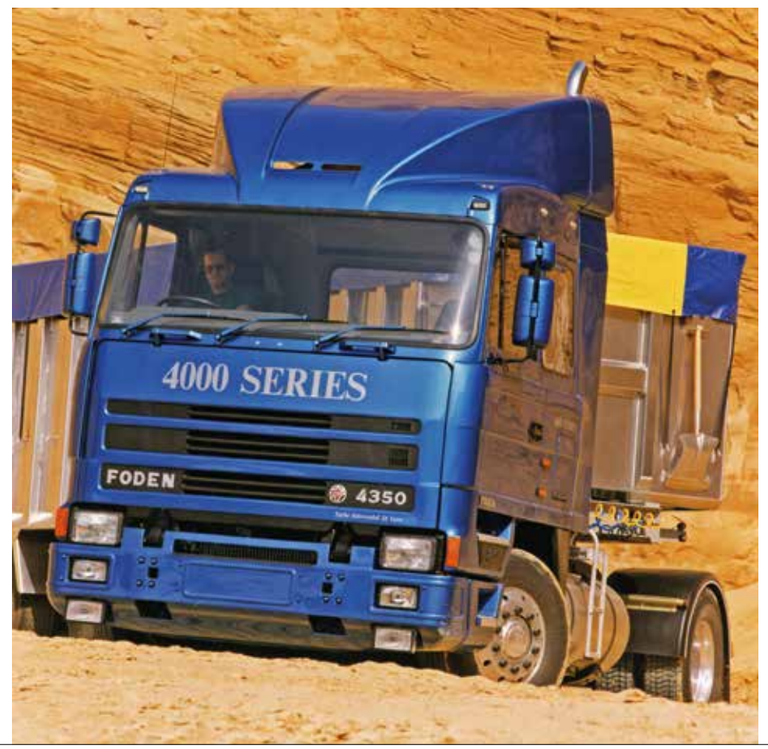
It took a while for the Jake Brake to make its way across the Atlantic, as Cummins engines were in their infancy in this market in the early 1960s. Cummins offered them as either an option or retrofit, but there was limited take-up. The first one to be retrofitted was to an ERF tractor unit belonging to Midlands-based Joseph Foulkes (Wednesfield), and ERF again exhibited a Cummins-powered tractor fitted with one at the 1966 Commercial Motor Show. But operators were slow to recognise the benefits. *CM* ran a few features about operators' vehicles fitted with Jake Brakes. Safety conscious tanker operators such as ICI fitted them to its fleet of Atkinson tractor units, and our tester went out to try one for himself. He was very impressed by the tremendous retardation offered, particularly on the hilly North Yorkshire Moors.



The operator reported very low rates of brake wear and the test drive highlighted another benefit of the system – faster and cleaner up-changes if the Jake Brake was set on the automatic function, bringing it into action as soon as the throttle pedal was released. It killed the revs instantly but didn't stall the engine, which allowed lightning fast upward changes with the 9-speed Fuller Road Ranger constant-mesh transmission. Ironically, this is now a feature of many of the modern-day automated transmissions, where the engine brake is used to kill the revs and the clutch brake to slow the rotating mass in the constant-mesh 'box, to get the quickest change on an uphill gradient. Fifty years earlier skilled drivers were doing exactly the same with a gearstick, pedals and a dash-mounted switch!

Bedford offered the option of a Jake Brake on the TM range powered by Detroit V6 and V8 71 series two-strokes when it was introduced in 1974. The distinctive engine note preceded the arrival of a TM. We only encountered a couple of two-strokes with engine brakes, but blimey they made a noise, with the wail of the engine and then the machine gun rattle of the Jake. One truck that most would have thought to be a natural fit for a Jake Brake was the Ford Transcontinental with its Cummins engines. But fitment of the system on a 14-litre NH engine does increase the height of the rocker covers, preventing its installation under the already (by the standards of 1975), towering Berliet-sourced cab, so it had to make do with a sliding-gate exhaust brake instead.

Flying the flag: ERF was a great advocate of the Jake Brake, fitting it to this EC15 with 550hp CAT engine



BRIT OF ALRIGHT

Take-up of Jake Brakes was relatively slow in the UK for some time, but drivers lucky enough to experience the high levels of engine braking offered soon became converts, especially in really hilly areas. Jacobs took over marketing the system in the UK in the mid-1980s and began working closely with the truck manufacturers fitting suitable engines. ERF in particular pushed the product. The concentration upon Cummins engines with the CP and later E series helped to get the Jake Brake concept in front of more end users. The success of the smaller displacement L10 engines, which were far lighter making them ideal for multi-axle rigids, brought powerful engines brakes to a new sector of the market. Foden and Seddon Atkinson also played an important part in this process.

In the family: Foden offered the system with Cummins and Caterpillar engines in the Alpha range

Tipper operators and their drivers really came to love the combination of Cummins 10-/11-litre, Eaton/Fuller 'box and Jacobs engine brake. The ability to come down long descents in the Peak District, the Mendips and other hilly areas, at far higher speeds with little recourse to the footbrake was a whole new experience. Also, brake life was greatly improved and journey times cut without driving recklessly. I remember having a run in an 8x4 ERF E10-325 demonstrator with 12-speed Eaton Twin Splitter transmission and three-position Jake Brake. It was a seriously good truck, with really rapid gearchanges, excellent handling and superb engine braking. The operator who had it on loan asked me what I thought of it? I said that "I am a bit worried", which was understandable because I was the local Volvo salesman at the time and was trying to sell him an FL10 8-wheeler.

Brand new: Jake Brakes were also marketed under the Cummins C Brake name

The Volvo was a very good truck too, but even the most partisan supporter would have to admit that the exhaust brake on the 9.6-litre engine was pretty much next to useless. In fact, Volvo did run a campaign offering to fit Telma Electro-magnetic retarders to FL7/10 8-wheelers, at a heavily subsidised price. They worked very well, but added quite a bit of weight, something like 350kg if I remember correctly, while the Jake Brake added less than 35kg.

Although the system sold in reasonable numbers in the UK, the gradual demise of British truck manufacturers meant there were fewer opportunities for Jacobs Vehicle Systems (as the company was now termed) to sell to its traditional

customer base. So it started to cast its net far wider. It developed a system to fit the Volvo 12-litre engines used in the F12 range, suitable for the TD120/121 and 122 series motors. A few were sold and I can recall driving one in the distinctive colours of Maguires of Cheltenham. It worked quite well pulling a laden tipping trailer, but it wasn't as effective as the Jake Brake in the equivalent Seddon Atkinson Strato it also ran. The extra capacity of the 14-litre Cummins, and having 4 valves per cylinder made a difference, as opposed to the 2-valve per cylinder Volvo motor. It seemed quite strange to have a pretty effective engine brake in a Volvo. It still had the distinctive bark when in operation, but it was a good deal quieter than the Cummins.

RIVAL ARRIVAL

Although there was no real collaboration with Volvo on this, it was a sign of things to come when Volvo introduced its own take on the Jake Brake, with the VEB (Volvo Engine Brake) on the new overhead camshaft D12. The combination of an engine brake working directly on the 4-valve layout and the standard back-pressure regulator provided levels of retardation never seen before on a European truck engine. It even shaded the mighty Jake Brake in this respect, offering a viable alternative to a retarder. This coincided with the introduction of new EU regulations regarding secondary braking systems for ADR work. The appeal of an effective engine brake was that it was cheaper and lighter than a retarder in a very cost/payload conscious sector.

Jacobs then went on to work with a number of truck manufacturers to develop effective engine brake systems for their engine ranges. This collaboration was with DAF and Renault to begin with, but has expanded to include many more in recent years. Its technology is now used by Mercedes-Benz/Detroit Diesel, Deutz, Ford Otosan, Hino, Hyundai, Navistar, Isuzu, FAW, and a number of other Chinese manufacturers. The technology now encompasses far more than just engine braking, and includes a number of valve actuation and manipulation systems, along with selective cylinder de-activation systems. They offer reduced emissions, better combustion and cold starting, and other benefits include retaining heat in exhaust systems, which is particularly effective in urban situations with heavy traffic congestion.

Making it fit: Jacobs developed a version of the braking system for the Volvo F12

Probably its most interesting development is the HPD (High Power Density) version of the Jake Brake, which increases the number of available engine braking cycles by as much as two-fold, giving far higher levels of retardation even at low revs, producing a peak of 611kW braking power from a Mercedes 13-litre engine at 2,500rpm and maintaining a high level as the revs drop. It is also far quieter than any existing system, which is an important consideration.

GOING STRONG

The combination of ultra-high overall gearing, ever more effective aerodynamics and reduced rolling resistance means that modern trucks gain speed more rapidly than ever on downgrades. This makes an effective engine brake linked to a GPS-controlled cruise system vital on our congested roads, to both keep a safe distance between vehicles and maintain journey times. No European manufacturer has taken up this technology yet, but Sinotruk in China has specified it on its latest 11- and 13-litre engines, which can only be a good thing considering Chinese operators propensity for overloading their trucks.

There is still plenty of life in Clessie Cummins' brainchild – just be sure to use it properly. □

NEED TO KNOW

The newer HPD version of the Jake Brake has a higher level of retardation even at lower revs, thanks to increased engine braking cycles. The noise is less too!