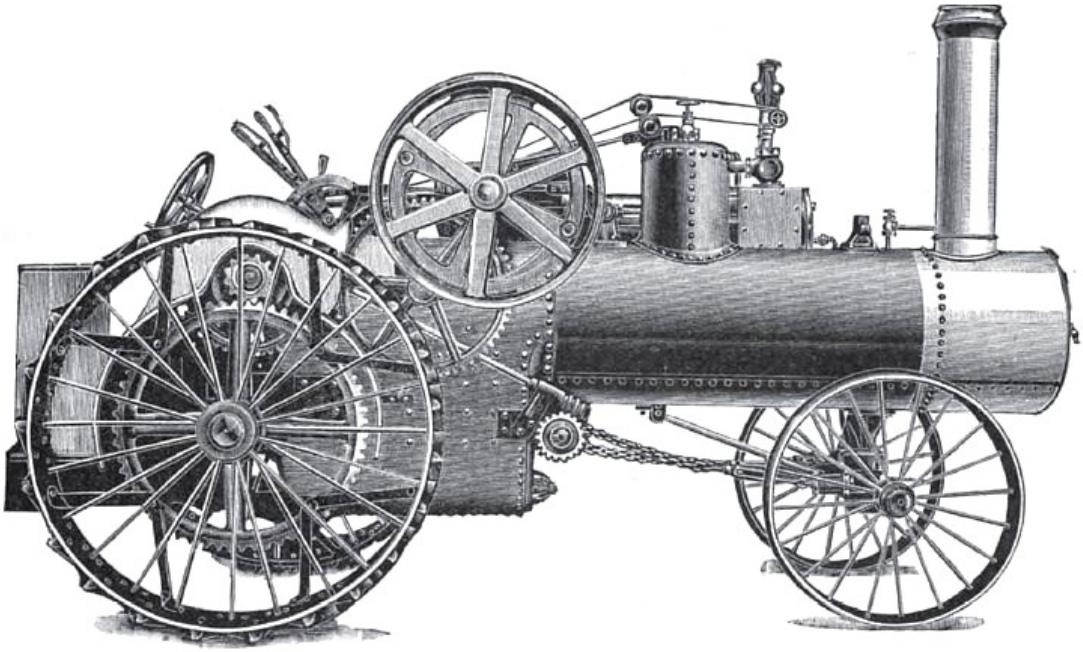
THE BAKER VALVE GEAR FOR STEAM LOCOMOTIVES

(Some notes from various sources)

Abner D. Baker was born March, 1861 near Fredericktown, Knox County, Ohio. When 15 years of age he moved with his parents to a farm a few miles east of Swanton, Ohio.

He had a common school education, and when he was 23 years old went to Akron, Ohio, and worked as a machinist in the Empire Reaper Works for about three years. From there he went to Erie, Pennsylvania, and worked one year in the Erie City Iron Works. Later, he went to Detroit, Michigan, where he worked in the Frontier Iron Works for about three months.



At this time he returned to Lucas County and started a repair shop on his father's farm. He conducted a prosperous business there for a few years, and in 1895 he opened a similar shop in Swanton, about 20 miles southwest of Toledo, Oh. They built steam traction engines, grain threshers, and large gas tractors. Their last steam engines were built in 1929, but their large gas tractor business was booming. A 25-50 model gas tractor they shipped to Lincoln, Nebraska for testing at the University developed 75.88 HP in the belt, and 55.72 drawbar HP (apparently the highest of any wheel tractor up to that time). The Baker traction engines used the Baker centre-hung reverse valve gear, Baker balance valve and seat, adjustable boxes for rear axles, and the Baker Uniflow Cylinder.

He conducted the Swanton business as a repair shop until 1901, when it was incorporated under the name of the A. D. Baker Company and they engaged in the manufacture of steam traction engines. Mr. Baker had already built five traction engines as a personal business enterprise before he organized the stock company.

Mr. Baker married in April 1886, and a son—who became the mechanical engineer of the company—was born in 1891. The company enjoyed many years of prosperity under the able management of Abner and Louis Baker.

Although he didn't invent it, Mr. Baker developed, perfected, and patented the radial reverse gear that bears his name, *"…and all good authorities on valve gears say it is the best reverse gear ever put on a steam traction engine or a locomotive."* The inventor was an employee by the name of Gifford who lived about six miles north of Swanton, just west of Assumption, Oh.

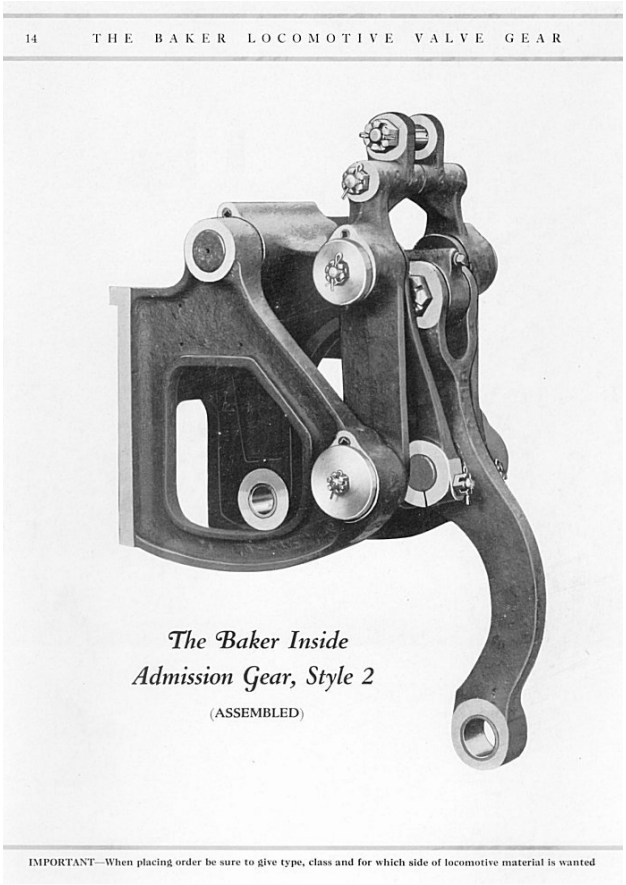
The Baker high pressure steam tractor with automatic stoker and water regulator was an interesting and economical machine. His first engine for his steam tractor was a double-simple. He next used the cross-compound type, but did not like the indicator cards from it, so finally used the tandem-compound type with piston valves and centre-crank, and superheated steam. Had he been able to completely separate the cylinder oil from the condensed exhaust steam, this engine would have been a great success. Baker was quite active in his advanced years, going to the factory nearly every day. He died in June, 1953.

The Marshall Gear (James Thompson Marshall) is described as a modified Walschaerts valve gear (another source says a 'modified Hackworth' gear) first applied to a Great Northern Railway mineral locomotive in 1901 and a Class C2 in March 1903. There was no external change visible on the locomotive as a result of this modification. The motion was derived from two eccentrics, one of which gave lap-and-lead movement by swinging the link backwards and forwards on its suspension bracket. The other eccentric was set at 90° to the crank and rocked the link by means of a bell crank on the hanging link pin. The position of the radius rod die pin in the link determined the direction of movement and the cut-off. Showing little advantage over the normal Stephenson link valve gear, it was removed in April 1907 to ease maintenance.

The Baker valve gear was patented March 3, 1903 and re-designed for railway locomotive use in 1908. Their catalogue claims they get a full port opening when the piston has travelled only 3/8" from dead-centre. An Advance salesman, George Shannon of Battle Creek, Michigan, said there was nothing gained by that early admission, and I said, 'How about getting rid of the exhaust quickly?' He replied, 'Well you got me there.'

This valve gear introduces the angular elements of the Marshall gear into the Walschaerts in a complex yoke drive with a bell crank. The Baker Locomotive Valve Gear was produced by the Pilliod Co. of Swanton, Ohio. Apart from the support given by the Pilliod Company, any advantages are

more apparent than real, though doubtless the Company would not agree. Simulation confirms its complexity in arriving at valve events predictably similar to the Walschaerts yet more costly to produce.



Countless gear inventions merely sought to bypass patents and can be dis-counted in practical terms unless the student has a particular interest. Unprotected by patents, Stephenson's gear—properly designed—can be made to produce equality second-to-none and the Walschaerts can approach this performance.

It seems odd that elements like the Marshall lever arms, Baker yokes and bell cranks, Greenly offsets and many other attempts to allow correction have not been generally perceived as what they really are. The timing distortions of rotary-to-linear motion and vice versa are similarly present in all swinging arms and rockers - an arc is simply part of a circle and the same principle applies to both. It is therefore not surprising to find complex mechanisms little better than Hackworth gear in its simplest form. It is wise to include the members of suspension and reversal as legitimate constituents of the mechanism with the same ability to distort distribution.

The claimed advantage of the Baker gear was that with all members connected at fixed pivot points, there was greater equalisation of wear. The Baker valve gear replaced the expansion link of the Walschaerts gear with an assembly of levers and links that produced the same effect of allowing continuous variation valve travel. The remainder of the gear is the same, so that the return crank and combination lever take the same form, although the proportions are usually modified.

One commentator (Carl B. Erwin) states… *“The Baker-Pilliod was possibly the most perfect of any of the valve gears. Both of these gears open the ports quickly as the crank passes dead centre, dwells for a split second then, due to the motion of the 'lap and lead lever' or, as some called it the 'intervening bar'* [also, ‘combination lever’] *closes quickly for cut-off. Near the end of the stroke the valve is moving fast and gives a quick release so there is little back pressure. Engines equipped with these gears could move heavy trains and saved steam by utilizing expansion.”*

Wikipedia states that strictly speaking it was not a valve gear but was a variable expansion mechanism adapted to the Walschaerts layout replacing the expansion link and sliding die block. The Baker arrangement used more pivot bearings or pin joints, but avoided the die-slip inherent to the expansion link, with the aim of lessening wear and the need for service. It could also facilitate longer valve travel. The gear set is standard for any engine; and, in the event of damage by accident, or other urgent need, the whole can be removed, and replaced by a fresh set taken from store, without taking the engine out of service. The advantages of the Baker gear have always been debated, the main criticism being the number of pin joints and possible lost motion.

Each of the valve gears address different methods of adjusting the valve timing by using a link and link block (or by its omission such as the Baker gear, which uses a bell crank) and the locations of the reach rods in relation to the radius rod/bars (Walschaerts/Baker and Young, respectively), union links and combination levers. They all did the same thing, just a different approach to the issue of valve timing and/or maintenance.

Baker's chief advantage was that there were no parts sliding on each other, all of the movement took place on the pins [needle bearings], which were easy to replace. Not only that, but the parts of the Baker gear were the same size regardless of the engine size, so the parts bin in the roundhouse could be much smaller [not an issue for NZR who really only had the one application of this gear]. Many would argue that Walschaerts had a smoother motion and more precise events than Baker gear.

The Baker valve gear had one operating advantage over the Walschaerts in that it could be set up for a larger valve with longer valve travel, 8-1/2" versus about 7" for Walschaerts, and was generally more rugged and could operate a heavier valve better. The longer valve travel also equated to a higher speed for the valve and hence more horsepower to move it.

The longer valve travel was connected with "super power" engines, as it allowed larger steam openings in the valve bushings, making the steam flow more efficient. NYC, N&W, and C&O were probably the biggest users of Baker valve gear. Lots of Lima engines had Baker gear, but I always wondered why the SP 4-8-4's didn't use it. Maybe Lima suggested it and SP just said no. Other non-Baker roads would be NP, GN, UP, ATSF, WP, DRGW, MP & PRR. I'm not sure the UP and ATSF power could be called 'super power'… the engines were just large.

The Baker-Pilliod gear supposedly gave quicker valve events for any given cut-off but was quite complicated. Some railroads didn’t think it was worthwhile, although N&W obviously thought it was worth the cost.

As far as development was concerned, the Baker gear offered the advantage of providing a longer valve travel without introducing excessive angularities into the valve gear. After 1911 N&W never

used another valve gear. The A class of 1936 used Baker gear with a long valve travel. The only refinement thereafter was the application of McGill 'Multirol' needle bearings for all the connections in the gear.

Baker-Pilliod required a royalty payment and the Baker gear was more complex and heavier with many more parts than the Walschaerts.

[A personal view, from looking at this equipment, is that any benefits to locomotive operation would depend upon the locomotive steam chests having been designed specifically for this equipment and the individual engineman having an intimate knowledge of how to modify regulator and reverser settings to best advantage. Whether or not this ever eventuated would have depended upon whether or not the railway concerned sought to provide specific training in the use of the Baker gear. I doubt that the NZ Government Railways ever did. No engineman that I asked (in the context of my early service around the Ja class) could provide anything more than the most cursory explanation of how the yoke mechanism worked, and many couldn't even recount the names of its parts. Nonetheless, some NZGR steam drivers who ran both types of gear on the same locomotive class (Ka) have described how they soon learnt to handle the reverser slightly differently with the Baker gear.

Although Baker-Pilliod—in their technical description—sought to claim a speed advantage due to the design of the gear, there was no obvious element of the Baker gear that would provide any speed advantage to a steam locomotive not specifically built to use it. In New Zealand the gear was used interchangeably (on the Ka class) with Walschaerts gear. This would suggest that these locomotives were never specifically designed for Baker gear.]