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## Bottom Bracket Gears – a historical perspective

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### Introduction:

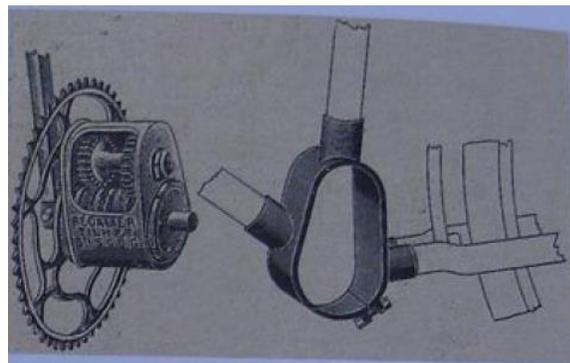
There have been two well-known types of multi-speed gears used on bicycles in the past 120 years, the **epicyclic hub gear** and the **chain derailleur**. Both of these essentially place the gearbox at the rear wheel. Yet there is also a little-known third way, the **bottom bracket gear**, where the gearbox is integral with the crankwheel assembly in the bottom bracket. In this paper, the various forms of successful bottom bracket gears and their evolution in England, Germany, Switzerland, France, Japan and Taiwan over the years will be described.

### The early 1900's in England and France

*Sunbeam* were one of the best known bottom bracket gear manufacturers in this era, sometimes combining their 1903 2 speed epicyclic bottom bracket gear with their 1906 3 speed rear hub to give a choice of 6 ratios (e.g. the 1909 *Marston Golden Sunbeam Six-Speed* with oil-bath chaincase). Overall ratios spanned an impressive 263% with an unlikely top gear of 129".



1909 Sunbeam epicyclic 2 speed bottom bracket<sup>8</sup>



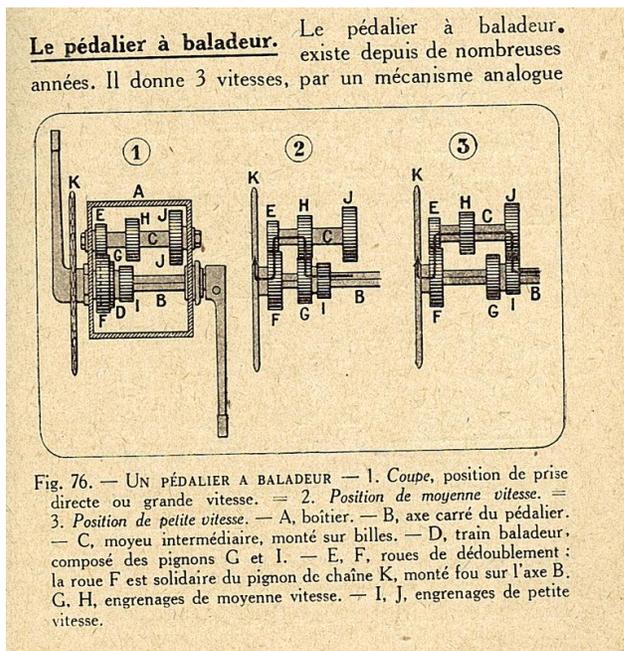
1908 Tilhet bottom bracket spur gear<sup>2</sup>

James also had a design of two speed epicyclic bottom bracket gear in 1906, which sat outside the frame, actuated by a Bowden cable on the crossbar linking through the down tube to the gear. It was fitted to their own bicycles as an option, and allowed other normal bicycle frames to be retrofitted.

The French *Pedalier Tilhet* was another bottom bracket gear put into production in those early years (1908). It used a bulky spur gear box mounted in a large frame cutout around the bottom bracket. The low gear was really low at 0.5, with a direct high gear. No cables or rods were used for shifting, instead back-pedaling was used to change gears. However this did not always work well, with unintentional shifts.

There were also many prototypes in both countries during this experimental time that either never saw production, or were 'in the catalogue' just once.

One French design that proved more lasting was the ingenious Magnat-Debon 3 speed bottom bracket gear from Grenoble (there was also a rarer 2 speed version). Patented in 1903 for both the UK<sup>20</sup> and France<sup>21</sup>, it was in production from 1902 to at least 1928, before being replaced by a conventional Simplex 3 speed derailleur in the early 1930's. Magnat-Debon made bicycles and motorcycles, merging with Terrot in the 1920's.



The Magnat-Debon 3 speed gearbox (Direct High 1, Normal 2, Low 3) An Edwardian Magnat-Debon, note rotating disc on x-bar<sup>19</sup>

The design used a steel gearcase/bottom bracket with aluminium sides. A layshaft carried the matching gears opposite the pedal shaft, the pedal shaft dual gear block on a square axle was shifted sideways by an ingenious rack and pinion mechanism, with selection from the crossbar by rotating a disc. Carefully chamfered gears ensured the crash box operated smoothly for long life. Gears gave a very wide 217% range, with top

gear being direct (selected by 6 dogs on the sliding gear block). The ratios were 1.0/0.65/0.46 for great hill-climbing ability (typically 66"/43"/31" gears), well-suited to the Alpine terrain around Grenoble.

### The Thirties in Germany

It was in the 1930's that bottom bracket gears (*Tretlager Getriebe*) really blossomed in Germany, as did domestic bicycle production (which ballooned from a million bikes in 1932 to 2.6 million in 1935). Unlike the 2 and 3 speed hub gears being manufactured at the time by *Fichtel & Sachs* (Schweinfurt) and *Sturmey-Archer* (Nottingham), these were parallel spur gears, not epicyclics. It is worth noting, in the context of innovation, that the domestic *F & S* were trailing *Sturmey-Archer* at this time, with just 2 planet gears and a crude shift mechanism in their cable-operated 2 and 3 speeds. The brilliant chief engineer William Brown held sway at *Sturmey-Archer* during this creative time<sup>9</sup>. Also, as the Thirties progressed, German bicycle makers were officially discouraged from using 'foreign' technology.



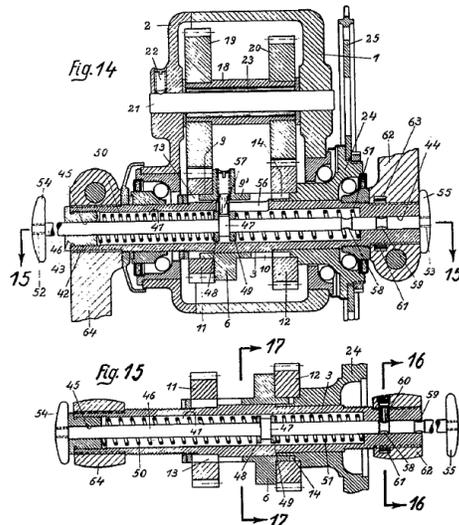
German domestic bicycle production in millions, by year<sup>3</sup>



Dealer display board for the 1935 Wanderer 2 speed<sup>8</sup>

There were at least 6 German bottom bracket gear manufacturers during this bottom bracket 'golden age', including large combines like *Wanderer* (Chemnitz). *Wanderer* had started in 1885, and in admiration of J.K.Starley's *Rover* bicycle, called themselves *Wanderer*. By the 1930's they were producing cars and motorcycles, as well as a full line of town and country bicycles. They even used Dr.Ferdinand Porsche as consultant on some of their car designs. In 1935, their 2 speed bottom bracket gear for bicycles was introduced. The gears ran constant mesh in an oil bath for long life. The *Wanderer* gearbox provided ratios of 1.0/0.77 (all bottom bracket 2 speeds of this era were normal/low gear combinations for hill climbing on 26-28" wheels). Shifting was initially by a ball and jointed rod linkage to a lever on the down tube. However in the late 1930's, they followed up their success with a clever invention that did away with cumbersome frame linkage manual shifters – the **heel button on the pedal axle**. The ingenuity of the design lies not just in the prompt and intuitive shifting, but the visual cue that always tells you which gear you are in (left button in means low gear etc.). This is unlike the 1960's kickback shift 2 speed hub gears from *Bendix* or *Fichtel & Sachs*, where you never really knew what gear you were in when stopped at a traffic light. I

know this from personal experience, having ridden both heel button and kickback gear bicycles to work on a daily basis.



Wanderer patent for heel changer, August 1939<sup>6</sup>



1936 Wanderer original 2 speed with shift rod

The heel button patent<sup>6</sup> was awarded to *Wanderer* in Switzerland just a month before the Second World War erupted. The concept will be familiar to many from the Swiss *Schlumpf* bottom bracket epicyclic 2 speed of the 1990's, which used the same idea. *Wanderer* did not just add on the heel button, they redesigned the entire gearbox to make it compact and lighter, completely eliminating the internal helical shifter drum shaft. Alas, postwar, their huge factory (or what remained of it after 3 years of Allied air raids) was in the Soviet Zone, and *Wanderer* all but disappeared from the bicycle scene.

Other German bottom bracket gears from the mid-thirties<sup>7</sup> included 2 speed units from both *Bismarck* and *Brennabor*. The *Bismarck* (1936-1940) was unusual in that it used twin chains running inside the bottom bracket box, either of which could be locked to the chainwheel by an 8 pin sliding driver in the centre to select either a 1.0 or 0.73 ratio. The small chain crankwheel was mounted on a separate axle behind the pedal shaft. The *Brennabor* (Brandenburg, Berlin) ran in an oil-tight enclosure, using a sliding claw between the two constant mesh gear trains to select direct or low (1.0/0.77 ratios). *Stadion* was a German/Czech company producing bicycles. In 1935 they introduced a 2 speed bottom bracket design in Germany, using a rod linkage to a hefty ball shift lever on the down tube. After the war, only the Czech factory remained.



1935 Brennabor 2 speed bottom bracket gear, rod shifter



1936 Bismarck, twin chains and offset crank sprocket<sup>22</sup>



1935 Stadion 2 speed bottom bracket<sup>8</sup>

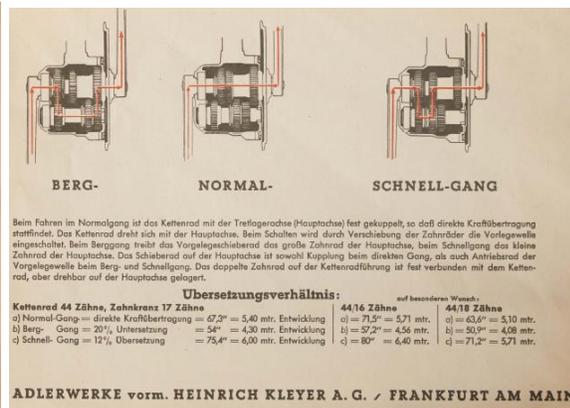


1935 Wanderer internals<sup>8</sup>

And then things got even more interesting. *Adler*, of Frankfurt am Main (manufacturing typewriters and bicycles) introduced a 3 speed bottom bracket gear in 1935, both on their own bikes and for use by others (eg *Primarius* of the Netherlands). *Adler Werke* (*Eagle Works*) promoted this new design quite heavily, it used a gated hand lever on the

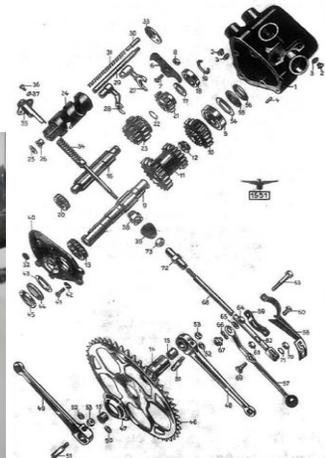
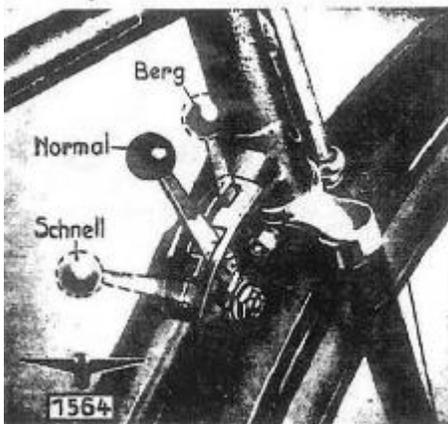


From the 1935 Adler 3 speed brochure<sup>5</sup>



(Berg is low gear, Schnell is high gear)

down-tube to shift. The 3 speeds of 1.17/1.0/0.8 were rather a closely spaced set of ratios, compared to a 3 speed hub gear, giving only 146% overall instead of the 177% of a *Sturmey Archer* AW. A bigger problem was the non-constant mesh gears, which had to be crashed into each other to shift. The *Adler* 3 speed eventually acquired a poor reputation for reliability, despite being an initial sales success.



The 1935 Adler 3 speed bottom bracket gear and shifter<sup>4</sup>

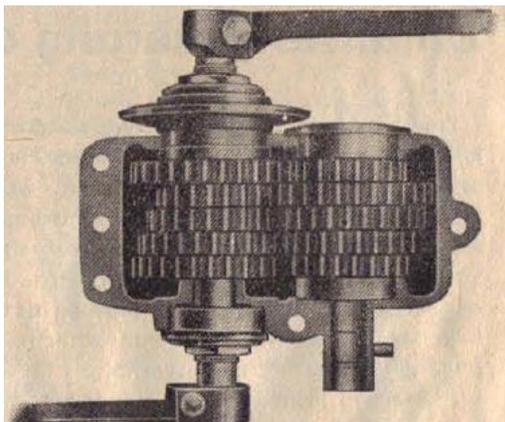
The last blast came from *Wippermann*, the chain manufacturer near Dortmund. They produced a four speed constant mesh gearbox in 1938 called the *Rappa* (originally designed in Rapperswil, Switzerland). This same gearbox was also made in Sweden (Hermes) and Denmark (Hamlet) as well as its native Switzerland<sup>22</sup>.



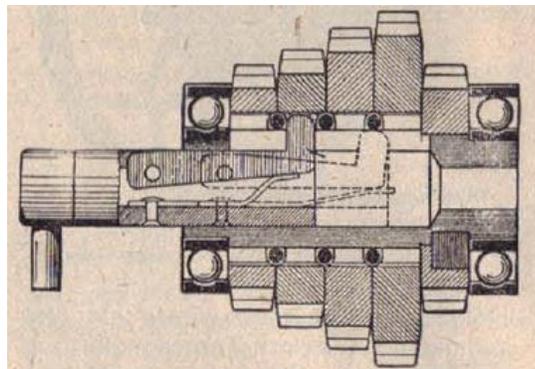
The 1938 Rappa 4 speed bottom bracket gear



Rappa gear shift



Rappa internals - 5 gear trains, 4 ratios<sup>12</sup>



How the Rappa inner shifter locks each gear ratio in turn<sup>12</sup>

Advertised as being intended for mountainous terrain, the *Rappa* was a sturdy design, but it came too late to benefit from the 1930's boom in bicycle gears. It was fitted to several bicycle makes, including *Rappa* themselves, and *Wittler*.

## Switzerland Awakes

Perhaps stirred by the initial success of the *Adler* 3 speed, a Swiss company in Bienne called *Phoebus* (later *Sport A.G.*) developed possibly the best 3 speed bottom bracket gear of the 1930's. The 1938 design was called the *Mutaped*, it remained in production for 20 years and was quite widely fitted to Swiss and Dutch bikes of the time (eg *Phoenix*



The 1938 Mutaped three speed, no rod shifter

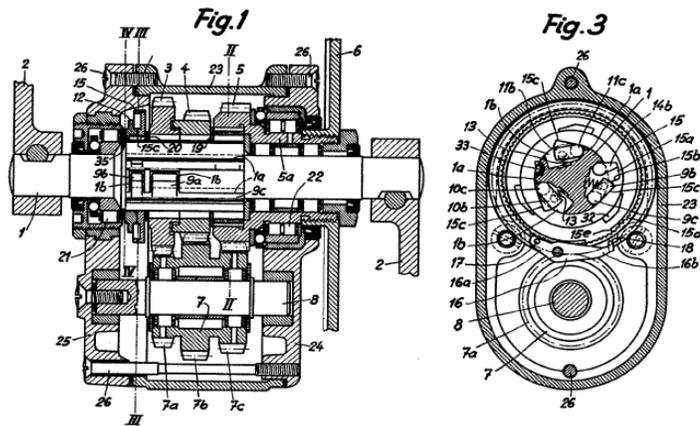


Mutaped internals<sup>10</sup> showing the 3 gear trains

in the Netherlands). *Phoebus* were a bicycle dynamo and headlight manufacturing company, not the most obvious choice for a new bottom bracket gearbox. It was likely they hired an external industrial designer for the elegant *Mutaped*. Lightweight, with a cast aluminium housing (most of the competition used cast iron) and constant mesh gears, it had an ingenious method of shifting that needed no external gear lever or shift linkage. One simply pedaled backwards to cycle the gears 123-123 etc. by means of internal spring loaded ratchets, that locked each gear train in turn.



Mutaped advertisement



Cross-section of the 3 speed gearbox, from the Mutaped patent<sup>11</sup>

One downside to their approach was the need to back-pedal through 2 gears to shift down (say from 3 to 2). The other practical disadvantage was added uncertainty about which gear was one in at a stop, with 3 possibilities.

Offsetting this was the compact elegant design with no dangling rods or cables for shifting. The idea has recently been revived for the 3 speed version of the *Strida* folding bicycle. See the section on **This Century** for a description of the *Sun Race Sturmey-Archer KS3*.

### France and the late 1940's

But it was the French who brought the bottom bracket gear up to modern times, in 1948, with the revolutionary *Vilex* 5 speed gearbox. Designed by Jean Raymond Barthélemy Monge of Pierrefitte-sur-Seine (Paris) and manufactured in Bordeaux, it was fitted to bicycles made by *Mervil* (Pontarlier) and subsidiaries *Excell* and *Asterion*. The *Mervil* version was called the Mervilex.

Jean Monge was a prolific inventor, there are 5 patents to his name from July 1948 to October 1952: 2 French, 1 German, 1 Swiss and 1 US. Ironically they describe 3 and 4 speed versions of the B.U.E.C., not the 5 speed that actually went into production. Interestingly, the 3 speed had 3 ring gears, a compound planet gear and a single sun gear, whereas the 4 speed had just 2 ring gears, a compound planet gear but 2 sun gears. Evidently he merged the two ideas to create a 5 speed epicyclic.

The Vilex was also aimed at the moped market, which was booming in the early 1950's: there was a separate sprocket and changed internal mechanism for the engine drive input on this version, whilst retaining pedal drive to be a 'legal' moped.



The 5 speed Mervilex bicycle, 1948



Brochure on the B.U.E.C. Vilex 5 speed bottom bracket gearbox<sup>13</sup>

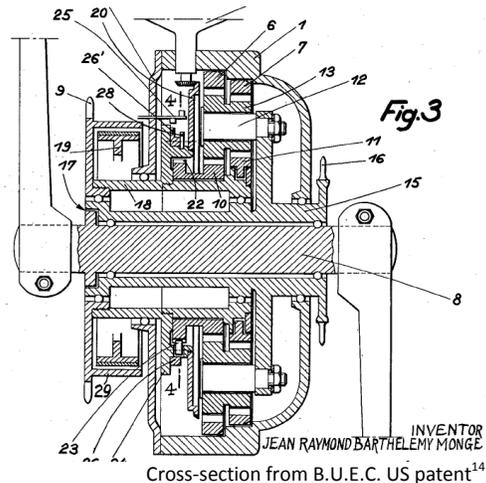
Using a complex epicyclic train in a compact package, it had everything but the kitchen sink built-in. Shifting was accomplished by a Bowden cable linkage to a crossbar mounted shift lever. A weatherproof drum brake with internal expanding shoes was built-in, operated by the right-hand handlebar lever. This was possible because the

freewheel was also built-in at the pedals, allowing a fixed sprocket/wheel at the rear for braking forces transmitted through the chain. This meant the chain was always turning at road speed, even if the pedals were stopped. Even lighting was built-in, using a bottle dynamo driven by a pinion gear off the brake drum, to ensure lighting even when coasting or backpedaling. There were also provisions for a speedometer drive and an anti-theft immobilizer. Alloy castings were used for the housings, to keep weight down.

Typical of the thoughtful design, the external chain and sprocket teeth also served to provide cooling airflow for the brake drum attached. The gear mechanism ran in an oil bath, requiring just a 'shot glass' of thin oil added every 3 months. The range of the gears was astounding, the "development" of 2m to 7.5m corresponded to a 375% overall ratio. Note the very large rear sprocket on the full-size fixed wheel, this was needed by the overdrive gear ratios. The *Vilex* unit would have been tailor-made for modern small wheel folding bikes, where a normal size rear sprocket would probably work just fine.



Large rear fixed wheel sprocket on Mervilex



This was truly a weatherproof touring bicycle for all seasons, a 'system design'.

The *Vilex* could be in theory be fitted to a normal bike frame, although the bottom bracket brazed joints had to be desoldered and the tubes shortened, an unlikely choice for most owners. The complete gearbox was called the *B.U.E.C.* (for *Boite Universelle d'Equipements pour Cycles*) *Vilex*. There were many sophisticated design touches, such as ball bearing planets to reduce friction. Regrettably, the *Mervilex* bike was only in production for a few years before *Mervil* closed its doors in late 1950. The *Vilex* bottom bracket gearbox design deserved to be in production for many more years, so modern was its system concept.

### Japan in the 1990's

*Shimano* introduced a production 5 speed epicyclic overdrive bottom bracket gear in 1994, aimed at upgrading the vast domestic commuter bike market in Japan. Titled

internally the *FG-5S10*, but fitted exclusively to Miyata domestic bikes as the *Miyata FM-5*, it had two large sun gears and 3 compound planets giving a substantial range. Ratios were wide at 1.00 1.31 1.39 1.91 and 2.21. It did not succeed commercially in its chosen market and was only in production for a few years.

*Bridgestone* (the biggest Japanese domestic bicycle manufacturer), on the other hand, produced the long-lasting *FM4* design for their own domestic bikes at the same time. The 4 speed bottom bracket compound epicyclic, with handlebar cable shift, was often



Miyata FM-5 5 speed



Inside the complex FM-5 crankwheel (Shimano FG-5S10) - huge sun gear for high ratios

offered combined with a 3 speed *Shimano* rear hub to give **12 available gears**. *FM4* ratios were 1.00 1.61 1.79 and 2.00, also wide. This sturdy bottom bracket gear remains in great demand in California for retrofitting to project bikes.



Bridgestone FM4 4 speed bottom bracket gear..



..fitted to a classic Japanese domestic commuter bike

### This Century – Schlumpf, Sturmey Archer and Strida

The *Strida* is a unique folding bike with a triangular frame, stub axles and belt drive, dating back to 1986 in the UK (it is now made in Taiwan). With such a design, a conventional rear hub gear is all but impossible, and derailleurs are impossible. To double the number of gears on the *Strida*, in 2010 Florian Schlumpf adapted his successful *speed gear* bottom bracket design from the 1990's and added a large belt drive crank wheel. The *Schlumpf* uses the 1938 *Wanderer* heel button shift concept, with a thin external epicyclic 2 speed of very wide ratio (1.00 1.65), cleverly engineered to fit most existing bike frames. A very large sun gear is needed to get the high step-up ratio (see photograph of internals below). I bought and fitted a *Schlumpf* in 2011, to up the ratios on my 2009 *Strida* from a single 54" to 40"/66" – improving the speed of the daily commute to work over rolling terrain. Though expensive to buy, the Swiss *Schlumpf* was beautifully designed and manufactured.



Strida version of the Schlumpf, note **golden** shift button



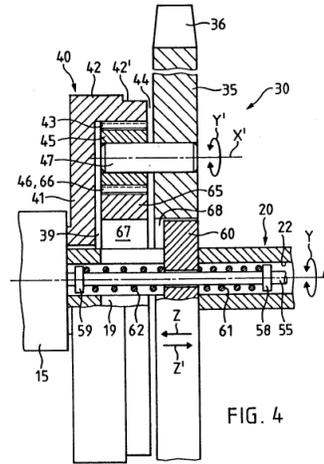
Schlumpf epicyclic internals (huge sun gear) and heel shifter<sup>14</sup>

I put 8,000km on the *Schlumpf* with no issues, unlike the welded aluminium *Strida* frame which eventually fatigued through at two different locations. The *Schlumpf* heel button was fast, easy to use and reliable, with a clear visual cue of high and direct gear.

There was also a licensed clone of the *Schlumpf Strida* gearbox at the same time, made in Taiwan by *ATS*, and fitted to the *Strida MAS* as OEM two speed equipment by the current manufacturers of the *Strida*, *Ming Cycle*. *Ming Cycle* are based in Taiwan's bicycle manufacturing centre, Taichung, on the West Coast, about 150km SW of Taipei. The *ATS* 2 speed did not fare as well as the original *Schlumpf* 2 speed in the reliability stakes, to judge by comments on the *Strida* owners website.



The author's Schlumpf 2 speed Strida, after frame weld failure

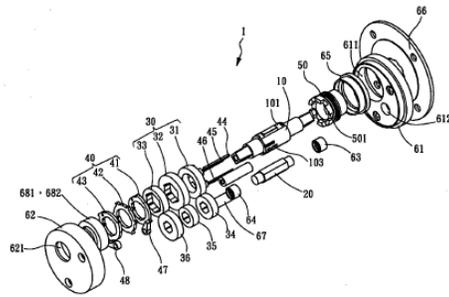


Schlumpf 2 speed bottom bracket gear, heel shifter<sup>15</sup>

Ming Cycle then contracted with Sun Race Sturmey-Archer (also now in Taiwan) in 2012 to design and produce a special 3 speed bottom bracket gear for the *Strida Evo*, the KS3. This uses back-pedaling to effect a gear shift, in the style made familiar by Mutatec in 1938, as in 123-123 etc. It is not an epicyclic, rather it uses tiny spur gears and a layshaft inside the enlarged bottom bracket housing on the *Strida*. The overall range of 159% is less than with the previous Schlumpf two speed (165% range), though with an intermediate gear. Ratios are 0.79 1.00 1.26. Long term reliability will take a few years to judge.



Sun Race Sturmey-Archer KS3 3 speed bottom bracket for Strida<sup>17</sup>



Exploded view of Sturmey-Archer KS3 spur gear trains<sup>18</sup>

So, in a sense, the *Strida* has brought back the 1930's heyday of production bottom bracket gears. Not bad for a bicycle that started out as an Art School thesis project in London 30 years ago.

**The bottom bracket gear may be sleeping, it is not gone..**

### Acknowledgements:

I am indebted to Raymond Henry for bringing the French bottom bracket gears to my attention, to Mary Weller for translating sections of the 1933/1942 German book *Der Fahrrader Mechaniker* (reprinted 2012), and to Una Brogan for alerting me to the Magnat-Debon that she saw near Pernes-les-Fontaines. Lastly Endre Varsa (Hungary) has been a great resource on bottom bracket gear bicycles, supplying information from his own collection and museums.

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22. Photograph and information supplied by bottom bracket bicycle collector Endre Varsa of Hungary.