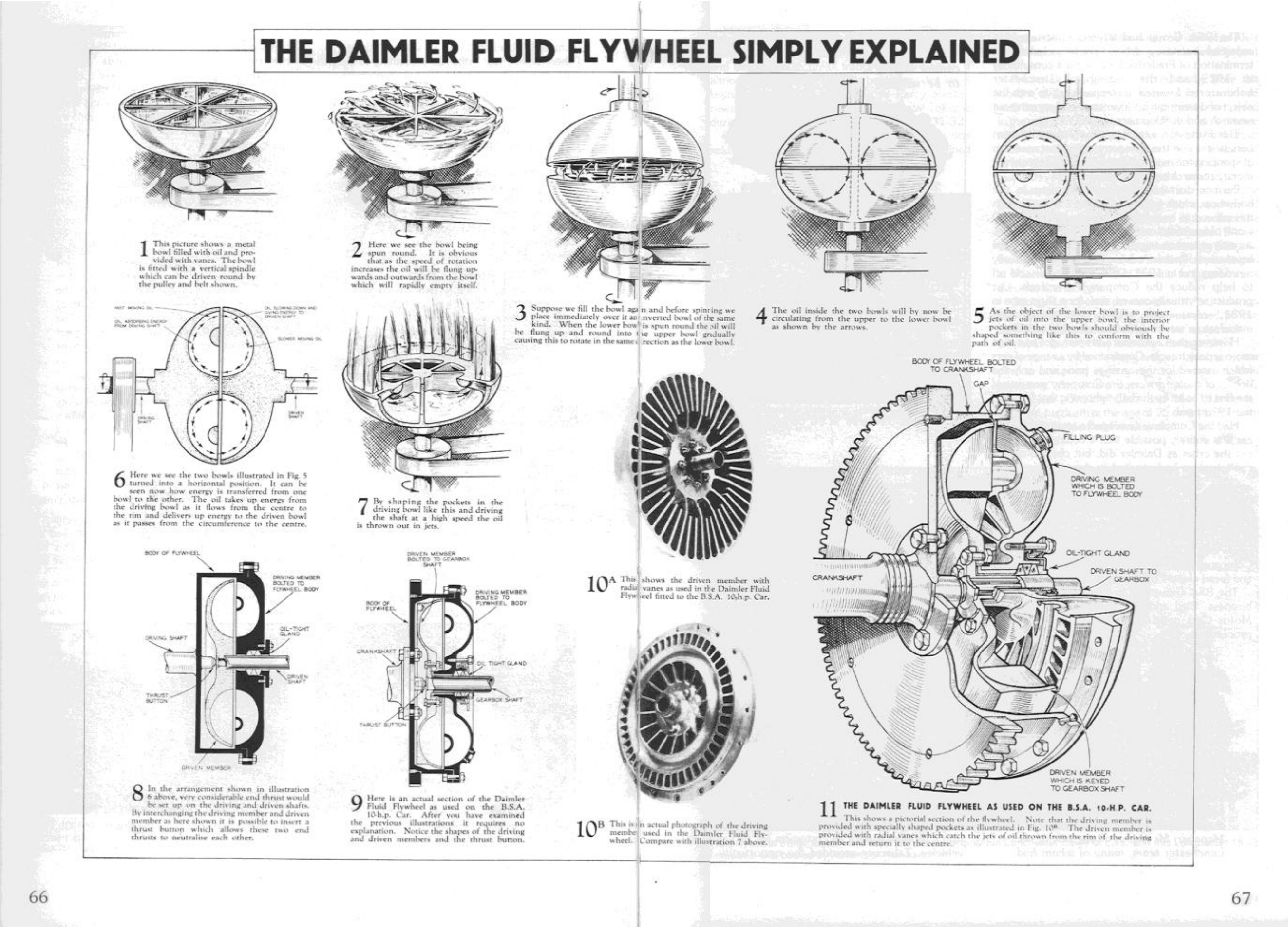
The Daimler Ferret fluid flywheel

A fluid flywheel is a hydrodynamic device for transmitting rotating mechanical power as an alternative to the flat-plate mechanical clutch widely used in cars and commercial vehicles. A similar hydrodynamic appliance is the torque converter which is effectively a gearbox, increasing torque producing (unlike a conventional gearbox) a continuously variable reduction in speed.

The key characteristic of a torque converter is its ability to multiply torque when the output rotational speed is very low, thus providing the equivalent of a reduction gear. The torque converter has an additional component, a stationary member called the stator. A simple fluid coupling can almost match rotational speed but it does not multiply torque. Both the fluid flywheel and the torque converter share common elements: the driving and driven members, attached to the engine and gearbox respectively, have no direct contact with one another. The Ferret uses a fluid flywheel and not a torque converter.



Download this Figure here, and the operational description from the Wheeled Vehicles EMER V622 here.

The flywheel comprises a sealed chamber filled with hydraulic fluid (typically OM13 ISO10 light oil. ISO15 Shell Tellus Tx15 can also be used) containing an impeller (the pump) driven by the engine and a turbine connected to an output shaft. The impeller is a toroid disc connected to the engine's crankshaft. The fluid flywheel is completely automatic in action. The bowl-shaped rear casing, facing forward, is the driving member which completely encases the driven member. The turbine situated at the rear of the flywheel nearest the engine and attached to the input shaft of the gearbox, is the driven member. Sectioned and exploded diagrams can both be downloaded here.

As the oil spins upwards and around in a toroidal motion it takes the energy from the driving turbine as it flows from the centre to the rim, delivering energy to the driven member as it passes from the circumference to the centre. By shaping pockets in the driving bowl or pumping turbine, the oil is thrown out as jets at high speed into the driven member. This impact, directed at a tangent, causes the driven member to turn in the same direction as its neighbour. The fluid flywheel forms a flexible coupling between the engine and gearbox, transmitting power from zero at tick-over; 90% transmission at 1/3rd full speed [1,500 revs/min] to 98% at full power.

Despite the efficiency loss, moderate slippage of the coupling provides a smoother, more even flow of power by absorbing engine and powertrain vibration, rather than allow it to be transmitted to the output shaft or surrounding equipment. Fluid couplings therefore give a very smooth drive take up, reducing shock loading on the gearing, drive-train and prop-shafts; they exhibit virtually negligible wear. As such fluid flywheels are ideal for accelerating heavy loads from rest smoothly without any operator skill. They are ideally suited to armoured vehicles, and ships for which Hermann Föttinger's original design was manufactured.

The design was adapted for buses by Harold Sinclair in the 1920's to prevent lurching when changing gear. By 1933 it was adopted by Daimler in conjunction with the Wilson self-changing gearbox for their flagship cars and military vehicles. Fluid flywheels require very little maintenance apart from a periodic oil change. They are excellent for short stop/start work if used in conjunction with a full epicyclic gear train, such as exists on the Ferret.

If the speed of the impeller is very low, such as at idle speed for an automobile engine, the torque exerted on the turbine output shaft will not be enough to overcome the shaft's inertia, allowing the shaft to remain stationary without stalling the engine and eliminating the need for de-clutching. Engagement of the different gears through the drive-train in any vehicle fitted with a fluid flywheel has to be by brake bands, hence the particular design of the Ferret gearbox.

Although flat-plate clutches have no inherent slip, give better fuel consumption and allow engine braking to be used to slow the vehicle, they do have a significant disadvantage. Mechanical friction clutches are not very good for moving heavy equipment, since overcoming the inertia from a static position creates a lot of heat due to clutch slip. These flat-plate clutches are very prone to heat failure - particularly with heavy vehicles and require some form of actuation either by the driver or a transmission unit. Fluid flywheels have therefore found favour with marine vessels, heavy tractors & armoured vehicles (everything from the Daimler and AEC armoured cars, through to the Dingo and the CVR(W) Fox) particularly where smooth driving with minimal wear is important and fuel economy is not a primary concern.

Because some of the kinetic energy imparted to the fluid is lost to friction (raising the temperature of the fluid rather than causing motion within it), the driven turbine in a fluid flywheel always slips (rotates slower than the pumping impeller), particularly at very low speeds. Never leave the Ferret running in gear while stationary for a period as the fluid flywheel oil will overheat. The following will cause excessive slip:

- **Don't pump the accelerator while the vehicle is standing in gear with the engine running!**
- **Don't drive on heavy ground in too high a gear**
- **Don't use too high a gear when some obstruction is retarding the vehicle or forward progress**

The greatest amount of heat is generated on starting from rest. Natural convection and conduction through the casing dissipates the small amount of heat generated during normal working through the drive-train. If the engine races in all gears, the most likely cause is low oil level in the fluid flywheel, possibly because the over-heated oil has burst through a hub seal and evaporated – a tell-tale is white acrid smoke. The routine service schedule is here. The fluid level in the flywheel was to be checked after the first 500 miles, and every 1000 miles/3 months thereafter.

It is very difficult to drain the fluid flywheel *in situ* without pulling the engine and gearbox out. Removal instructions from the Field Repair EMER are given here. The oil capacity is about 9¾ pints which will flood out all through the base of the vehicle before any can be drained from the hull.

YouTube videos:

United States Army fluid flywheel explanation = https://goo.gl/y99bAc
Daimler armoured car engine and driveline details = https://goo.gl/BbzNoo