

Spinning an historical yarn about Power-Take-Off shafts

By Dr Graeme Quick

Over the centuries, there have been many types of drive systems on wind, water, steam or horse-powered stationary power. Getting rotary power from the prime source to another machine has particularly challenged inventors from the horse through to the tractor era.

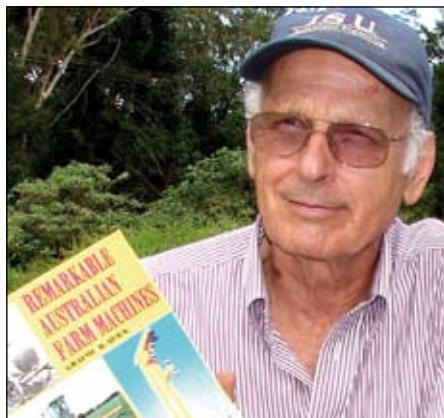
The medal for the very first recorded power take-off on a piece of mobile machinery on the other hand ought to go to an Aveling and Porter Bell-type reaper. This steam-powered outfit was put on show at the 1878 Universal Exposition in Paris.

An artist's drawing (below) of that outfit clearly shows a front-mounted reaper ahead of the steam traction engine, with the reaper live-powered by a system of chain drives from the steam engine – that's a Power Take-Off!

On the other side of the Atlantic – and at around the same time – there were American combine-harvester builders who piped steam from the boiler of the primary traction engine by flexible hose to an auxiliary steam engine mounted on harvesting machines.

This was a 'live steam PTO'. George Stockton Berry did it first in California. He was also the first in the world to build a self-propelled combine harvester. That was in 1883.

Berry was shrewd enough to utilise the crop straw as fuel for the steam boiler. The threshed straw of this self-fuelled machine was discharged from the separating section of the combine onto a chute, then delivered to a trailer platform adjacent to the



Graeme Quick.

boiler where it was stoked into the boiler grate for fuel.

A supply of straw would be stacked on the trailer rack at night ready for the 30-minute task of getting up steam the following morning. As the rack filled up during the day's harvest, any excess straw beyond what was needed for the boiler was dumped onto the ground. These straw dumps were then used later as fuel for the same traction engine when it was disconnected from the harvester and used for tillage.

Why save the straw? Well, wood and coal were scarce in the Benicia district of California and fossil fuels were yet to come in the 1880s.

So that was how a steam PTO worked on a harvester.

DEVELOPMENT OF THE TRACTOR PTO

The French got there first! Arguably, the first tractor PTO was on the French Gougis tractor in 1907. In 1919, the In-

ternational Harvester Company (IHC) began experimenting with PTO-equipped International 8-16s, and in 1921, the PTO became available on special order for Model 15-30.

The 1924 Farmall 'Regular' had the PTO as an integral part of the tractor's design.

The 540 rpm PTO standard

As manufacturers saw the advantages of the PTO, standardisation of PTO shaft rotation speeds, coupling size, and splining became essential. The American Society of Agricultural Engineering (ASAE), set up a committee with representatives from tractor manufacturing companies with the mandate of establishing a PTO standard so that tractors and implements from different manufacturers would be interchangeable and readily connectable.

It took about five years to become reality, but by 1931 ASAE had mediated a standard for the PTO that could be applied to any implement.

There was much discussion about the best PTO speed. It eventually shook out at 540 rpm on that first PTO standard (now ASAE Standard S203.14).

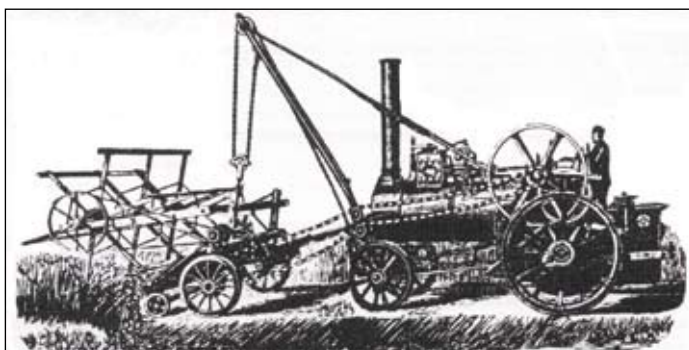
But why 540 rpm?

The ASAE committee worked at great length to develop a standardised PTO. Their mandate required various features to be standardised:

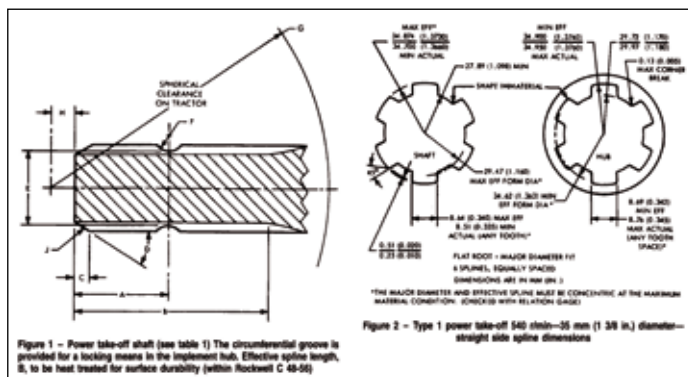
- Shaft rotational direction;
- PTO size, shape, and location; and,
- PTO speed.

Several PTO speed options were raised.

Some may have thought that 525 rpm



Aveling and Porter had a transmission drive PTO on an 1876 Bell-type reaper in England.



Excerpt from ASAE Standard S203.14 regarding the 540 rpm PTO.



A Kubota tractor powering a macadamia orchard spray unit through the PTO at Wamuran, Queensland.

would have been a good choice because of the denominator in the classical horse-power equation:

$$\text{BHp} = \frac{\text{Torque (lb.ft)} \times \text{Speed (rpm)}}{5250}$$

So if 525 rpm had been chosen, horse-power at the PTO would simply be torque (in lb.ft) divided by 10 – very convenient for the bloke on the dynamometer.

Machines most needing PTOs

While this standard was being devised in the 1920s, trailed mowers, binders and grain harvesters were in most need of a PTO.

The fastest shaft speed on those machines was typically the sicklebar, which operated at 500 to 600 rpm at normal forward travel speeds.

Trailed machines at the time were ground-driven by a bull-wheel which would slip under adverse conditions. The need for a drive that was related to the tractor's engine speed instead of ground conditions was apparent.

So in 1927 the ASAE committee adopted the first PTO standard:

- The shaft would rotate clockwise and run at 536 +/- 10 rpm.
- The output shaft would have six splines

and a diameter of 1 3/8 inch (35 mm) and may be considered for tractors up to 87 Hp (65 kW).

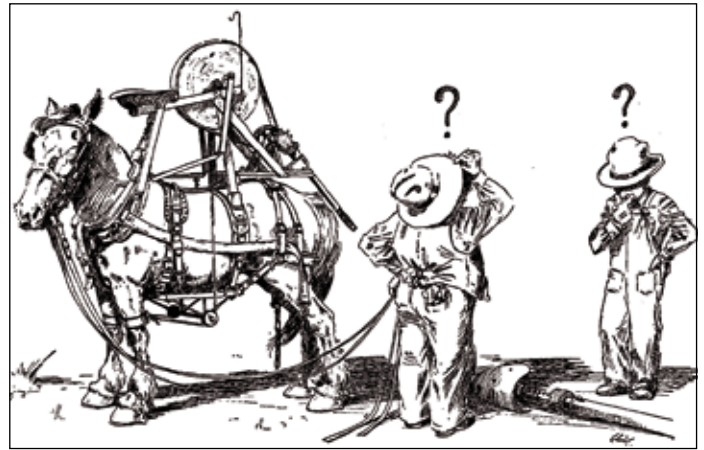
In 1958, an additional standard to apply to higher power applications was adopted for a 1000 rpm PTO. At the same time the original PTO speed was rounded off at 540 rpm. The two newer 1000 rpm specifications would differ in shaft size – the larger with 20-spline, 1 3/4 inch (45 mm) diameter shaft to suit tractors up to 255 Hp (190 kW) – the smaller with 21-spline 1 3/8 inch (35 mm) diameter shaft for tractors up to 160 Hp (120 kW).

All three types would rotate counter-clockwise when viewed from the tractor seat.

Live PTOs and not so live!

In a tractor with a transmission-driven PTO, the PTO is driven directly from the transmission – the PTO is disengaged by the tractor's clutch. This configuration is simplest, but whenever the tractor forward motion slows, so does the PTO.

That arrangement often requires an overrunning clutch to disengage the PTO – if the PTO is rotating faster than the transmission, a PTO-driven attachment with high inertia would move the tractor.



Debate still raged about whether the tractor could replace the horse in 1928 when IH produced a booklet "Muscles or Motors" to help persuade customers.

That's a definite hazard.

Tractors with a live PTO on the other hand, have a two-stage clutch. Pressing the clutch pedal half-way will disengage the transmission, pressing it fully will disengage both transmission and PTO. This configuration allows the operator to slow down or change gears while the PTO is still running.

The third type is the independent PTO, which has a separate PTO clutch. As with a live PTO, this allows for full control over the tractor while separately controlling the PTO.

Independent PTOs may have mechanical, electric or hydraulic engagement.

The most recent PTO standard is that for compact tractors and mowers, namely the 2000-rpm PTO, for tractors up to 27 Hp (20 kW). Finally, there are front PTOs in the same power ranges.

Be thankful, but cautious

A tractor is only as useful as the equipment that's hitched onto it. The PTO has truly made tractors the all-round farm workhorse. But make sure the PTO is appropriately shielded – many people have been seriously injured or killed by unshielded PTOs. ■

Charlton's

tackle 'n' bait

Specialising in...

Rods, Reels, Tackle, Lures, Fly, Soft Plastics,
Electric Motors, Sounders, Handheld GPS,
PLUS GREAT SERVICE and ADVICE

18 KERWICK ST REDBANK Q 4301
Fax: 3818 1153

Ph: 3818 1677

MAIL ORDER WELCOME

ALL MAJOR CREDIT CARDS