A Customized Tractor for Controlled Traffic Farming on Small Farms

By:

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Since the early 1990s in Australia, a gradually increasing area of grain crops has been managed under a production system where the high powered tractors, large harvesters and heavy trucks all have the same track settings of either 2m or 3m. This has allowed them to operate on permanent pathways, a practice known as "Controlled Traffic Farming" (CTF). The area has now expanded to around 5 million acres (2M ha) and the 3m track setting is becoming the accepted standard. In the field, the width of the combine harvesters and planters are matched at perhaps 9m, allowing the 3m tracks to be centrally spaced at the same distance and for chemical booms to be a multiple of this at 27m for example (Fig. 1).

The advantages are that the tractor can be less powerful because the wheels run on packed soil while only minimum or no tilling is required on the non-compacted beds in between. Neither is there any need to subsoil every few years; water penetration is better, there are no ruts or ridges left over from previous operations, the fuel saved is substantial and the crops are much larger because of the zero compaction. Further explanation, in detail with the cost savings, can be obtained on the internet site www.controlledtrafficfarming.com and the ASABE paper noted in the references.

How can the small farmer benefit from CTF in the production of vegetables, fruit, nuts, flowers, seeds and bulbs, etc.?

First his or her tractor should be low powered (no higher than 45kW) and should use as many production parts as possible from current conventional tractors to keep the price low. It should be easily adjusted from the tractor seat for road and field use and vice versa. It should not be too wide in order to enable the Cat. II three-point hitch to handle the many mounted implements already in use. A maximum width of soil bed between the tracks of 3.66m should be satisfactory with a wheel track setting of 4.27m in the field.

Fig. 1. A typical Australian-style controlled traffic farming system with all 3 m track widths.

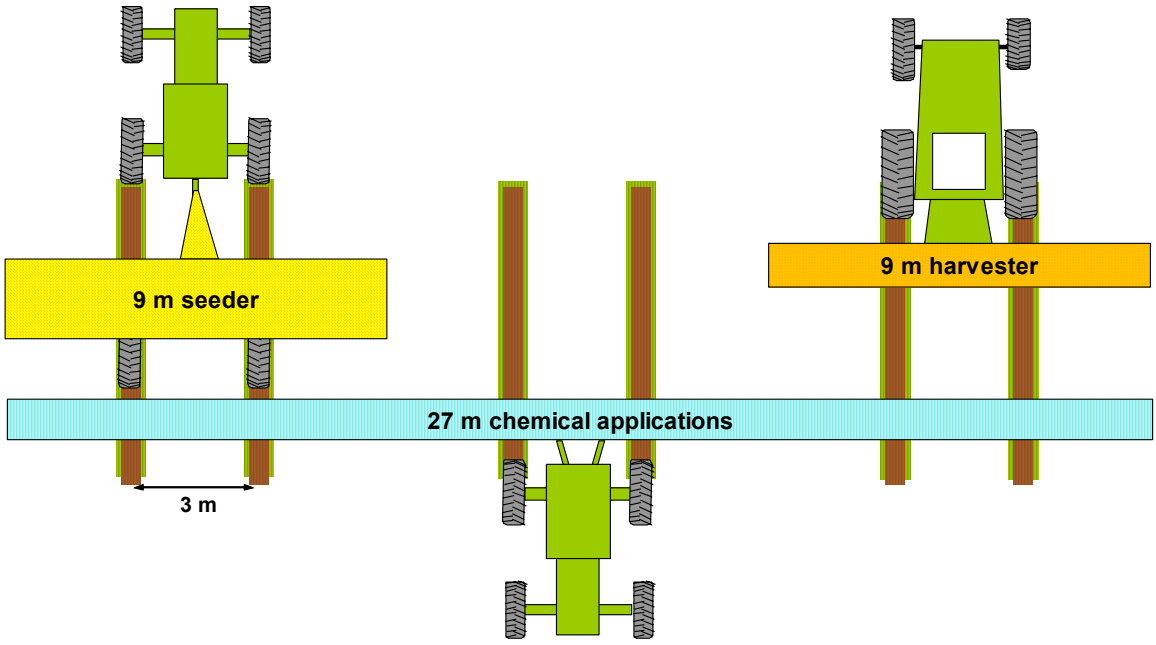
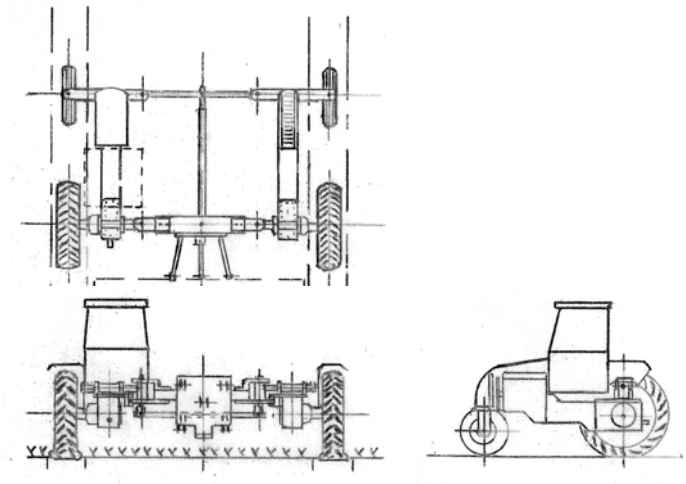


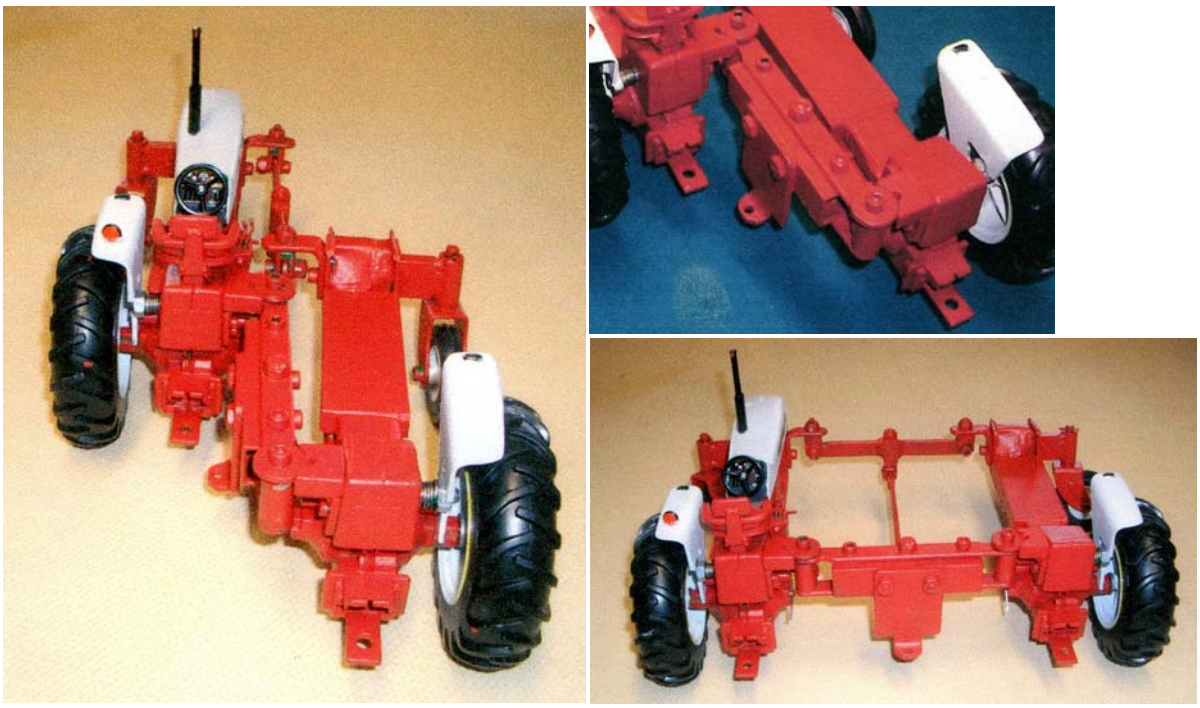
Fig 2 shows a plan, side and rear view of a tractor which meets the above specifications in the field configuration. It consists of a control unit on the left and a slave unit on the right. The control unit is basically the same as a typical production tractor consisting of an engine, transmission, rear axle assembly and sheet metal etc. One front wheel and one rear driving wheel have been removed including the fender, axle shaft, bell housing, planetary driving gear set, differential gears, differential lock and brake. A means is provided to connect the remaining planetary gear set to the differential housing in order to drive the remaining rear wheel. A cast plate replaces the bell housing and holds the bearing cup which supports the differential housing. The hydraulic lift housing is removed but both the power take-off (PTO) and the drawbar are retained.

Fig. 2. Plan, rear and side view of a tractor tailored to controlled traffic farming



The slave unit consists of a transmission and a rear axle assembly which drives one wheel of the opposite hand to the one in the control unit. The PTO and the hydraulic lift are not required but the drawbar is retained. It also has only one front wheel (of the opposite hand to the one on the control tractor) and is rigidly supported by side channels protruding forward from the transmission housing. These also carry ballast weights to make the slave drive unit equal in weight with the control unit. Fig. 3 shows a 1/16 scale model of the tractor in both the field and road configurations.

Fig. 3. A 1/16 scale model of the controlled traffic tractor showing it in road configuration on the left, field configuration on the right and folded detail top right



Single front wheels can be used because they run on packed soil making front wheel assist drives unnecessary. They also are easier to turn through greater angles when Helac hydraulic rotary actuators (www.helac.com) are used and controlled with a steering wheel. Freely mounted castor wheels can allow steering through transmissions controlled by levers similar to those of zero-turn lawn tractors.

The transmissions in the control and slave units are either hydraulic with a pump(s) and motor or electric with a generator(s) and motor. The transmissions must be able to share the engine power equally between the control and slave units, the latter being driven from the control unit through hoses or cables.

The control unit and the slave unit are joined together with a cross beam at their rear ends and a smaller cross beam at the front end. The rear beam has horizontal pivots at both ends to allow the two units to articulate with each other on uneven ground and vertical pivots to enable the beam to turn through 90 degrees (in the plan view), when changing the track from the field position to the road position and vise versa. The vertical pivots are integrated with Helac hydraulic rotary actuators (www.helac.com) which assist when

the track is changed and which locks the beam rigidly in position in both the field and road positions (see Fig. 4 below).

Fig. 4. Details of the vertical pivot which enables the beam to turn through 90 degrees when changing the track from field to road configuration

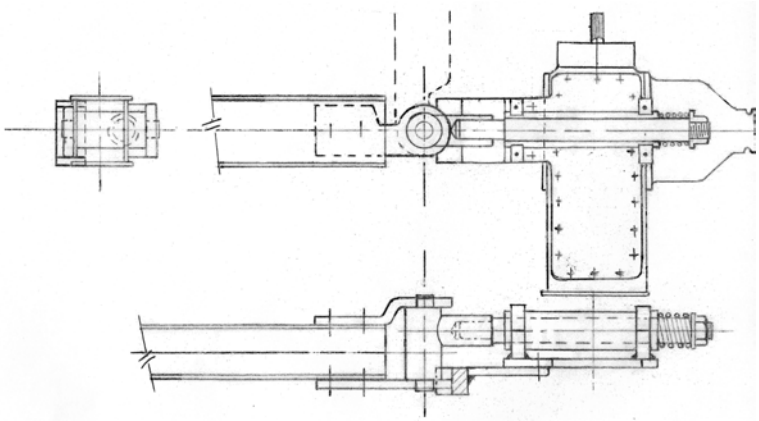
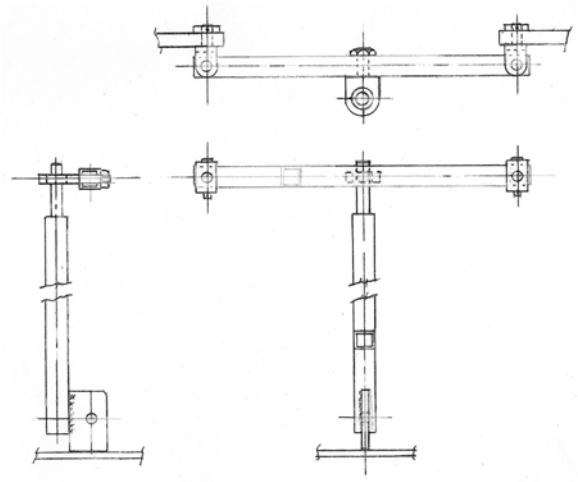


Figure 4 also shows how on an actual tractor, as compared to the model, the horizontal pivots can be connected to the control unit and the slave unit with sleeves which allow the beam to be lowered into position on to two half bearing blocks attached to a plate which is bolted to the opening on top of each rear axle housing, formally covered by the hydraulic lifts, and then held in place with two half bearing caps. The horizontal pivots are spring loaded against the outer ends of the sleeves longitudinally in order keep the lower plate, which has a circular end attached to the rear cross beam, firmly in contact with the mating circular cut-out attached to each rear axle housing. This arrangement keeps the two driving units upright when the track is being changed and also allows the two units to articulate with each other in the road position.

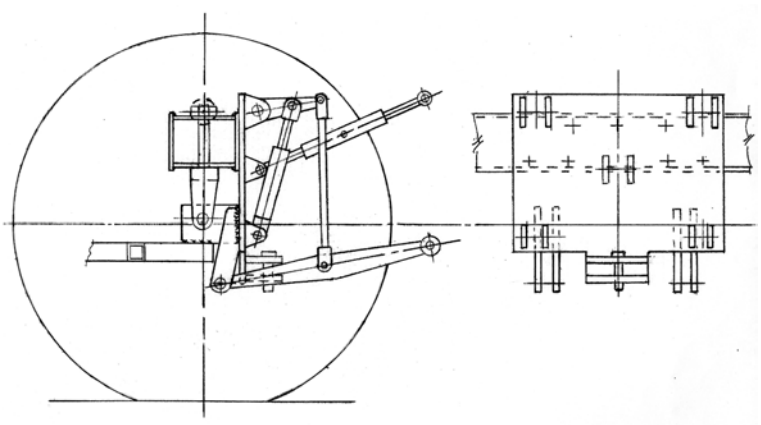
The front cross beam is attached to each driving unit with vertical and horizontal pivots to allow for articulation and to maintain them parallel to each other when the beam is rotated through 90 degrees to change the track. The front beam also reacts to vertical loads at its center from a torque arm attached to the rear cross beam (Fig. 5).

Fig. 5. Detail of the torque arm attached to the front and rear cross beams



This transmits the torque from an implement attached to the three-point hitch evenly between each drive unit. The three-point hitch and drawbar are mounted on a steel plate bolted to the rear of the cross beam so that, in the field position, its front face makes contact with the rear end of the torque arm. This makes the torque arm and the rear cross beam revolve as one unit in the field position and to be no longer effective when rotated through 90 degrees in the road position, so allowing the arm to oscillate at its horizontal pivot on uneven ground. See Fig 6 below.

Fig. 6. The three-point hitch and drawbar are mounted on a steel plate bolted to the rear of the cross beam. The torque arm rigidly attached to this unit and running forward to the front beam therefore rotates with the rear cross beam as one unit when in the field configuration. As the unit is rotated through 90 degrees into the road configuration, the torque is disengaged allowing the arm to oscillate at its horizontal pivot on uneven ground



To comply with the road regulations in different countries the control unit with the cab and the slave drive unit can be interchanged during manufacture. The cab can also be mounted on the slave unit so that it can be easily rotated 180 degrees for forward and reverse operations.

When the tractor is shipped from the place of manufacture to the dealer or farmer the two cross beams and the torque arm can be shipped separately. The control unit and the slave drive unit are connected together with a short round slave shaft allowing it to be driven onto a truck etc. See Fig. 7 below.
When the front wheels are steered with hydraulic actuators, only the control unit is used to drive and steer the tractor on the road. The rear axle on the slave unit is disconnected from the transmission and is free to turn (because there is no differential), and the front wheel on the slave drive unit is fixed in the straight ahead position. The track is a maximum of 2.69m, legally suitable for most roads.

Should the tractor be used permanently in the fields and never driven on a road, neither the vertical pivots on the rear and front cross beams nor the hydraulic rotary cylinders which operate the rear cross beam, are required. Should this situation arise the tractor would most likely use the transmissions for steering in the field with front wheels that castor.
PTO driven implements are powered from the PTO drive on the control unit.

Fig. 7. After removing the cross beams and torque arm, the control unit and slave drive unit can be connected together to provide a shipping configuration for the controlled traffic tractor

The method of construction of the tractor makes it easy to adapt existing designs of high clearance tractors should there be the need for such a vehicle.

Increasingly, Australians and others are using satellite guidance and auto-steering systems to set out the controlled traffic tracks and to find them again when tillage or drilling operations have covered them over. While expensive, satellite guidance can easily pay off on the larger properties and costs are decreasing now that a larger number of systems are being sold. (www.controlledtrafficfarming.com)

When an implement is too heavy or large to be operated on the three-point hitch, such as a harvesting wagon, it can be pulled by the tractor by attaching it to BOTH drawbars of the two drive units and using castor wheels to run on the controlled tracks. This makes the implement revolve with the tractor during turns in almost the same space as mounted equipment. This cannot be done with a single hitch on a conventional tractor. For road use the trailer can be pulled from a hitch attached to one of its narrow sides.

References:

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Acknowledgements

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Addendum

John Foxwell is seeking an interested party to take on the production design and manufacture of this invention. Please contact him direct through his e-mail at the front of this article.