Eight tractors in the 35-45 h.p. class. Part 2

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G. H. Vasey

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EIGHT TRACTORS IN THE 35-45 HP CLASS

Summary report of tests on tractors in the 35-45 h.p. class by the Australian Tractor Testing Committee, based on Tractor Tests Nos. 38 to 45.

by

W. F. BAILLIE and G. H. VASEY
Department of Agricultural Engineering
University of Melbourne
April 1967

PART 2

Fuel consumption

All the models in this series had diesel engines. Two distinct types of diesel engine may be distinguished, the choice of which by the manufacturer largely decides the questions of fuel consumption and fuel economy. These are the direct injection type which uses a spray nozzle injecting fuel directly into a combustion chamber formed in the piston crown, and the indirect injection type which uses a pintle nozzle injection fuel into a pre-combustion chamber formed in the engine block or head. The direct injection system is inherently more economical in fuel than the indirect system as illustrated in Table 4, and requires no special starting aid.

<table>
<thead>
<tr>
<th>Test No.</th>
<th>Direct or Indirect Injection</th>
<th>Fuel consumption (gal./hr)</th>
<th>Specific fuel cons. (lb./h.p.-hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>At full load/ rated speed</td>
<td>At varying loads from 10 hr test</td>
<td>At best economy</td>
</tr>
<tr>
<td>38</td>
<td>I</td>
<td>2-3</td>
<td>1-8</td>
</tr>
<tr>
<td>39</td>
<td>D</td>
<td>1-8</td>
<td>1-4</td>
</tr>
<tr>
<td>40</td>
<td>I</td>
<td>2-9</td>
<td>2-1</td>
</tr>
<tr>
<td>41</td>
<td>D</td>
<td>1-9</td>
<td>1-5</td>
</tr>
<tr>
<td>42</td>
<td>I</td>
<td>2-3</td>
<td>1-9</td>
</tr>
<tr>
<td>43</td>
<td>D</td>
<td>2-3</td>
<td>1-7</td>
</tr>
<tr>
<td>44</td>
<td>D</td>
<td>2-0</td>
<td>1-6</td>
</tr>
<tr>
<td>45</td>
<td>D</td>
<td>2-1</td>
<td>1-6</td>
</tr>
</tbody>
</table>

The table shows the full load fuel consumption from the engine tests, and the average fuel consumption that was recorded over a 10 hr drawbar test consisting of four 2½ hr sessions at 45 per cent., 60 per cent., 75 per cent. and 90 per cent. load, representing a typical hard days work.

Fuel consumption (lb. or gallons per hour), since it does not take into account the differing power outputs of the various tractors, does not clearly show the difference between the two systems; a better measure is Specific Fuel Consumption, that
is, the ratio of fuel consumption to power output, lb. per hour per hp output, usually written lb/hp-hr.

The specific fuel consumption of an engine, or fuel economy as it is sometimes called, varies not only with its design as mentioned above, but for a given design varies with load and speed; the pattern of this variation for a given engine is of considerable technical interest, and is best shown by a graph as in Fig. 3 in the full Technical Reports of tests. For this summary, it will be sufficient to compare the models at the combination of load and speed where each gives its best economy. This is usually at about 80 per cent of full load at about 3/4 of rated speed.

From Table 4, the three indirect injection models (Nos. 38, 40, 42) at best economy average 0.45 lb. of fuel per shaft hp-hr; the direct injection models (Nos. 39, 41, 43, 44, 45) average 0.39 lb./hp-hr. That is to say, the direct injection types are some 13 per cent, more economical on fuel than the indirect injection engines.

As it happens, fuel consumption is not usually regarded as of much concern with small general purpose farm tractors. Generally their load factor is small and the annual hours of work are few, so that fuel does not become a large item in the annual operating costs. Nevertheless, a difference of the order of 13 per cent on fuel bills spread over the life of the tractor could add up to $200 or so.

**Drawbar performance**

The field drawbar performance of a tractor is highly variable. It depends on the soil—its state of cultivation or vegetative cover, its moisture content; it depends on the tyres—their pressure and their tread pattern; and on the tractor weight and the distribution of the weight between front and rear axles, on the height of the drawbar, the direction of the pull and on many other factors.

Tractor drawbar tests, done on a hard level test track, give an indication of the best that the tractor can do; any agricultural surface would develop less pull and allow more slip, and hence give less speed and power than the tarmac test track. The purpose of the standardised track and test conditions is to eliminate the variability that would come from ordinary field surfaces and so to permit valid comparisons of one test with another.

Once again the complete drawbar performance of a tractor is best shown in graphs as in the full Technical Report of tests. For the present purpose we may compare some points taken from these graphs, and quoted in the Abridged Reports of tests.

**Table 5.—Drawbar performance at maximum recommended weight**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>39</td>
<td>33</td>
<td>3</td>
<td>3-5</td>
<td>3,600</td>
<td>4,500</td>
<td>5,750</td>
</tr>
<tr>
<td>39</td>
<td>28</td>
<td>3</td>
<td>3-2</td>
<td>3,300</td>
<td>4,000</td>
<td>5,190</td>
</tr>
<tr>
<td>40</td>
<td>36</td>
<td>3</td>
<td>3-7</td>
<td>3,650</td>
<td>4,400</td>
<td>5,110</td>
</tr>
<tr>
<td>41</td>
<td>31</td>
<td>5</td>
<td>3-8</td>
<td>5,100</td>
<td>3,600</td>
<td>5,660</td>
</tr>
<tr>
<td>42</td>
<td>32</td>
<td>2</td>
<td>4-5</td>
<td>2,700</td>
<td>4,600</td>
<td>5,990</td>
</tr>
<tr>
<td>43</td>
<td>38</td>
<td>3</td>
<td>4-0</td>
<td>3,550</td>
<td>5,500</td>
<td>6,630</td>
</tr>
<tr>
<td>44</td>
<td>35</td>
<td>4</td>
<td>4-7</td>
<td>2,850</td>
<td>5,000</td>
<td>6,170</td>
</tr>
<tr>
<td>45</td>
<td>36</td>
<td>3</td>
<td>3-5</td>
<td>3,800</td>
<td>5,100</td>
<td>4,970</td>
</tr>
</tbody>
</table>

* The gear giving nearest to 4 m.p.h. at full power.

It should be remembered that the drawbar performance shown for the Fiat 415 (40) represents the engine running at rated speed (2,500 rpm). As mentioned earlier this should be regarded rather as a reserve speed (for example, fuel consumption is high at this speed). At a more practical engine operating speed, say 2,200 rpm, the drawbar power for this model would be about 33 hp.

Similarly for the John Deere 1010 (442), the road speeds for the various gears would be more practical at 1,900 engine rpm as determined by the stop on the governor lever; at this speed the drawbar power would be about 28 hp. Making these allowances the same two sub-groups emerge as were noted in the comparison of engine powers.

Included in the table also is the maximum pull obtained in the lowest gear. This is not a particularly useful index, though much is sometimes made of it in advertising. It has been included here simply to make the point that tests which permit unrealistic amounts of added ballast tend to show pulls far in excess of these values and should be disregarded. Under the Australian test rules, which limit ballast to the maximum the manufacturer recommends for normal field use,
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the figures in the table are the best test-truck pulls; they may be approached, but will never be realised by the tractor in any normal field situation.

**Gear ratios**

Another matter about which information is obtainable from the drawbar tests is the spread of gear ratios provided, and the travel speeds covered by the various gears. This is important in deciding how a tractor matches with the various field jobs for which it is intended. The chart (Fig. 1) depicts some of the features that distinguish the eight models in this series.

In the lower gears (below 3 mph), wheel-slip sets the limit to the pull that can be delivered. Because of the low level travel speed in these gears full drawbar power is not reached even though high pulls are obtainable, the full power of the engine is not called upon. The travel speed at which the greatest power is obtained in these gears is shown by a "spot" on the chart.

In the other gears, at the higher travel speeds lower pulls are obtained though sufficient to bring the engine to full power and even to lug it down to its stalling speed. For these gears, the "spot" on the chart indicates the travel speed at which the engine gives full power, while the line to the left indicates the range of travel speeds over which the engine may be lugged down to the speed at which it gives its maximum torque.

If the engine is already delivering full power at is rated speed, any further increase in drawbar load on the tractor will cause the engine speed (and so the travel speed) to fall, while the torque output of the engine rises to meet the extra load; this is what is known as "lugging." All the models in the series had satisfactory lugging characteristics.

Lugging can be continued down to the engine speed where the engine gives its maximum torque (usually at about 3/4 of rated speed), but no further or the engine will stall. In practice few operators would go quite this far, and few manufacturers would recommend it for any length of time.

After the engine has been lugged down towards maximum torque, the only way in which further load increases can be met is to change to the next lower gear.

<table>
<thead>
<tr>
<th>Test N°</th>
<th>Travel Speeds in Working Gears (miles per hour)</th>
<th>Road Gears (m.p.h.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>38</td>
<td>0 1 2 3 4 5 6 7 8 9</td>
<td>11,15</td>
</tr>
<tr>
<td>39</td>
<td>0 1 2 3 4 5 6 7 8 9</td>
<td>12,18</td>
</tr>
<tr>
<td>40</td>
<td>0 1 2 3 4 5 6 7 8 9</td>
<td>15</td>
</tr>
<tr>
<td>Standard</td>
<td>1 2 3 4 5 6 7 8 9 10</td>
<td>10</td>
</tr>
<tr>
<td>Multipower</td>
<td>1 2 3 4 5 6 7 8 9 10</td>
<td>12,17</td>
</tr>
<tr>
<td>42</td>
<td>0 1 2 3 4 5 6 7 8 9</td>
<td>13</td>
</tr>
<tr>
<td>43</td>
<td>0 1 2 3 4 5 6 7 8 9</td>
<td>15</td>
</tr>
<tr>
<td>44</td>
<td>0 1 2 3 4 5 6 7 8 9</td>
<td>13,17</td>
</tr>
<tr>
<td>45</td>
<td>0 1 2 3 4 5 6 7 8 9</td>
<td>12,15</td>
</tr>
</tbody>
</table>

Looking at the chart then, the *International A414* (38) with six forward gears in the working range meets these requirements, with some overlap where most tractor work is done, that is, between 3 and 5 mph; *David Brown* (43) achieves the same result with five gears in the working range. For users whose requirements might include slightly faster speeds above 7 mph for example, David Brown offer an alternative version of the model with a slightly faster final drive.

Some criticism can be made of all the others, as follows:

The *Ford 2000* (39) had the obvious weakness of having two gears the same (4th and 5th), leaving an awkward gap between about 4 1/3 and 6 mph. This was rectified on the companion *Ford 3000* (44) which had a true eight speed box; however, it will be seen that this still has two gears unnecessarily close together between 1 and 2 mph, while the spacing is wide from 2nd to 3rd, and from 3rd to 4th. The 2000 now has this gearbox.

The *Fiat 415* (40) has the range from 1 1/3 to 4 2/3 mph covered, but has a wide gap then to the 9 mph 5th gear. Many operations requiring between 5 and 7 mph could...
only be dealt with at reduced governor settings and correspondingly reduced power.

For the Massey-Ferguson 135 (41) the chart shows both the standard gear box, and the added gears provided by the optional “multi-power” fitting as tested. It will be seen that the standard gearbox has a gap between 2nd and 3rd, and wide spacings between 3rd and 4th, and between 4th and 5th gears. The addition of the “multi-power” set (an extra cost of about $140) fills these gaps, but introduces as many as three gears between 1½ and 2 mph, and 3 road speeds, 12, 17 and 22 mph. With “multi-power,” however, the changes between any gear and its corresponding “multi-power” gear can be made “on-the-move.”

The John Deere 1010 (42) shows a well-selected overlapping set of gears though all speeds may be regarded as too high. These speeds however, correspond with rated engine speed of 2,500 rpm; at 1,900 rpm as discussed earlier, a more practical range of speeds would be provided.

The Nuffield 10/42 (45) again shows that a multiplicity of gears in itself does not necessarily provide the best solution; with 4 gears below 2 mph, a wide spacing still remains between 6th and 7th gears, around the important speed of 4 mph. The Nuffield however, is the only one that goes any way towards providing a low low gear (1 mph or less) for slow-speed tasks that might require a large part of the power of the engine to be available through the pto to function a driven machine.

PTO and drawbar (B.S. 1495)

British Standard 1495: 1964 Agricultural Tractor Details has already been mentioned in connection with pto and belt speeds. It covers as well a number of other design details upon which general agreement has been reached in the British agricultural machinery world. Perhaps the most important of these are the dimensional specifications for the drawbar and pto, their location, and the recommended zones of clearance between and around them. Since much local equipment follows British practice the standard is a useful guide.

Though part of the formal test is to check the tractor for conformity or otherwise with this standard, it is not possible to tabulate here all the points covered by it; two important dimensions only will be looked at. These are the height of the pto above the ground and the height of the drawbar.

<table>
<thead>
<tr>
<th>Test No.</th>
<th>P.T.O. Height (in.)</th>
<th>D.B. Height (in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>38</td>
<td>25</td>
<td>18</td>
</tr>
<tr>
<td>39</td>
<td>19</td>
<td>n.a.</td>
</tr>
<tr>
<td>40</td>
<td>22</td>
<td>11</td>
</tr>
<tr>
<td>41</td>
<td>20</td>
<td>14</td>
</tr>
<tr>
<td>42</td>
<td>30</td>
<td>17½</td>
</tr>
<tr>
<td>43</td>
<td>25½</td>
<td>11</td>
</tr>
<tr>
<td>44</td>
<td>19½</td>
<td>n.a.</td>
</tr>
<tr>
<td>45</td>
<td>25</td>
<td>9</td>
</tr>
</tbody>
</table>

The Standard lays down for the pto 21 in. to 26 in. above ground with a preferred height of 23 in. For the drawbar it specifies 12 in. minimum with adjustment up to 18 in. maximum. Included in the clearance requirements is a minimum clearance of 8 in. between the top of the drawbar clevis and the centre line of the pto; this is necessary for the satisfactory hitching and operation of pto driven machines.

Looking at Table 6, the John Deere is exceptional since it is specifically a high clearance tractor; the implements it would be called on to function would be designed with this in mind.

Nos. 40, 43 and 45 come near to full compliance with the specification in providing a full range of height adjustment for the drawbar, with the pto sufficiently high (though still within the specification) to give the recommended minimum clearance over most of the range.

Of the others, Nos. 39, 41, and 44 obviously have the pto set too low to provide adequate clearance with the drawbar even at its lowest setting. This can be said even though the drawbar fittings for Nos. 39 and 44 were not available for inspection. With No. 38, barely adequate clearance is available, and then only at the lowest setting of the drawbar which is 18 in. above ground, the maximum height recommended in the standard.

A close reading of the individual test reports will reveal other points of comparison within the standard.
Three-point linkages (B.S. 1841)

British Standard B.S. 1841: 1951 specifies dimensions and design features for two categories of three-point linkages. Though it is not proposed to tabulate for the various models all the points covered by this standard, it can be said that the linkages on all models conform with the standard, or differ only in minor and unimportant ways from it.

The point of most interest is the facility provided on some models for picking up category 2 as well as the smaller category 1 implements, and providing the specified range of movements to enable both categories of implement to be operated. Nos. 38, 40, 43 and 45 have this dual facility; the others are for category 1 only.

Other features of the various hydraulic systems not covered by the standard may be of interest. In spite of differences in the layout of controls and the variety of colourful descriptive titles given in the operators' manuals to the various functions, all models in the series provide essentially the same three basic functions, which may be identified as follows:

(a) “position control”—a function whereby the lower link hitch points are maintained fixed in position with reference to the tractor.

(b) “draught control” a function whereby the draught of the implement is maintained constant by a built-in response to the compression forces acting in the top link.

(c) provision for external circuits.

Though all models provide these basic functions, some (Nos. 38, 39, 44) provide also means whereby the speed of the upward lift may be regulated; others (Nos. 41, 44 45) provide means whereby the speed at which the implement drops into the work can be regulated. On No. 43 and No. 45 provision is made for regulating the weight transfer from mounted implements fitted with depth wheels. A safety lock for use when working around the implement, or to hold position while transporting, is provided on No. 38 hydraulically, and on No. 43 by a mechanical overcentred catch. The “pressure control” facility on No. 41 was mentioned earlier in section 2.

The relative ease of manipulation and the convenience of the layout of the wide variety of systems of control of three-point linkages are questions for the would-be buyer.

One of the aims of three-point linkage mounting of implements is to make use of weight transfer from the implement to the driving wheels of the tractor as an aid to traction. Part of the formal test is to check the maximum weight transfer obtainable from the linkage. For all models the hydraulic system was capable of transferring more weight than was needed to bring the static weight on the rear wheels up to the maximum ballasted weights used in the tests, showing that the ballast was not overstated. For all but Nos. 40 and 42, application of the hydraulic lift would have to be limited, however, because at full application the recommended maximum rear tyre loads would be exceeded. For No. 45, full application also lifted the front wheels off the ground.

In the light of these tests it can be said that in practice no better drawbar performance could be obtained with weight transfer from mounted implements than the test drawbar performance under full ballast as discussed earlier.

Driver's accommodation and controls

It is not possible at present to put objective measures on many of the features that go towards driver comfort and ease of operation. Our subjective assessment of the various models is made under the following headings according to a scale that runs: Unacceptable, Poor, Adequate, Good, Excellent.

(a) Access: Nos. 38, 41 and 45 we rated as having adequate access to the driver's area; Nos. 39 40, 43 and 44 we thought were good—the designers in setting out the working area for these new models had considerably cleared the access to the tractor. For No. 42 we thought the access was obstructed by the pedals.

(b) Footroom: was considered adequate on all but No. 41 where the footplates were too far below the seat and obstructed by pedals.

(c) Seat: A clear distinction can be made in favour of a seat mounted on a parallel motion linkage as against one
that is rigidly mounted or one that is pivoted. Of the eight models, the two Fords (39, 44) and the David Brown (43) provided a parallel linkage mounting with a torsional rubber spring readily adjustable for the driver's weight. Nos. 38, 41 and 42 have rigidly mounted seats, and rely only on upholstery for shock absorption; No. 40 has the seat pivoted on a leaf spring with a coil spring support adjustable for driver weight; No. 45 has the seat pivoted at the front with a solid rubber support at the rear.

(d) Controls: The preferred location and operation of controls is another matter laid down in B.S. 1495:1964 already referred to. All models except No. 45, whose basic layout probably pre-dates the standard, generally conform to the standard. Exceptions are:

No. 40 has a fuel stop that is not retained in the off position—an unsafe feature.

No. 42 has no latch between the independent brake pedals—again unsafe.

No. 43 has the fuel stop "pull to start" not "pull to stop" as recommended—a possible source of confusion and so of danger.

No. 45, though differing in many respects from the standard, is not inconvenient in its layout, though the differences in themselves might confuse some drivers and so introduce an element of danger.

CONCLUSION

Many other items of information in the individual test reports might be of interest to particular readers, but there is no room to set them all out here.

Sufficient has been said to show that an intelligent study of tractor test reports can provide answers to many of the questions that arise when facing a choice between comparable models. Clearly, there can be no conclusion of the sort “This or that model is best”; each has some points for which it might be preferred, and others on which it might be rejected for a given situation. The overall quality of design, material, and workmanship in tractors, at least in these smaller sizes, is uniformly high.

There remains the important, perhaps over-riding, considerations of price, terms, trade-ins, and the availability of service and spares.

Table 7 shows, as at March, 1967, the basic list prices and the prices of the fully ballasted models as tested.

Table 7.—Prices

<table>
<thead>
<tr>
<th>Test No.</th>
<th>Max. weight (lb.)</th>
<th>Shaft h.p.</th>
<th>Retail price $</th>
<th>$/shp as tested</th>
</tr>
</thead>
<tbody>
<tr>
<td>38</td>
<td>5,750</td>
<td>39</td>
<td>2,600</td>
<td>2,820</td>
</tr>
<tr>
<td>39</td>
<td>5,190</td>
<td>34</td>
<td>2,470</td>
<td>2,560</td>
</tr>
<tr>
<td>40</td>
<td>5,110</td>
<td>38 (39*)</td>
<td>2,300</td>
<td>2,410</td>
</tr>
<tr>
<td>41 (a)</td>
<td>5,660</td>
<td>38</td>
<td>2,660</td>
<td>2,850</td>
</tr>
<tr>
<td>41 (b)</td>
<td>5,660</td>
<td>38</td>
<td>2,660</td>
<td>2,850</td>
</tr>
<tr>
<td>42</td>
<td>5,990</td>
<td>39 (34*)</td>
<td>2,410</td>
<td>2,580</td>
</tr>
<tr>
<td>43</td>
<td>6,630</td>
<td>46</td>
<td>2,790</td>
<td>2,890</td>
</tr>
<tr>
<td>44</td>
<td>6,170</td>
<td>42</td>
<td>2,620</td>
<td>2,740</td>
</tr>
<tr>
<td>45</td>
<td>6,970</td>
<td>43</td>
<td>2,660</td>
<td>2,750</td>
</tr>
</tbody>
</table>

* The values in brackets refer to the lower engine speed; mentioned in Section 3.

(a) With standard transmission; (b) "Multi-power;"
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