SOME PRACTICAL ENGINEERING EFFECTS OF LEGISLATIVE LIMITS

John Dickson-Simpson M.I.R.T.E.

SYNOPSIS

In terms of the loads that modern commerce is expecting road transport to haul, regulations in Europe lag behind practical operational requirements.

Trying to make the best of over-tight legal restrictions is taxing the ingenuity of transport engineers. They are succeeding to a remarkable extent, but the capital costs of transport are inevitably increased as a result.

Dimensional limits are often proving more of a hindrance than weight limits because of the trend to bulkier freight. This is generating low-deck designs and close-coupled combinations.

But tight legal limits do sometimes stimulate more efficient engineering and more refined vehicles, and that is reflected in the products now emerging from European manufacturers.

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John Dickson-Simpson, M.I.R.T.E.

Because the figures chosen for regulations tend to be arbitrary, nice round ones, they place artificial constraints on transport efficiency. Too often they seem to fall just short of what is needed.

Width limits have made it just impossible, by the thickness of a hand, to stack two rows of pallets down an ordinary van. Weight limits have left trucks just short of being able to carry fully-loaded containers. Axle limits seem to be nicely chosen to give a good chance of a slight overload with half a metre alteration in the load position. Wheelbases can be decreed that are just 200mm too much to comply with an overall length limit.

These are just in the context of Western Europe - and especially in Britain, which almost invariably manages to hit on figures that are a step behind the rest of Europe - and, to add to the practical difficulties, is more conscientious about enforcement. But transport laws the world over have imperfections that illustrate all sorts of failure to meet the modern commercial and economic needs - or even to be in step with the best standards of safety.

It is the transport engineers who have to summon the ingenuity to make the best of arbitrary restrictions. Well, they love it, really. Ingenuity is what makes the job so absorbing. And perversely, restrictions can stimulate engineering to higher - or more finely tuned - levels, notwithstanding that the cost of transport is nearly always increased in the process.

Much has been, and still is being, achieved in this search for making legal limits tolerable.

My examples are European, but they are not exclusively so, because more and more transport problems are being shared internationally and worldwide exchange of information is brisker.

The width limits that persist - and only now are beginning to be relaxed a little - were invented before pallets were in common use and mostly conformed to standard sizes. An 8ft width arose from American influence: that was the width of containers for transport of military equipment - and they were injected into many countries as a result of the Second World War. The European continent did a metric rounding-off to 2.5 metres, and that is still the most commonly accepted dimension.

It is hard, however, to fit two rows of metric-standard 1.2-metre pallets within the interior of a van 2.5

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metres wide externally. And it is even harder to fit two rows of Imperial-size 48 inch pallets, which leave only 2.5 inches for the thicknesses of two walls, even before allowing clearances to slide pallets in or out and without allowing for the rough tolerances on wooden-pallet dimensions.

It has just about been done though, by slimming walls down to an inch thickness. The principal key to engineering success here has been the development of walls consisting of single panels that are laminations of glass-reinforced polyester bonded to a plywood core. Later variations on the theme have been steel, aluminium, melamine or phenolic sheet bonded to a plastics-foam, plywood or honeycomb core. Alternatives of interlocking aluminium extrusions or steel pressings have emerged as well.

Despite the introduction of such thin walls, pallets are still a tight fit, and the structural integrity of roofs and slim door frames has to be watched carefully. A more tolerant type of body has therefore been found to be the curtain-sider with tensioning straps or other rigidising elements integrated with the curtains - which are also pulled tight lengthwise by tensioners in the end posts.

Curtain-siders have no difficulty in containing even Imperial-size pallet-loads and they can even bulge around slightly over-width items without infringing the law. They are very popular in Britain, where the additional merit of affording sideways access to any part of the load down the whole length has been found an invaluable bonus - emphasised because of the intensive short-distance nature of freight traffic in a densely populated small country (trucks spend a larger proportion of time loading and unloading). For exactly that same reason the United Kingdom is pre-eminent in use of quick-swap demountable bodies and side-access van bodies with flush-closing side doors that entail no sacrifice of valuable interior width.

All such developments add to the capital cost of transport, productive as they are. One might argue that the ungenerous width limit has taxed engineering ingenuity in such a way that other rub-off benefits have accrued. But a simple van would have saved a great deal of money.

Now demands made on transport from other legal quarters have brought the 2.5-metre width limit to bursting point. That is the requirement of the food-hygiene promoters for cold-temperature transport. Thin-wall refrigerated vans have been tried in Europe, and they have really been surprisingly successful provided the insulation in roof, floor and ends has been made much thicker to compensate for the extra heat-gain through the sides. The constructional quality has had to be meticulous, however, and the few that

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have passed type-approval performance tests have been absolutely borderline, leaving no tolerance for in-service deterioration. In fact the Italians stopped accepting them. Crunch point was reached and width relaxations have been introduced in most European countries to allow insulated vans to have walls thick enough to carry perishable freight at the standards being demanded by the authorities.

It is learning-curve time, however. Instead of agreeing a common width, individual countries have applied their own rules. Some of the width limits are 2.53, 2.55, 2.58 and 2.6 metres - and, tentatively, just for insulated bodies. Sweden has sensibly adopted the same across-board revised width of 2.6 metres that now prevails in the United States. It is, one hopes, merely a matter of time before the general international width limit will be 2.6 metres. Much expense and bureaucracy could have been avoided by recognising much earlier the changing pattern of loads that road transport is being required to carry.

The changes imposed by modern commerce are making volume, not weight, a more frequent factor determining how much a truck can carry. The obsession with packaging everything has had a deep influence here.

There are plenty of operations where improved productivity depends on sheer payload. One clear example is that to carry a 30-tonne container means having a vehicle that weighs about 14 tonnes - and therefore that the 44-tonne gross requirement is a truth that will not flow away on the wind of political compromise. But the relentless shift to bulky freight is putting the priority more and more on volume. That is frustrated by height limits. There has been a 4-metre overall height limit on much of the European continent for a long time. In Britain there was no statutory height limit until 4.2 metres was imposed as an environmentalist quid pro quo for conceding an uplift from 32.5 to 38 tonnes in 1983.

Much engineering brainpower is therefore going into efforts to squeeze as much interior height as possible within the overall-height restrictions.

Chassis are being lowered - sometimes even step-framed, even though that brings the inconvenience of wheelboxes. One current experiment uses front-wheel drive to give maximum freedom in low chassis design.

Most operators still want a level, unobstructed floor, however. To get it lower is a matter of tyre size and tyre-to-floor clearance.

It is more likely the bump clearance above the tyre than the chassis height that determines how low the floor

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can be. So one method has been to make the springs stiffer. But then the ride is somewhat rough and load-shift can be a problem, to say nothing of adhesion for braking. Rubber springs (which, though stiff, have some progressiveness and suffer no internal friction) are a slight improvement. The ideal compromise is proving to be air suspension, which might well have more deflection than is desirable, but at least the bump movement is constant whatever the load. The ride quality is restored as well, especially when lightly loaded. Mind you, although "riding on air" sounds bliss, the actual ride quality depends greatly on the design - and there is a conflict here between cost and performance. Hefty trailing arms of quarter-elliptic leaf-springs clamped to the axle constitute the current favourite method because it is fairly cheap; but in single-side bump the axle acts as a massive torsion bar, shooting-up the ultimate stiffness. An alternative of my firm's, with jointed trailing arms and wide-spaced air springs to give inherent stability does not suffer such single-side stiffening, but it is more expensive. Still, apart from such finer points of argument, air suspension is proving the effective way of keeping down the floor height without spoiling the ride.

Getting the floor any lower means fitting smaller wheels - and they are, indeed, already the fashion in Europe.

As usual, engineering compromises are needed. Making the wheels smaller leaves less room for brakes. Going down to 16in and 15in wheels has too often proved to be beyond the scope of current braking technology with the brakes tucked inside the wheel. Introduction of disc brakes on the lighter trucks and buses has helped, but the commonly accepted minimum wheel size still seems to be 17.5in. For heavier weights the minimum seems to be 19.5in. In fact this is a size to watch, because its success implies its broader application in the future. It could even come to maximum-weight vehicles eventually. In the meantime they are staying with 22.5in (attempts to introduce 24.5in to Europe have failed).

Finding that there is a technological limit to wheel-smallness, the industry has turned to the tyre designers for help. They have done their jobs magnificiently - bringing out such an array of new low-profile sizes, featuring 80, 75, 70 and 65 per cent width-to-depth aspect ratios, that European operators are beginning to complain about confusion and shortages.

Nevertheless, low profile tyres have been the greatest contributor to reducing deck heights and therefore raising load-volumes. One way and another, ways have been found of lowering floors by about 200mm.

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Further than increasing the interior height and the width, there is only one other direction to go, which is to add more on the interior length. Legal limits intervene again.

For all practical purposes there is no meaningful length restriction on rigid trucks any more in Europe, because, since this year, they can now be 12 metres long. That is more than enough for most operators, and does rather demonstrate that operating conditions impose their own natural limits irrespective of invented figures. Where operators want more interior volume without making the vehicle unwieldly they fit a luton head - a forward extension over the cab.

With combinations, however, length limits are a vexing issue in Europe. With articulated trucks, which are limited to 15.5 metres overall length, British operators are in particular difficulty because there is, superimposed, an interior length limit of 12.2 metres on semi-trailers (another environmentalist quid pro quo for 38 tonnes). The problems are exacerbated by a persistent British habit of using semi-trailers with king-pin overhangs that are too short. This arises from practices that developed in the previous dimensional regime, and even if operators mended their ways on new equipment the fact needs facing that thousands of old short-nose trailers still have to be coupled. As short-nose trailers have more length behind the king pin there is frequent risk of exceeding the 15.5 metres overall limit with a sleeper-cab tractor. If they are coupled more closely they cannot then couple to a long-nose trailer (which is the rule rather than the exception in the rest of Europe). The I.R.T.E. has published a standard set of dimensions for tractors and semi-trailers so that British and continental equipment will interchange, but the manufacturers are slow to respond. Sliding fifth-wheel couplings are the only answer, but they bring difficulties in axle-weight distribution - which is also extra-sensitive in the U.K. because its axle-weight limits are (with Ireland at the moment) lower than those in the rest of Europe.

The dimensional difficulties with articulated units are forcing the searchers of more stowage length to turn to drawbar-trailer outfits. These are still restricted to 32.5 tonnes in the U.K. against the Common Market's agreed 40 tonnes. Nevertheless, the extra body length is very useful, and the continentals are of the same opinion. A drawbar outfit affords a total body length of over 14.5 metres instead of the artic's 12.2 metres. With close coupling between the towing and towed units there can be about 15.5 metres of body length. In terms of pallet area that is 30 against 24 pallets - a 25 per cent increase in load.

Close coupling is all the rage - another example of

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engineering ingenuity making the best of round-figure legal restrictions. Articulated vehicles were granted an extra half-metre a few years ago in recognition of the difficulty of accommodating sleeper cabs. No such concession for sleeper cabs was made for drawbar combinations, which remain held to 18 metres. So to get that vital extra row of pallets the cab has to have the sleeping compartment above its roof, the body has to be tucked close to the cab and the trailer has to be coupled closely to the motive unit.

Close coupling entails a complicated, heavy and expensive mechanism to push the trailer away from the towing vehicle when turning a corner. Otherwise the towing and the towed will clash. There is an unofficial competition to see who can couple closest. One West German design of daunting cost claims to get the gap down to 250mm. Generally, though, 600mm is the practical limit - and even that is risky in Britain where there are too many road-dips that make the tops of bodies dive towards each other.

Now, having seen what the drawbar enthusiasts can do, semi-trailer people are trying out similar techniques to get an extra metre on the interior length. So continental artics are being introduced with 2-metre king-pin overhangs and even with turn-activated moving fifth wheels. The continentals do not have the 12.2-metre limit on semi-trailer length.

Unwillingly, perhaps, the tight limits that prevail in the U.K. do sometimes improve the efficiency of engineering. The axle-weight limits (10.5 tonne on a driving axle) and the quite strict enforcement against overloading mean that chassis weight is more important than it is on the Continent. Risk of axle overloading can be cut by having an extra axle, and, indeed, the British vehicle-taxation structure positively encourages more axles to reduce road damage. Extra axles do bring yet more incentives to cut vehicle weight, though. Consequently British truck engineering (what is left from the savage recession) is more finely honed than the continentals', despite the British trucks having bigger brakes and strong front axles.

The framing of noise regulations in the whole of Western Europe has also brought an admirable state of refinement and has stimulated slower-revving engines that are consequently giving better fuel consumption.

So maybe tight legal restrictions are not all bad.

MAX AXLE WEIGHTS	SINGLE AXLES: 10.17 tonnes if dead; 10.5 tonnes if sole driving axle; 9.2 on a single-tyred axle but 7.12 if it is a steering axle next to another one and without load-compensating suspension.

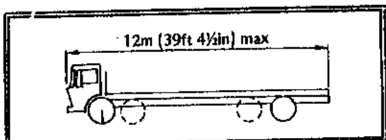
TANDEMS (Two closely-spaced axles)

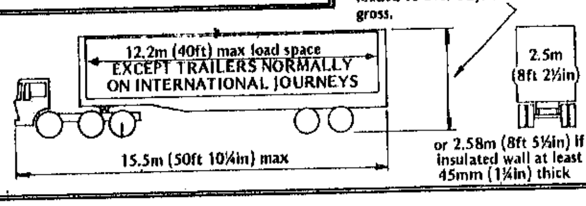
Maximum bogie weight (tonnes)	Smallest spacing for given plated weight: Equally plated axles	Unequally plated—neither axle more than 10.17tonnes	Unequally plated—one axle more than 10.17tonnes
10.5			1.05m (3ft 5½in)
12.2		1.02m (3ft 4¼in)	
15.26		1.05m (3ft 5½in)	1.20m (3ft 11¼in)
16.26	1.02 (3ft 4¼in)		
16.27		1.20m (3ft 11¼in)	
16.5			1.35m (4ft 5¼in)
17.28	1.05m (3ft 5½in)	1.35m (4ft 5¼in)	
18.0			1.50m (4ft 11¼in)
18.3	1.20m (3ft 11¼in)	1.50m (4ft 11¼in)	
18.8	1.35m (4ft 5¼in)		
19.0		1.80m (5ft 11in)	1.80m (5ft 11in)
19.32	1.50m (4ft 11¼in)	1.85m (6ft 1in)	1.85m (6ft 1in)
20.00	1.80m (5ft 11in)		
20.34	1.85m (6ft 1in)		

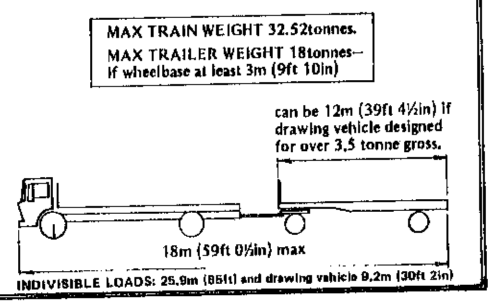
TRI-AXLES (Three closely-spaced axles)

Maximum weight on any axle of bogie (tonnes)	Smallest spacing between adjoining axles
6.0	0.70m (2ft 3½in)
6.2	0.80m (2ft 7½in)
6.4	0.90m (2ft 11½in)
6.6	1.00m (3ft 3½in)
6.9	1.10m (3ft 7½in)
7.1	1.20m (3ft 11¼in)
7.5	1.30m (4ft 3in)

Total load on three axles (tonnes)	If any one axle exceeds 7.5tonnes plated: Max weight on centre axle	Smallest spread (total)
18.29	over 7.5t	less than 3.0m (9ft 10¼in)
20.33	8.39t	at least 3 0m (9ft 10¼in)
22.36	8.64t	at least 3.8m (12ft 5¾in)
24.39	9.15t	at least 4.6m (15ft 1¼in)







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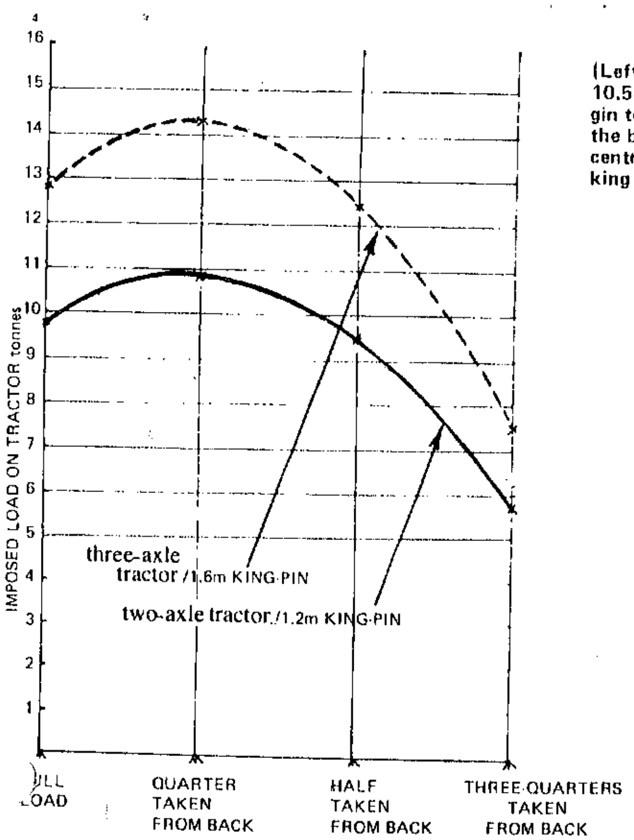
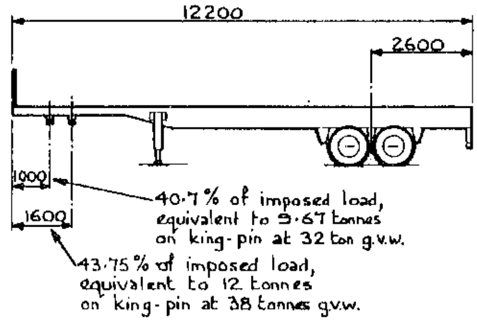
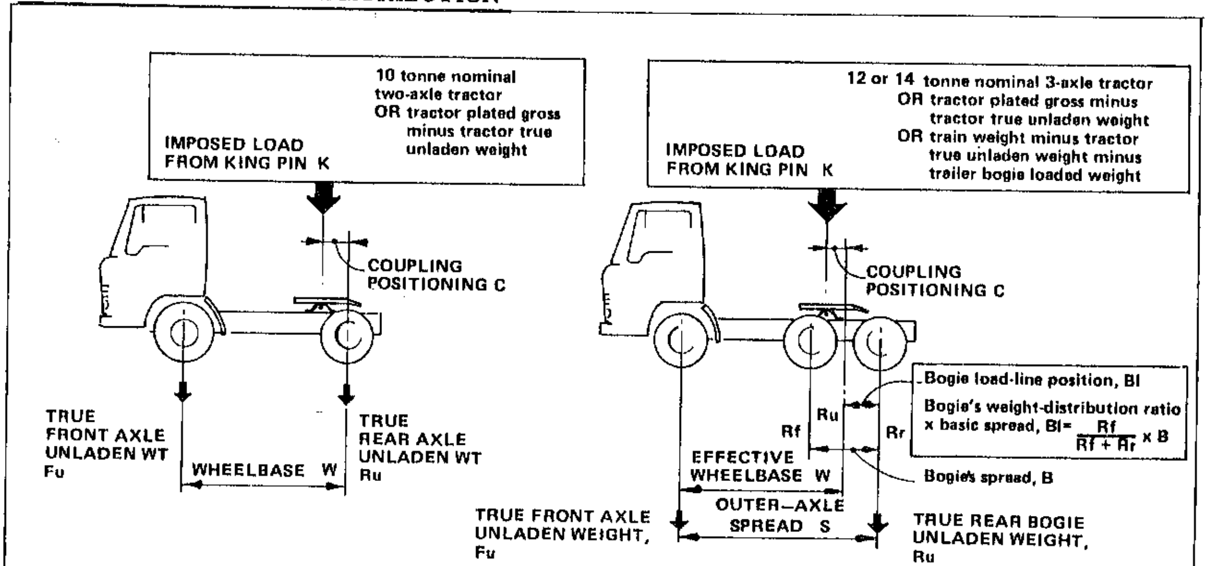


(Left) Why it seems prudent to use the new 10.5-tonne (10.3-ton) drive-axle weight for margin to avoid overloads. As load is removed from the back of the trailer the forward shift of centre of gravity puts extra load through the king pin and on the tractor.



(Above) With dual king pins a tandem-axle trailer can suit either two- or three-axle tractors.

CALCULATING WEIGHT DISTRIBUTION

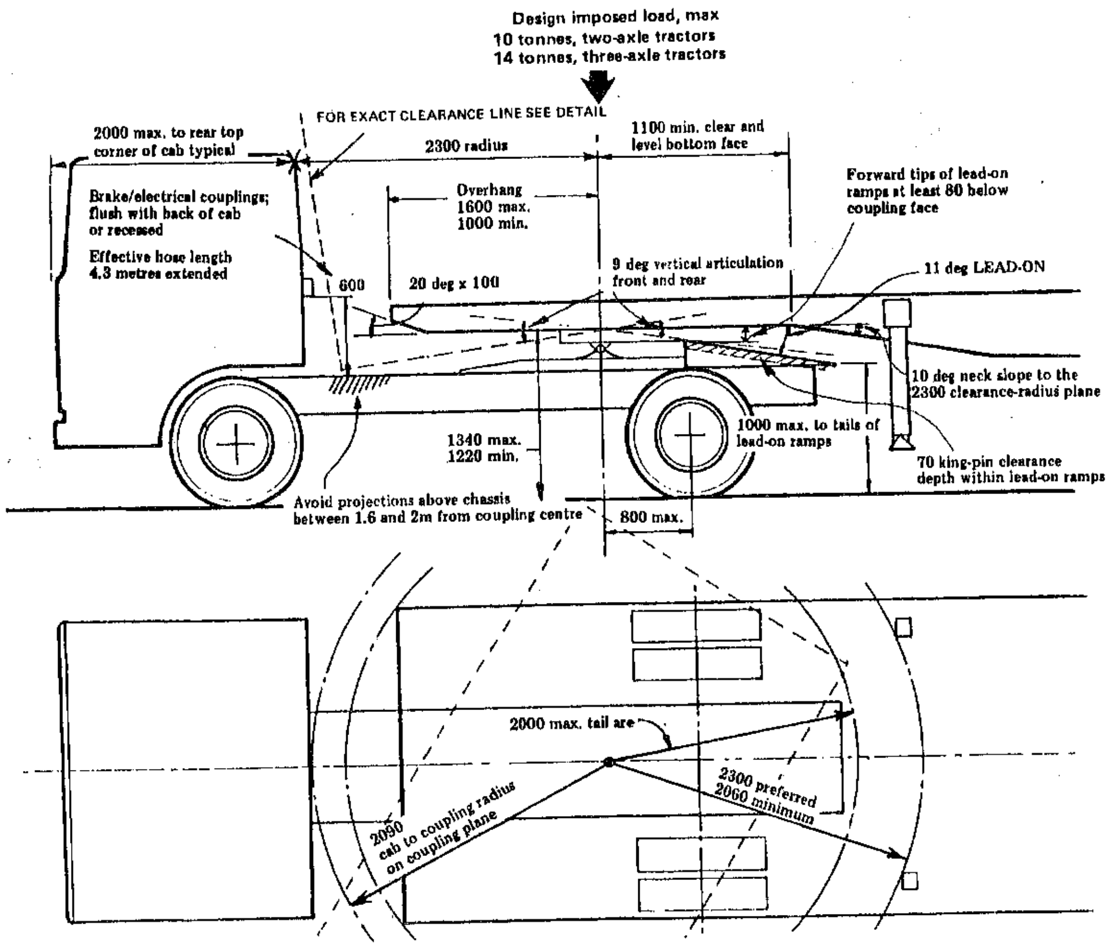


Fi - the imposed weight on the front axle $= \frac{C}{W} \times K$

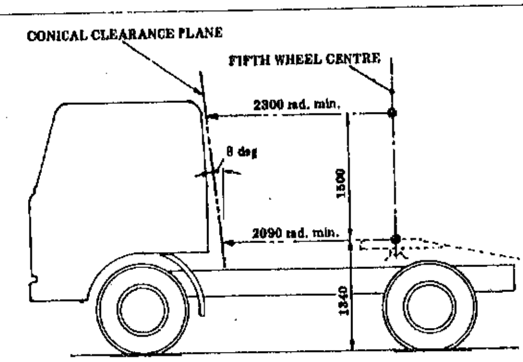
Ri - the imposed weight on the rear axle or bogie $= K - Fi$

Total weight on front axle $= Fi + Fu$

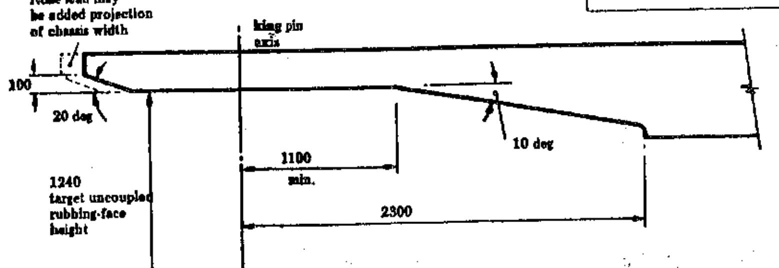
Total weight on rear axle or bogie $= Ri + Ru$



THE I.R.T.E. COUPLING CODE DIMENSIONS



CAB-CLEARANCE LINE

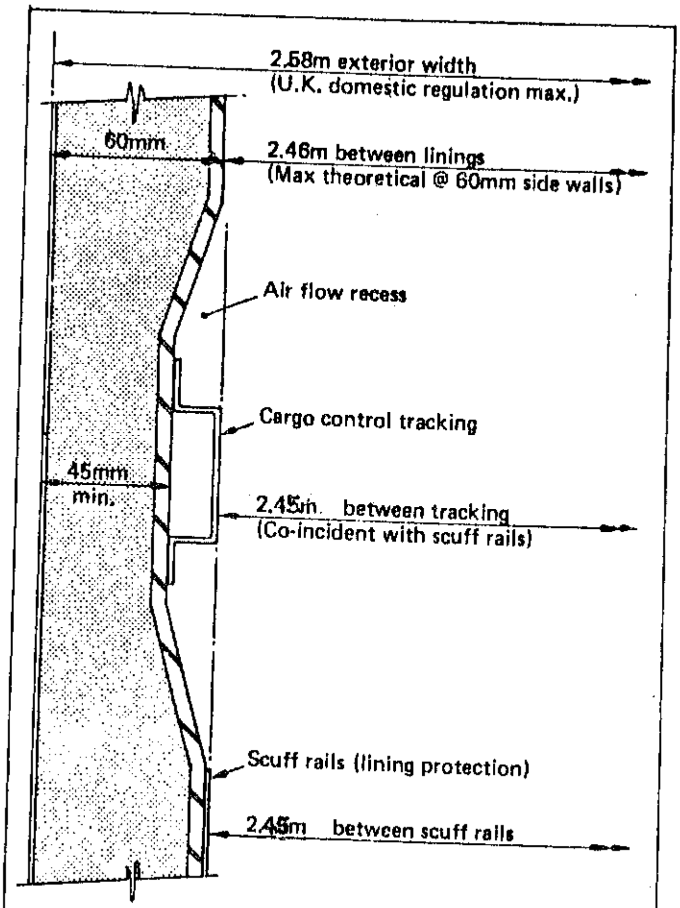


RECOMMENDED TRAILER-NECK PROFILE

Target coupling heights:
1320 or 1240

EUROPEAN DIMENSIONAL MAXIMUMS FOR ARTICULATED SEMI-TRAILERS	Incl. tolerance interpretations		
	Length (m)	Height (m)	Width (m)
Belgium	15.66	4.04	2.60
Denmark	16.00*	4.00	2.55
Ireland	15.50		2.60
France	15.50	no restrict.	2.55
Greece	15.50	4.00	2.50
Holland	15.66	4.00	2.60
Italy	15.50	4.00	2.55
Luxembourg	15.50	4.00	2.60
U.K.	15.50+	4.20	2.58
W. Germany	15.81	4.00	2.53
E.E.C.	15.50	4.00	2.50
Portugal	15.50	4.00	2.50
Spain	15.50	4.00	2.50
Finland	15.50	4.00	2.50
Norway	15.50	4.00	2.50
Sweden under	24.00	4.00	2.60
Austria	15.50	4.00	2.50
Switzerland	15.50	4.00	2.50

* Semi-trailer overall length restriction of 12.7m
\+ With a domestic limitation of 12.2m for trailer interior length. (refrigerated only)
Increased widths are being discussed for Portugal and Spain



Side wall section
composite panel

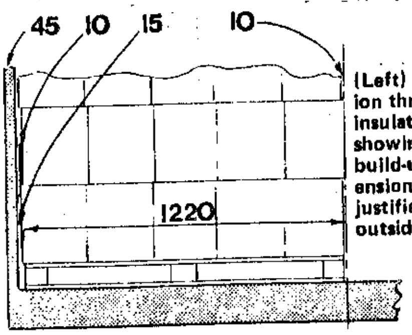
For T.I.P.'s 2.58m wide refrigerated trailers a 60mm side wall with longitudinal recesses to carry cargo-control tracking has been designed. The tracking then does not intrude on the interior width any more than the scuff plates along the bottom of the wall – but the insulation is more effective than if the walls were the minimum-allowed 45mm all the way up. The table on the right compares thermal efficiencies (the lower the heat gain figure, the better).

Exterior width (m)	Nominal side wall thickness (mm)	Nominal internal width between linings (mm)	Thermal performance: typical heat gain rating of complete body (watts/sq m/deg C/hour)
2.50	100	2300	.25
	75	2350	.28
	35	2430	.37
2.58	45	2490	.35
	60	2460	.32
	60 (with recessed cargo control and air flow channels)	2460	.34

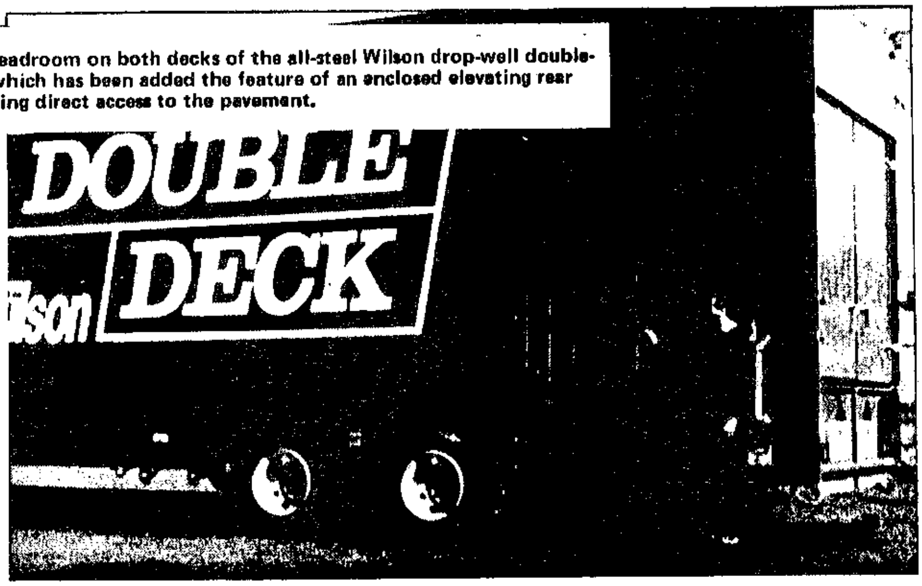
MAXIMUM TRAILER LENGTH

	1.62m nose	2m nose
D.A.F. (2500)	12900	13210
D.A.F. (3300)	12690	13000
E.R.F.	12882	13192
Foden	12822	13132
Ford	12830	13140
Iveco	12650	12960
Leyland	12820	13130
M.A.N.	12870	13180
Mercedes-Benz	12775	13085
Renault	12740	13050
Scania	12740	13050
Seddon	12770	13080
Volvo	12700	13010

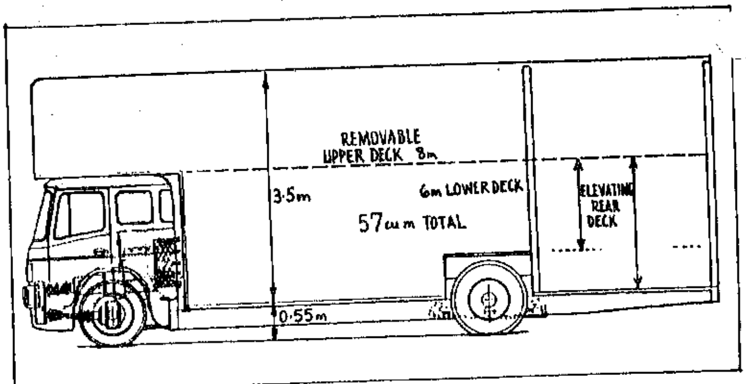
(Left) The maximum trailer lengths obtainable with long-nose semi-trailers coupled to sleeper-cab tractors The E.R.F. (Right) affords close coupling.

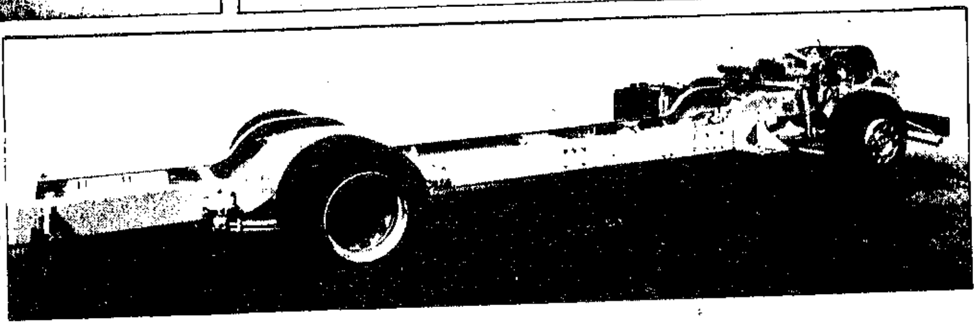


(Left) Half-section through an insulated body showing the build-up of dimensions that justifies 2.6m outside width.

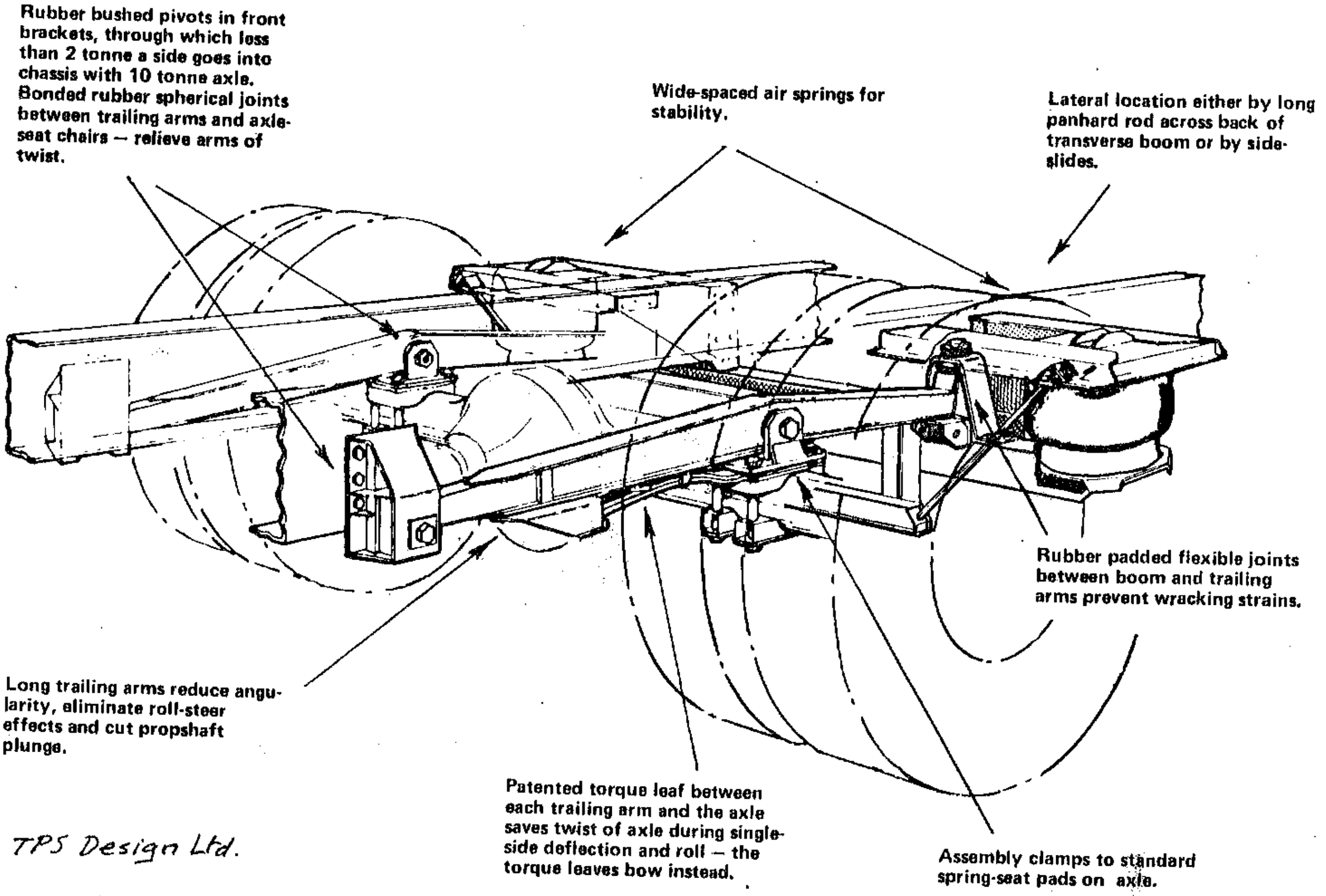


Adequate headroom on both decks of the all-steel Wilson drop-well double-decker, to which has been added the feature of an enclosed elevating rear floor affording direct access to the pavement.

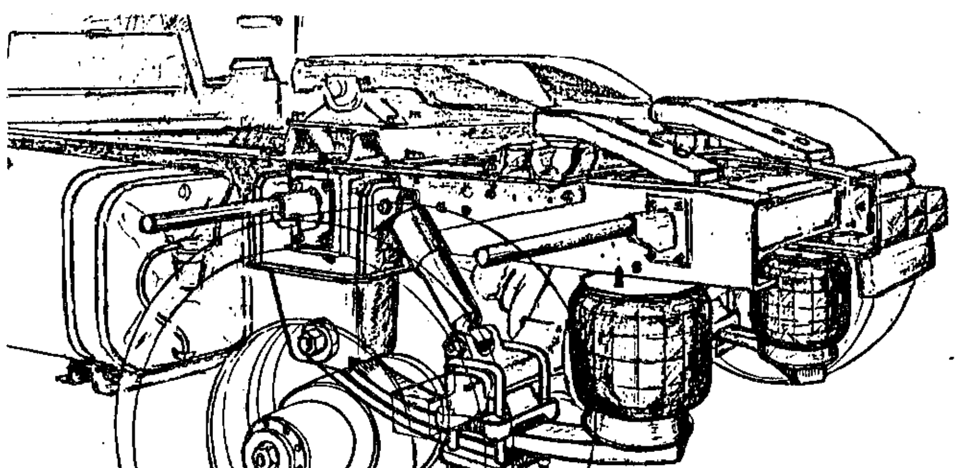




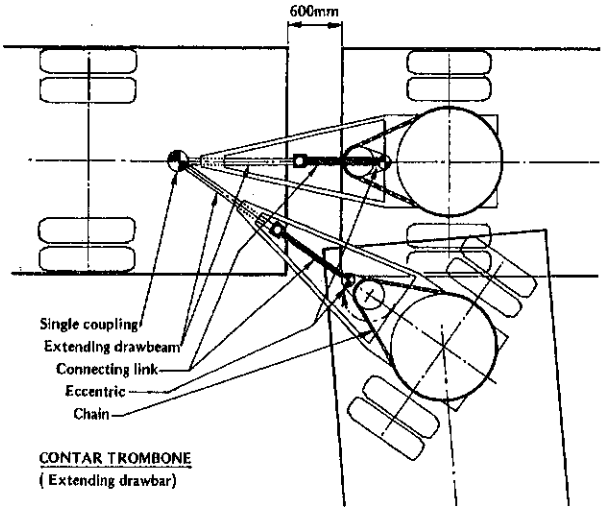
The dropframe chassis that are emerging offer extra load volume from lowering the floor by about 2ft. Front wheel drive offersextra freedom in low-deck design despite some length often being added to the front end. The Titan conversion of an M.A.N. (above, left) gives an unobstructed deck over low-profile tyred 15in wheels, while the lower floor of a luton-van version of the Frank Bennett design (above, right) would mean narrow wheelboxes. Only E.R.F. (right) offers a drop-frame chassis off-the-peg, though just, as yet, for 16 tons gross and in two-axle form.



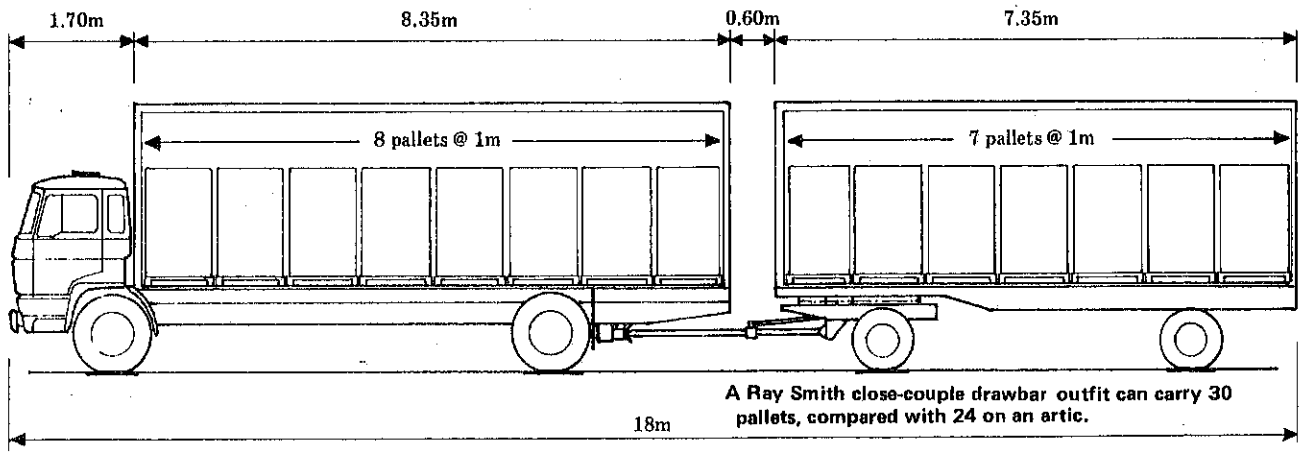
TPS Design Ltd.



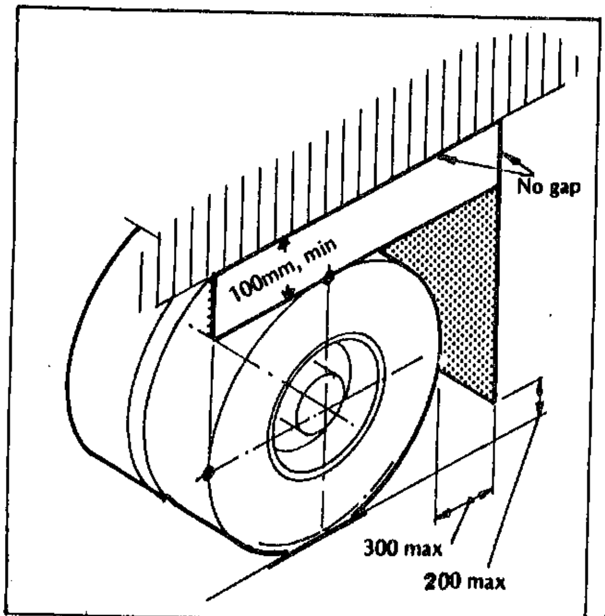
Dunlop air suspension



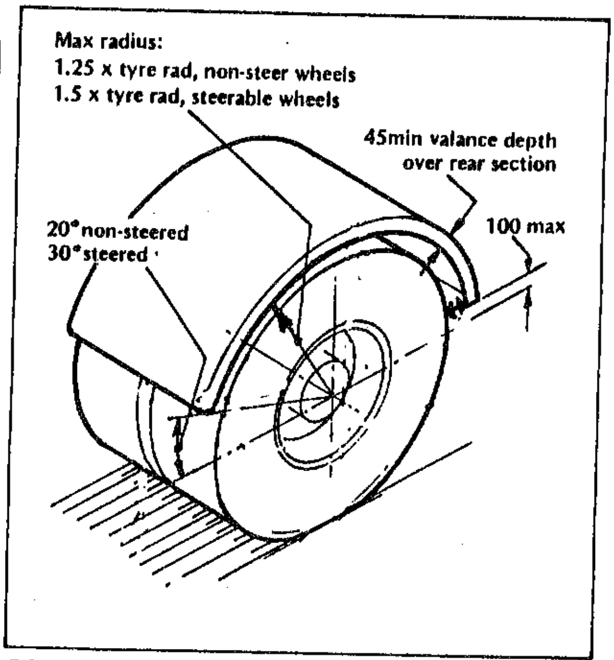
CONTAR TROMBONE
(Extending drawbar)



A Ray Smith close-couple drawbar outfit can carry 30 pallets, compared with 24 on an artic.



With valanced-flap arrangements the bottom edge of the valance has, unladen, to be no higher than the top of the tyre. Its front edge must not be farther back than the front of the tyre.



B.S. minimum requirements (unladen) for mudguards.