THE COMMANDO FRAME

Mark Woodward
(documents via Ken Sprayson)

Ken Sprayson sent me a copy of an article from 'Motorcycle' dated October 1967. Ken went on to say "*I feel this goes a long way in answering Stan Dibbens' query on 'why Norton Villiers stopped using the Featherbed frame'* (Rh363 March 2018). *In the light of the subsequent failures with the Commando frame, it is, in some parts, slightly amusing.*

It was always my opinion that Dr Bauer tended to 'look down his nose' on motorcycle engineers when considering their designs as being outdated. Perhaps Stan can comment on riding Featherbed Nortons at over 100mph?

Although Stephen Bauer was good with the slide rule in working out loadings, he obviously had little experience of stress concentrations and low load fatigue failures." The article text was thus:

Bob Currie probes the logic of the Norton Commando with Norton Villiers director of engineering, Dr Stephen Bauer.

Like it or loathe it, you must concede that the 745cc Norton Commando was the hit of Earls Court. From door-open to closing time, the two Commandos on display were ringed with admirers and critics.

The engine was taken for granted (it was the familiar Atlas, of course). But why - argued the visitors - the unorthodox frame? Why the big rubber mountings? Why carry the rear fork on the gearbox plates? The best man to answer these and other questions is Dr Stephen Bauer, director of engineering at Norton Villiers. So we went to Wolverhampton to ask him.

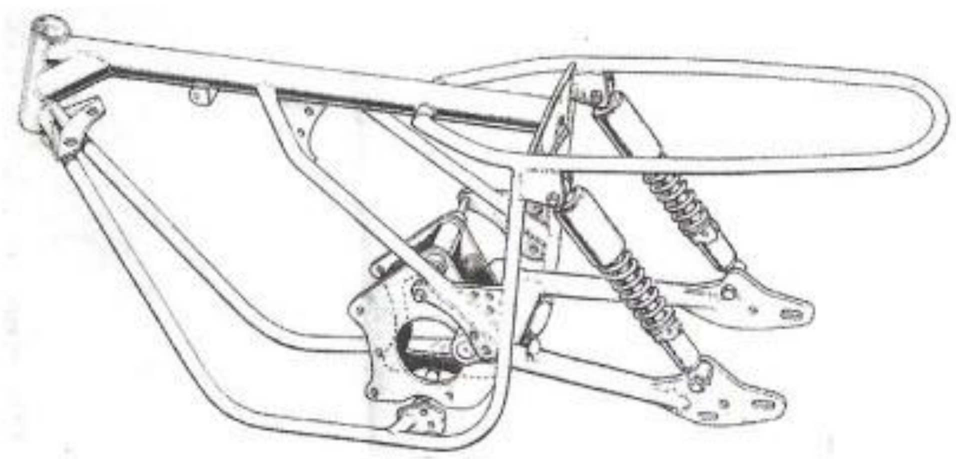
Q1) Dr Bauer, since its introduction in 1951, the Norton Featherbed frame has earned a respect little short of worship. Why change now from such a world-famous design?

A1) The Featherbed is still a very fine frame, but not necessarily the ultimate. 16 years ago it was far ahead of its contemporaries. But other factories have not been idle, and now it is not any better than anyone else's. We want a frame that is better than the others.

Q2) You consider we have reached a limit in conventional frame design?

A2) Certainly. A present-day frame is fine up to, say, 100mph but beyond that it just isn't stiff enough. Take any fast machine round a bumpy bend at 110 and 115mph and it seems to have quite a few hinges in the middle. Any

Though the frame makes a considerable break from convention, the Commando is by no means freakish in appearance - decidedly handsome in fact ...



The new frame complete with rear suspension and gearbox plates; the rear fork is pivoted on those, not on the frame structure.

To resist twisting and bending, the backbone is of light but large-diameter (2¹/₄") tube and care has been taken that it is not weakened or flattened in any way at the welded joints.

You will note that the rear part of the backbone, the sections of the engine loops which rise to the upper damper mountings, and the two angled struts form a triangular structure. All forces on the frame are taken through the top tube and those triangulations. The remaining tubes are unstressed and serve merely to provide locations for the engine and rear mudguard.

improvement in handling is more important than pushing up the bhp. Raise cornering speed and you raise average speed.

Q3) How does a designer raise cornering speed?

A3) By ensuring that the front and rear wheels keep their proper relationship, no matter how rought the surface. That isn't so simple as it sounds.

For example, one rather curious condition which affects handling on a bumpy bend, is deflection of the rear tyre when the machine is banked over. The tendency is to thrust the whole machine around its longitudinal axis and that can be very detrimental to fast cornering.

Mainly, however, it is a matter of increasing the resistance to twisting along the roll axis (to use an aircraft term); resistance to longitudinal twist, if you like.

It is important also, that the frame shouldn't bend sideways and so provide a genuine hinge in the middle.

Q4) Presumably, one could stiffen a frame by adding struts and, thereby, weight. But the Commando frame seems to be extremely light.

A4) Yes, only 24lb. That's because the whole frame has been designed so that all forces are taken by straight tubes and there are no bending moments on any structural member except the backbone.

Q5) You say that this is a straight tube design, but I notice that the angled struts are, in fact, curved inwards to join the top tube.

A5) That is so, but the bent portions of those struts are not stressed.

There is a very large gusset plate at this point which takes over from the load-carrying straight sections of the struts.

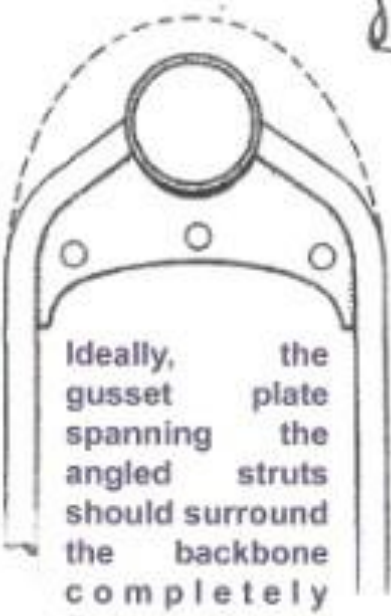
Those straight sections are in tension or compression only and are not subject to bending, so they can be made of relatively light tubing.

For no better reason than convenience, we project them down, round under the engine and up to the steering head, as duplex loops.

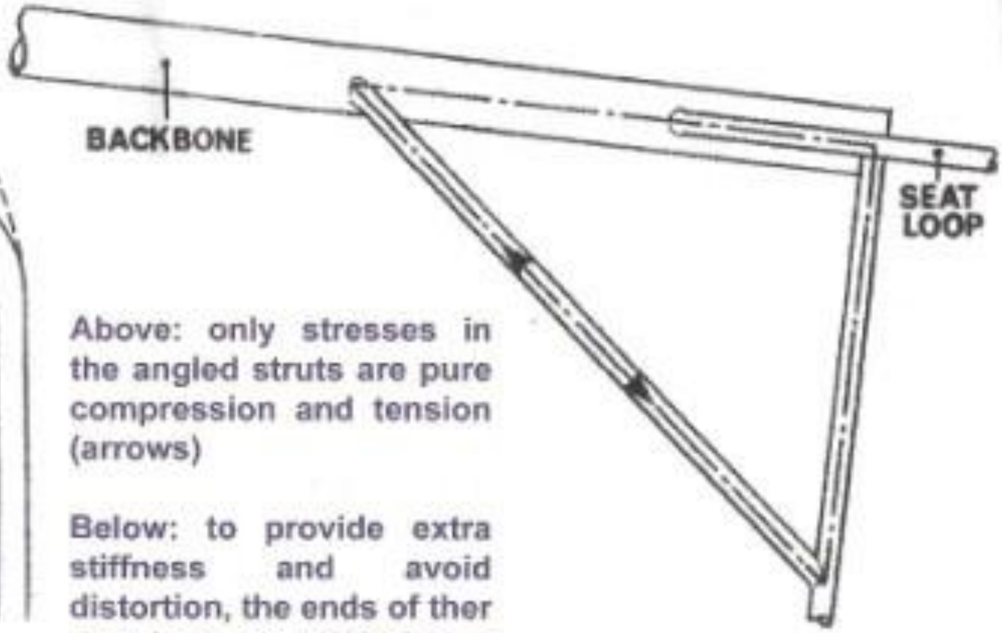
Ideally we should extend the gusset plate, which connects the tops of the angled struts, so that it surrounds the top tube completely and so keeps it round; but this would be untidy and in experiments, we found that this was not strictly necessary.

Q6) There is a transverse plate at the rear of the top tube. What is its purpose?

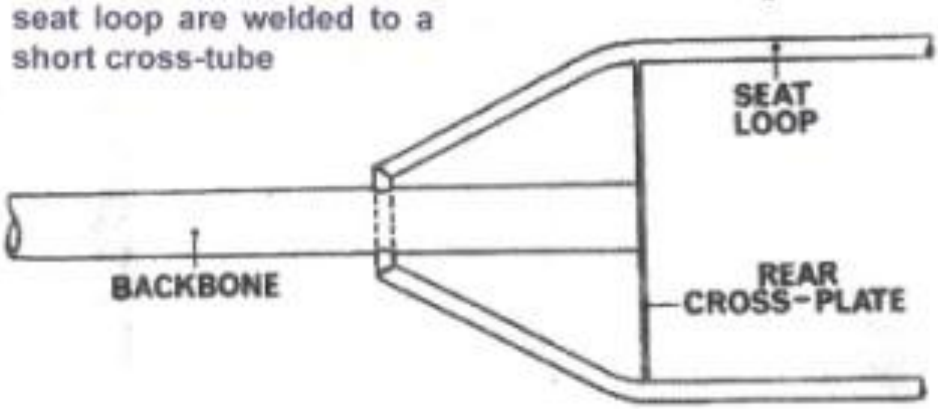
A6) It connects the tops of the main loops, of course, and affords us an enormously strong structure yet one with little weight. Pull or push on those main loop members, in the plane of the tubing, and you will see that the



Ideally, the gusset plate spanning the angled struts should surround the backbone completely (broken line) to keep it round in section. In practice this was found unnecessary



Above: only stresses in the angled struts are pure compression and tension (arrows)



Below: to provide extra stiffness and avoid distortion, the ends of ther seat loop are welded to a short cross-tube

twisting moment is carried right through to the steering head.

Notice, too, that the forward ends of the seat loops form subsidiary triangulations with the cross-plate and the backbone - again giving immense rigidity.

At the front, the backbone is strutted to the steering head by a U-section gusset. The idea here is to carry the weld round a large proportion of the circumference of both the backbone and steering-head tube, so helping to maintain the circular section of these parts.

Q7) Most controversial feature of the Commando is the arrangement of engine gearbox and rear fork as a sub-assembly mounted on rubber within the main frame. Why was this method adopted?

A7) Let's take the mountings first.

Imagine an engine totally unsupported in space. Now, if the crankshaft is rotated slowly, the centre of gravity of the engine follows a heart-shaped path around the crankshaft axis. Start the engine and it would oscillate around that path – which may be no more than 1/16" from the shaft axis.

If we could mount the engine on a suspension soft enough to allow it to oscillate in that way without transmitting the oscillations to the frame, we should have the perfect suspension. That is what we have attempted to achieve.

There are three suspension points - at the front, at the top rear of the gearbox, and at the cylinder head.

The mountings are large in diameter and quite long, but they are held at the sides very firmly indeed. The idea is that the engine should be free to move in the plane of the crankcase, but it cannot twist in the frame.

Q8) And carrying the rear fork from the gearbox plates ...?

A8) That follows surely? Suppose we were to mount the engine on beautifully soft rubber yet the fork remained pivoted on the frame. Well the pull of the chain when the engine is driving would drag the engine-gear assembly back hard against the mounting bushes and so cancel their affect.

Again, the oscillations of the engine would be transmitted through the chain and sprockets and back through the fork arms to the frame. In fact, during experiments, we found that the chain would scarcely stay on the sprockets.

You see, though the weight of the engine is about 150lb, chain pull could be around 3,000lb, and that would cause more deflection in the rubber mountings than would the running of the engine itself.

In a conventional frame, the offset pull of the chain has to be taken by the frame itself and if (as is often the case) the rear fork is pivoted on rubber bushes, there is considerable sideways deflection of the fork when the throttle is opened. The Commando fork pivots on bronze bushes and the chain pull is an internal, not external force. So far as the main frame is concerned the load remains in line with the longitudinal axis, not on one side of it.

Q9) It sounds fine in theory, but does it work in practice?

A9) We would never have put such an unorthodox design on the market without thorough testing. Our prototypes have covered some thousands of miles. There is some low-frequency vibration, but that can be disregarded. It is the high-frequency vibration which causes discomfort; in the new Norton, this has disappeared completely. As for the backbone frame construction, this is also used in our AJS Scrambler frame (though rubber mountings are unnecessary with a two-stroke). There we have a frame far lighter than any of our competitors' products – but we have never bent one yet. That proves the point I think!