1898 Voiturette - Update On A ¾ Scale Home-Build Design.

Ian Hopper – Built-For-Fun EV's

I'm pleased to say I've managed to make a bit of progress with the design of the ¾ scale Argyll Voiturette discussed in issue No.44. Starting from the vehicle data and sketches described in the last article I've been able to work-up the design to a stage just short of detailing, so all the important aspects of the layout have been defined and I think I've a reasonable idea about the structure and the important mechanisms for steering, suspension and drive. As a quick reminder Figure 1 shows one original Voiturette in my local transport museum in Glasgow and my starting sketch for a ¾ scale electrically powered version.

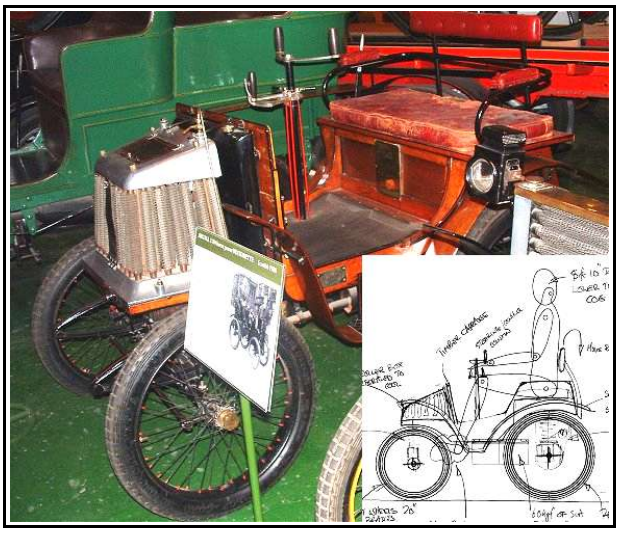

Figure 1, An original Argyll Voiturette and, inset, my starting ¾ scale design sketch.

For those of you who may be interested in designing your own vehicles in addition to building them a few words might be of interest about the approach and tools I've used.

I worked-up the design with a combination of pencil and paper and computer assisted CAD drawing and modeling methods. Off course neither the pencil nor the CAD software do any of the thinking for you but both are invaluable in building and retaining the growing "picture" of the vehicle as you work through the layout and details. The general course of the work was to establish 2-dimensional scale constructions of the vehicle on both paper and in the computer (as seemed most convenient at the time) and to progress from these to 3-dimensional solid models of the parts and eventually of the whole design.

In terms of the order of the work I started knowing wheels sizes, wheel base, rider size and position and guesstimated sizes and positions of the heavy battery pack. These formed the basis of the starting sketch but also were set out to scale in CAD, I then basically worked from the bottom of the vehicle up, trying to set out the key sizes and positions of the important structures, mechanisms and parts. There's no clean time line I can report I'm afraid but the rough order of my first pass over the design was:

- beam axle structures and configurations,
- suspension arrangements and beam axle movement guidance,
- front wheel steering & support arrangements,
- principal subframe construction and battery pack support,
- upper carriage appearance & construction – mainly the side panel shapes, bonnet, dash panel, seating position and mudguard shapes,
- drive configuration, motors positions & support & speed reduction stages,
- ackerman geometry and steering column mechanisms.

There was a good deal of overlap & cross-referencing that went on and much thought was off course given throughout to how I actually hoped make the bits I was drawing. This all fed into a second pass over the design in which I was able to refine many of the part details. Shafts, brackets, bearing

positions, chain sprockets, torque attachments etc all were given much thought to take the design to the stage it is now. A considerable amount of detailing remains to be done however especially concerning the large number of fasteners that will be needed to hold everything together.

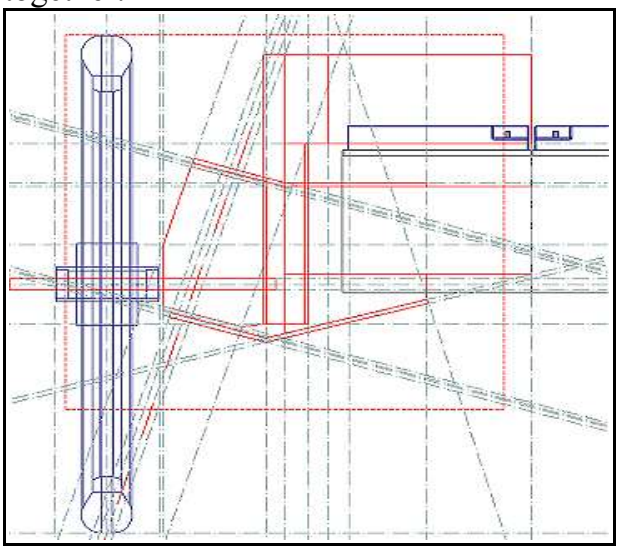

Figure 2, A typical designer's eye view of the work in progress – front elevation constructing the front wheel supports.

The images I have used to describe the design are CAD renderings from the most recent model revision. It's worth pointing

Figure 3, Wheels, beam axles & steering.

out that for most of the time this isn't at all how the design appears to the designer. In fact most of the time you end up staring at something much more like figure 2 - ie a work-in-progress made up of construction lines and half defined parts and their positions. This kind of image doesn't lend itself easily to communicating what's going on to others not directly involved in the design - hence the need to resort to a retrospective description. I'm a little bit disappointed about this because part of my interest in the project was to appreciate just a little of the thought processes the original designers may have gone through and the types of problems they might have faced. As an engineering designer by background I think it is an interesting way to appreciate some of the efforts of the original engineers who produced these vehicles and, in many ways, a more revealing way than focusing solely on one of their final output objects ie on a particular vehicle. For one thing you can understand immediately an inclination to innovate – you can't get to the end of a design project without feeling that there are things you would do differently and improve next time. I would have liked to have described the process using images drawn from the "growing" CAD model but couldn't figure out how to make this clear. Any way, mechanical design is a fascinating, albeit at times tricky activity which I think many builders would enjoy greatly if they gave it a shot. There's great satisfaction to be gained from building things, but to build things you've also designed is even better.

Where the design stands so far

Figure 3; 20" front and 26" rear spoked wheels on a 36" longitudinal wheel base – an almost straight ¾ scaling of the original. The lateral wheel base moved about a bit but I've ended up with 29", slightly wider than it should be but lending greater stability. The wheels are fixed to front and rear beam axles. The front wheels articulate to steer and I've managed to build in a tilted

Figure 4, Rear wheel electric drives.

king pin axis to keep the steering lighter and I'm hoping for some self-centering behaviour from the steering mechanism. The turning circle looks quite good so far. I'm having to build my own rear wheels from heavy duty rims, hubs and spokes I've sourced (Worksman quoted me about $300 to ship a set of their wheels to Scotland!). This isn't something I've done before but the results are encouraging so far with one rear wheel assembled but not fully tensioned. Front wheels are tough 48 spoke BMX bike wheels with their bearings stripped out to take a solid through-axle.

Figure 4; Two 600W electric drive motors are mounted to the rear beam axle and drive a rear wheel each through a two stage roller chain reduction arrangement. #25 chain from the motors (they come with #25 sprockets) and probably #35 chain drive to the final drive sprocket for a bit more strength. I had some bother fitting the drives in because I left them later than I should have and I forgot that the rear beam axle isn't fixed in space, it is suspended and moves about! Despite your best efforts there's always something lying in wait and overlooked that will eventually surprise you.

Figure 5. Suspension - the original vehicle's front and rear beam axles are suspended from its tubular subframe by leaf springs. For cost and availability reasons my hope was to use coil compression springs for the suspension but it became clear on examining this that in terms of providing general structural support leaf springs are much more capable than coils. In the original vehicle there is no other structural support to the axles other than the leaf springs – they resist (presumably without significant deflection or twisting) all the cornering induced sideways acting loads and the drive and braking fore-aft loads and torque effects that come through the wheels - all whilst still allowing the vertical sprung movement to take place – quite neat really! To replace the leafs with coils I found I had to solve the problem of

Figure 5, Suspension and sub-frame construction.

constraining unwanted sideways movement and torque induced rotations of the beam axles. There was no avoiding it - the axles needed to be guided, and the guide structure had to come down from the subframe. After some head scratching I decided on a kind of floating pin arrangement to keep the beam axles centered and vertical guides to constrain any rotation of the axles about their vertical or lateral axes.

Subframe - with a clearer view of what the beam-axles, suspension and steering arrangements were likely to be I could position the main longitudinal elements of the subframe. Not too wide so as to constrain the steering articulation and not so narrow to prevent the batteries from sitting between them or making the foot well area too narrow for my feet. I could also fill-in what I thought the beam axle guide structures would be like picking up from the positions of the subframe longerons as their main points of structural support. The coil springs are positioned as shown and their upper support is provided by 1” square hollow section secured to the top of the subframe longerons.

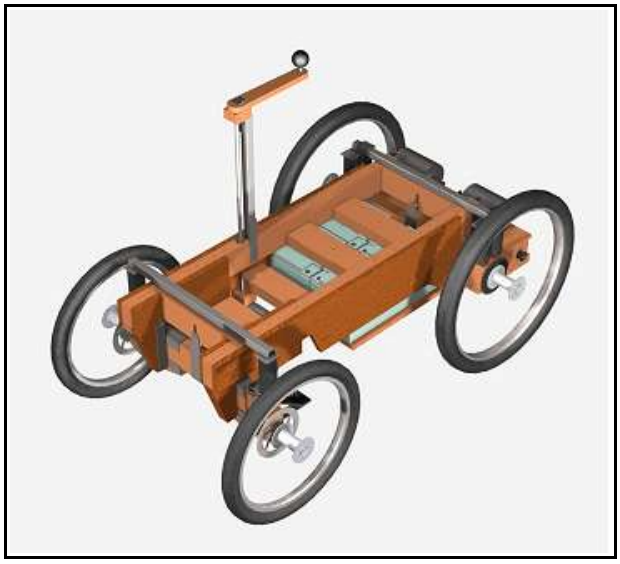

Figure 6, Showing subframe cross bracing and battery position.

Figure 6; the main cross bracing for the subframe is positioned to support the batteries as shown and to support some of the steering mechanism. I'm in two minds whether I need a closed floor - perhaps seeing the ground rushing by under my feet might be interesting!

By mounting the steering column on the longeron I've managed to keep the bottom half of the vehicle self-contained. It should be possible to simply lift the upper carriage right off. This should help the build and also any remedial or maintenance work I need to do on the vehicle. It might offer some possibilities for changing just the upper body design for other vehicle build projects.

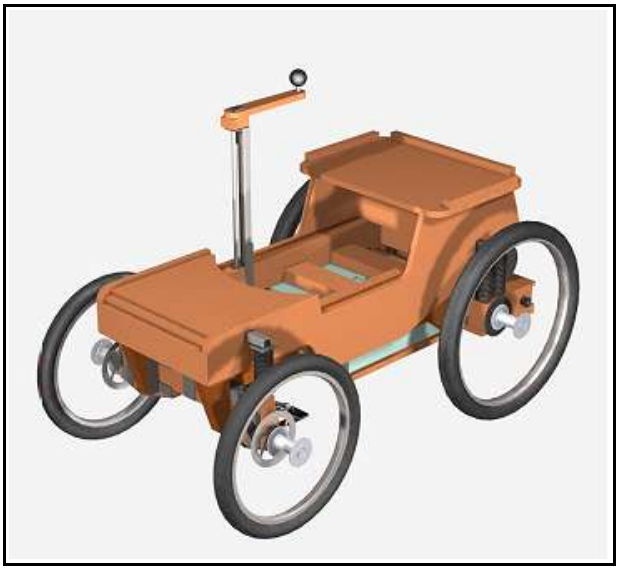

Figure 7, Upper carriage panels.

Figure 7; upper carriage side panels, seating position and front paneling added. All from 3/4” or 1/2” plywood. Fairly straight forward, but the side panels were the subject of a fair bit of alteration to try and get the vehicle appearance close to what I had hoped for. This is important off course because I want the vehicle to look attractive and to have clear visual connections with the original.

As with several other tricky areas of thedesign I found a useful technique was to take scale elevation paper prints of the vehicle from the CAD software and to use them as underlays for pencil sketch work. Once a working solution was found the relevant area of the CAD model could then be updated. It's as if some tricky configurational problems are easier to solve with a pencil rather than a mouse in hand.

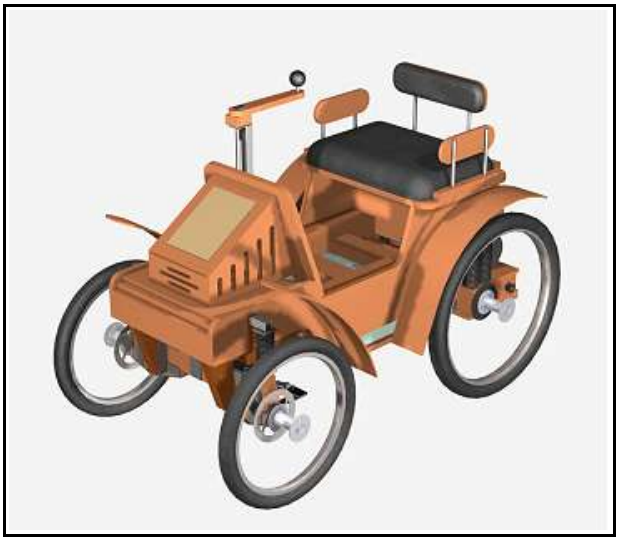

Figure 8, Bonnet, dash panel, seat rests & mudguards added.

Figure 8 shows the dash panel, bonnet, mudguards, seat cushions and rests added. The front "bonnet" area of the original Voiturette is the radiator for the front mounted engine. In this version I intend to house the motor controller there – as it also needs a flow of cooling air to keep it from overheating. I'll probably put the small number of indicators, switches etc required on the dash panel; at least a battery condition meter, on-off key switch plus any other lights etc that may be added. I quite like the idea of the reverse control being on the steering column somewhere in the form of a lever. The accelerator and main driving brake will probably be foot operated.The mudguards are another area where I'll have to learn some new build skills. The original has shaped plywood mudguards. I would like to make them from curved plywood too but have never tried to make free-standing curved ply parts. I've bent and secured ply sheet to curved formers in the past but I've never tried steam forming for example to produce a permanent self sustaining bend in wood. A quick search on the internet persuaded me it could probably be done – but I'll have to learn how before this project is finished – any suggestions anyone?

How does it look?

One of the great capabilities of a decent CAD modeler is its ability to produce rendered perspective images of the design – without any real skill input on the user's part. This makes it possible, long before the vehicle is built, to judge reasonably well what the vehicle will look like when it's finished.

Figure 9, CAD Rendering of the full ¾ scale vehicle.

Figure 10, And, in comparison, the real things.

I'm quite pleased with things so far although I'll leave readers to judge for themselves if they think I'm on the right tracks here with the design. It is however noticeable I think that my version is slightly "squatter" than the original and this is intentional. I did one or two calculations where I felt they were necessary and one was to consider the vehicle stability. As I had thought early on in the project, and as many of you will already know, these vehicles are not as stable as today's vehicles. Their centre of gravity is too high. Specifically the Voiturette will, under many tyre/road friction conditions, roll before it slides if subjected to heavy sideways loading. For this reason I've lowered the relative seating position slightly and increased the lateral wheel base. I've also tried hard to keep the heavy components low to lower the center of mass. Even so, if the vehicle is forced into its tightest turn circle at its full speed it is likely to tip. A sure indicator for the need for careful driving and for the need for wheels with good lateral strength which will not collapse under the significant sideways loading they might see. I also need to pay particular attention to ensuring the front disc brakes are effective. I wonder what the accident record of these types of vehicle was in their hey-day?

Where next?

As already mentioned there's a fair amount of detailing to do now, much concerning the many various joints and connections and their fasteners. Once this is done I can start to take scale prints of the vehicle parts and sub-assemblies from the CAD model that I can then use to build all the parts. Where necessary these prints can be dimensioned but often, especially if you're already familiar with the design, scale undimensioned prints can be used with an engineer's or draftsman's scale rule to obtain sizes. This isn't best practice in an industrial engineering setting but if you are both designer and builder it is relatively easy to keep things under control and represents an acceptable route forward.

My other main task is off course to start to collect all the parts and materials I will need. The motors are already on order and I have the wheels even if one or two are still in "kit" form! Other parts that I need to check I can get are the right chain sprockets and the suspension springs. The rest should be fairly easy to obtain. Oh yes, how to make the mudguards?

(PS Please send any suggestions on the mudguards or any other areas to Ian@builtforfun.co.uk . They will be most welcome.)

Note This article was originally published in Engines and Wheels™ Issue #45 and can be found at www.smallcarplans.com