Having A Go At A New Design

Ian Hopper (Built-For-Fun EV's)

The sight of many fine home-built machines on the small car plans web site has prompted me to have a go at designing and building my own replicar. But one with an electric drive. I thought that one or two articles describing how I get on might be of interest to readers of E&W and might also give some of you more experienced builders a bit of a chuckle. This one is about the project start.

What vehicle?

First thing I've to decide on is what vehicle. Most of the vehicles that appear on www.smallcarplans.com have, not surpisingly, US origins – Ford's Quadricycle being just one example. My own country, Scotland, has its own fair share of motor vehicle manufacturing history too, although little now remains by way of active manufacturing.

One of two Argyll Voiturettes in Glasgow's Museum of Transport

One particular company of interest to me is the now long gone Argyll Motor company which, together with its predecessor the Hozier Engineering Co. of Bridgeton, Glasgow was designing and manufacturing vehicles in Scotland from about 1898 up to 1932. My particular interest is in the company's very first vehicle design - the Argyll “Voiturette”. Released c. 1899 this very compact open carriage car shows marked similarities to the young Louis Renault's 1898 A-Type Voiturette built in France. Indeed one story I've found suggests that Alexander Govan, Argyll's main driving force, was encouraged in his efforts with his version after seeing the supply problems one London based “motor depot” was having with the Baby Renaults. In any case in the end Govan's version was sufficiently different from Renault's to persuade the latter not to sue the former! The vehicle type is of particular historical interest because Renault's was the very first to incorporate the drive layout of IC engine – gearbox – articulated drive shaft – to rear differential; a basic vehicle transmission layout that is heavily utilised right up to the present day. Argyll's version was popular too, differing significantly from the locally produced motorised “horseless carriage” type competition made in Scotland at the time.

What do I know about the vehicle?

What information have I got to work with? I've managed to unearth some reasonable sketches and have taken some approximate measurements from two restored models in my local transport museum in Glasgow. It carried two people. It had large diameter spoked wheels – about Ø680mm (27”) at the front and Ø830mm (33”) at the back; these were set on a 1230mm (48”) longitudinal wheel base. The lateral wheel base was about 850mm (33.5”) - quite a compact layout. In the Argylls I've seen the wheels and beam axles are leaf spring mounted below a tubular steel subframe which also carries the forward mounted engine and the drive transmission to the rear differential. The upper carriage is mainly

timber with rider and passenger seats set high above the rear wheels. It has several forward and one reverse gear (the numbers seem to vary in accounts, 3 or 4 being quoted) and, I think, hand operated drive and parking brakes. The steering tiller/bars and other control mechanisms are provided on a vertical control column set to the side and forward of the seats although a steering wheel appears on some later images I've seen.

Partly obscured side view on the Voiturette

Usefully I've also been able to find some performance information. The initial Argyll version was made with 2.75Hp French built De Dion-Bouton engines and had an 18mph top speed with a slow reverse. The Renault version is reported to have weighed 350kg (770lbs) unladen – probably about 500kg (1100lbs) with two adult riders – with these weights and sizes of engine the performance wouldn't have been spectacular!

Okay – so how to proceed?

My principal interest is in electrical drives in small vehicles and I would like to design a version of the Voiturette with one of these. This, together with the many practical constraints concerning tools, materials and components that home-builders must work with mean I'm not setting out with the intention of making an exact replica. The small question of my budget arises here also!

(As an aside here it's interesting to note that Renault's first vehicles sold for the equivalent of about 10 year's average salary at the time, my budget for this project is probably less than half the current average UK monthly income!)

I'd like, through the project, just to raise my hat to what was an innovative design of its time and to add some of my own ideas to make an updated vehicle that I am able to make in my modest workshop. Alex Govan and his small company made nearly one hundred voiturettes (with his patented gearbox) in 1900 but by 1902 it had already been dropped by the company in favour of bigger, more powerful designs. It seems that innovation and development of designs was as much an imperative in those early days as it is now for engineers. I'm sure neither Louis Renault nor Alex Govan would mind much if I were to modify their creations to produce something better suited to my own needs – they did it all the time! Renault's design was based on his converted De Dion-Bouton Tricycle and clearly Govan's design bears more than a passing resemblance to Renault's – both added their innovations.

I'd like to retain as far as is practicable the overall proportions of the vehicle - clearly it should look a bit like the original. There are some key limiting constraints though, many of which will affect the basic physical layout of my design -

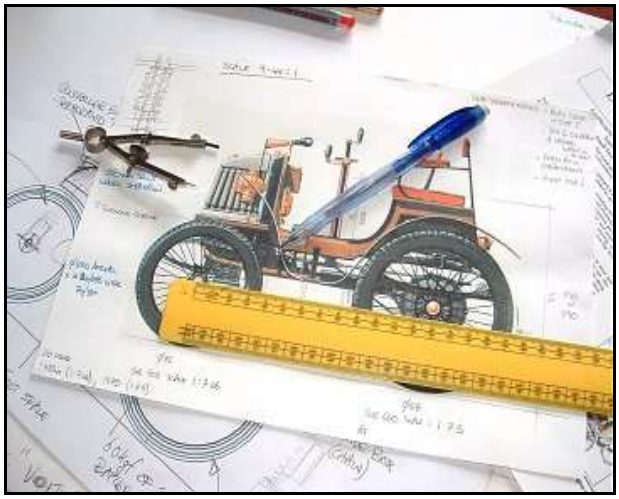
Wheels – there are not many bikes about nowadays with such large robustly made spoked wheels. I could try and get custom wheels built but would probably blow my entire build budget in the attempt. The ratio of the original 27” and 33” diameter wheels does however closely match the ratio of current standard 20” and 26” bike wheels and a reasonably accurate ¾ scale version could be made using these. (I bet several of you old hands could have told me that!).

Number of Riders – If it is to be a ¾ scale design it might be worth considering whether or not to design it as a single rather

than two man (person) vehicle. Or maybe at a push one adult and one child to allow the kids to ride along. This would certainly reduce the overall weight and hence the vehicle's power requirements with beneficial reductions in drive motor size and range between battery charges.

Center of Gravity (COG) – Looking at the images of the Voiturette it is clear that its COG is much higher than that of modern day vehicles. Off course the designer's principal concern here is vehicle stability, particularly on both controlled and forced cornering manoeuvres. On-the-flat stability is principally a battle between the self righting or restoring effect of the vehicle's downwards acting weight acting against the tipping or overturning effects of any sideways acting, mainly inertial, forces that arise due to the vehicle cornering at speed. Both these force components act through the vehicle's COG and the higher the COG the greater the overturning moments that arise from the lateral forces. Even without putting numbers to this it isn't to hard to deduce that there are two principal things that I can do to help matters here. One is to lower as much as possible the positions of all the heavy bits in the vehicle, including the rider, and the second is to widen as far as is possible the lateral wheel base. The latter increases the restoring moments developed by the vehicle weight at the point of tipping and the former reduces the cornering induced overturning moments.

It doesn't take a rocket scientist to spot a problem here though; both of these adjustments can easily conflict with my desire to retain the overall proportions of the original vehicle. It's a question of degree though, I should be able to improve the vehicle stability by slightly lowering the seating position, slinging the heavy batteries low and between the wheels and by not reducing the lateral wheel base by as much as the full three quarters scaling. These adjustments considered with the modest vehicle top speed of, say, 15 mph should be effective. Something to check in detail a bit later however.



Measuring-up from a good elevation drawing to determine sizes.

(The excellent drawing I used here was from www.histomobile.com – a site well worth a visit)

Turning Circle – A further item that can potentially affect the overall vehicle layout is its turning capabilities. Looking front-on at the vehicle it is clear to see that the front, steering, wheels aren't set all that far out from the vehicle's body. This suggests that the turning circle of the Voiturette wasn't all that tight; there simply isn't much room for the wheels to turn in to. I'd like to make my version of it reasonably manoeuvrable however and this will probably mean trying to increase the clearance between the wheels and the body – I would guess by reducing the width of the "nose" of the vehicle. This can be assessed graphically with some simple scale technical drawing and can be considered along with the Ackerman geometry arrangements for the steering components.

Vehicle Weight – As I have already indicated I think the original vehicle might have weighed up to 500kg (1100 lbs) laden. I'm looking at a target weight for my reduced scale single seater version of about half this figure, about 250kg (550lbs). With a single adult driver at 80kg (170lbs) and a guesstimated 60kg (130lbs) of battery this leaves me about 110kg (240lbs) for vehicle

structure and components. So long as I'm happy with the strength and rigidity I'd like to stick with a mainly timber subframe and upper carriage – I find wood is easier to work with, source and repair and demands less expensive tools.

Drive Power – The vehicle weight is significant off course because of its direct effect on drive power requirements and vehicle range between charges. I know that the original vehicle's 2.75 Hp single cylinder engine produced a reported 18 mph top speed. Everett Moore's Quadricycle design uses a 5.5Hp lawnmower engine and has a 15 mph top speed. I need to be able to select electric drive motors, probably two - each driving its own rear wheel to avoid me having to source and design-in a rear differential gear box. To make this selection I need to estimate power requirements and lacking other similarly spec'd electric vehicles to use as a reference I don't have much choice but to do some sums!

To get some power estimates in these circumstances I usually identify a number of operating conditions for the vehicle and estimate for each the drive forces that need to be applied to sustain the vehicle's motion. Taken together with the speeds of travel this allows me to calculate required mechanical power. Without going deeply into the maths, Table 1 shows some results.

The rough calcs show that for simple cruising at full speed on good flat drive surfaces about 400W (0.5Hp) is needed. This rises to about 1600W (2.1Hp) for full speed on hard gravel with a modest 1 in 20 gradient. Climbing steeper slopes, say a 1 in 8, needs a higher 2500W (3.3Hp) at full speed. If we bring acceleration into the equation – going from rest to 15 mph in 10 seconds on the flat takes about 1500W (2Hp). Trying to sustain this acceleration up our steep 1 in 8 gradient demands about 3650W (4.9Hp) just before the point of reaching top speed!

Operating Condition	*Total Drive Force Needed*	*Associated Vehicle Speed*	*Power Needed At Wheels*
Top Speed Cruise on dead Flat	61N (13.7lbf)	15mph (6.67m/s)	407W (0.54Hp)
Top Speed Cruise on Hard Gravel + 1 in 20 Gradient	238N (53.5lbf)	15mph (6.67m/s)	1590W (2.1Hp)
Top Speed Climb up 1 in 8 Gradient	381N (86lbf)	15mph (6.67m/s)	2540W (3.4Hp)
0 to 15 mph in 10 secs on the Flat	228N (51lbf)	15mph (6.67m/s)	1520W (2Hp)
0 to 15 mph in 10 secs up 1 in 8 Gradient	548N (123lbf)	15mph (6.67m/s)	3650W (4.9Hp)

Table 1. Approximate Drive Powers For 250Kg (550lbs) 15 mph Vehicle

So we have power requirements at the wheels ranging from 400W up to 3650W depending upon what we ask the vehicle to do. My candidate motors were two 600W electric scooter motors giving me a continuous power output of 1200W at full speed. I'm sure these will handle peak, short term outputs up to 2400W without too much difficulty so long as they are not asked to sustain this for any length of time. It looks like these could handle the on-the-flat cruising with short term accelerations but would struggle with any sustained 1 in 8 climbs for example. They would certainly not deliver full acceleration on a 1 in 8 climb. I'm happy not to expect my vehicle to do this.

My sense though is that 2 x 600W motors is still a bit underpowered. 800W versions of the motors are available, but I'd have to move up from 24V to 36V. This isn't in itself a problem but does mean that I need a 36V battery pack and this probably means moving up from 4 to 6 batteries – more space, weight and cost. My alternative is to reduce the vehicle's top speed – cutting from 15 mph down to 12 mph would take 20% off the power figures straight away –

worth thinking about if I can still use the cheaper 600W motors and 4 rather than 6 12V batteries.

Range – Given these powers and allowing a bit for motor inefficiencies I reckon when cruising on the flat on good drive surfaces I might just squeeze about 2 hours continuous use from 4 x 38AmpH 12V batteries – maybe 20+ miles on a single charge. This could though be reduced significantly if the vehicle has to take many steepish hills or if it does a lot of stopping and starting.

So where does all this leave me?

With all this stuff in mind I'm feeling reasonably confident there's a working vehicle in there, somewhere. Next step is to draft a sketch layout, shown below – prior to doing a more detailed mechanical layout.

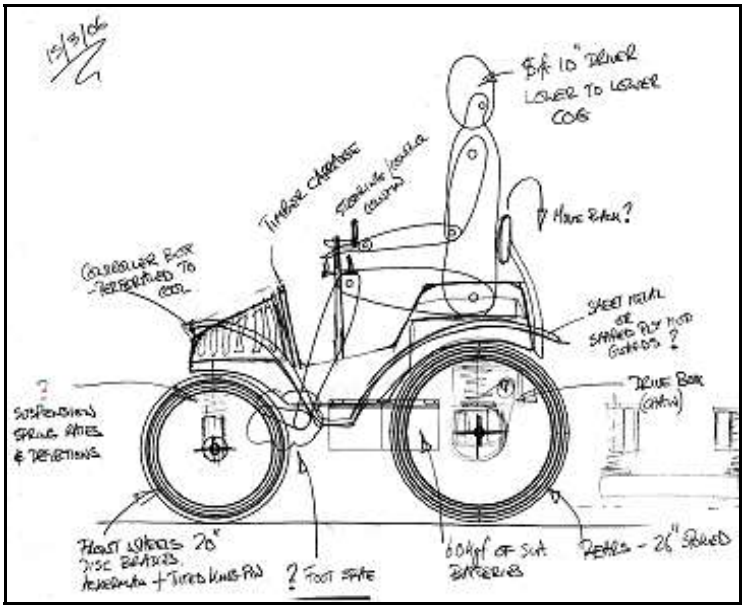
I've obviously lots still to think about - this is a long way from a finished design. I know the wheels are going to be a problem as I can't get the Worksman heavy duty wheels here in the UK. I need good brakes, the steering needs to be true and secure and the mechanical drive to the rear wheels needs to be right. Leaf springs for the suspension are likely to be out of my budget, so coil springs are more likely and, off course, there's the detail of the timber subframe and upper carriage to consider. Phew!

Alex Govan's obituary writer wrote in the Glasgow Herald on 28th May 1907, "The man who makes no mistakes makes nothing", before going on to describe how Mr Govan "for weeks on end... practically worked and ate and slept" in his factory solving one technical problem after another when developing his vehicles. I'm not so sure about the sleeping in the workshop bit but I do sense a bundle of mistakes coming my way!

I'll keep you all informed about developments.

You can contact the authour at Ian@builtforfun.co.uk

Note This article was originally published in Engines and Wheels™ Issue #44 and can be found at www.smallcarplans.com



A start – a scale layout sketch of the design – much to do

(but never underestimate the value of a good sketch).