T100/09 Materials and mechanics: the Moulton bicycle

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Narrator:
A machine develops and continues to develop. Take the Hobby-Horse; in 1791 this was just a toy, a moving seat. But when pedals were added it became the first real bicycle. Over the years, various models came and went, each striving for an easy, speedy ride but as the bicycle became more efficient, other problems arose. Solid wheels made them bone shakers. These were the days before the pneumatic tyre. The Penny-Farthing attempted to overcome this by having a large wheel which would ride over holes in the road. But when riders could get on them, they often fell off. They may look impressive, but weren't a success. The designs moved on, many were tried but none survived, probably because of their complications. By the early 1900s, the shape was getting nearer to the now familiar diamond frame structure with equal sized wheels. Was this the ultimate basic shape for a bicycle? One might think so. Although lots of things have improved, brakes, tyres and so on, the diamond frame structure still remained.

But then, in 1962, something radical happened. A new bicycle came on the market, this time with small wheels. Its designer was Alex Moulton. This programme is about the evolution of his design. While Alex Moulton himself tells his story of why he built it his way, observe how he used materials in novel ways to deal with such mechanics problems as compression, shear, strength and stiffness. You may disagree with his approach to design, you may disagree with his solutions. Think about it for yourself. For there isn't a unique solution to any design problem.

Alex Moulton:
It is the efficiency of a bicycle that fascinates me as an engineer.

Now, this is my own personal bike which I love riding. Let's go inside now, to the museum and have a look at how it all happened.

Now this is how it all began, as far as I was concerned. In 1956, the time of the Suez Crisis, I thought that I would turn to my old love, the bicycle, and get the very best classical one that I could, to ride about in the petrol shortage, and this Hitchins machine, I bought. And as you see, it's got high pressure tyres, a very light frame, and the best that goes into classical practice. And it is the efficiency of the bicycle that fascinated me right from the beginning. But riding this machine made me wonder whether we couldn't take the thing a stage further.

So that was the conventional bicycle and what did we do? Well, the first thing we had a look at was whether the classical position of riding was correct. And we bought a horizontal bicycle where the posture is recumbent and we soon found that it was more tiring to hold this horizontal position turning on the heavy thigh, than the classical. So a feature we were definitely going to use on the new bicycle was the standard riding position. 4'12"

Then we made, which is if you like called the groping period for a definitive form, a number of models. And they all had features in common, namely relatively small-sized wheels, the orthodox riding position and operating onto a pedal and crank mechanism, and some sort of weather protection on the front, the possibility of carrying some baggage on the back. And also important, an open frame in order that the bicycle could be unisex as it were and not have a differentiation of machines with a cross bar or an open frame as on the classical. 4'58"

Now with the small wheel it was very apparent from the beginning that we should suffer shock. So right from the first experiments we had in the first instance a front fork suspension - this is the fork, here is the wheel spindle here - and (in fact, that's the way around), with a little leading arm and a rubber spring. Now the first actual bicycle incorporating some of these features which we made incorporated this light alloy aluminium frame, which is as you see very light and thin, and the machine itself had this open form, the adjustment of the saddle there, and of the platform for carrying luggage there. The machine looked like this. Its first form in 1959. And when being ridden, like that. That was our Mark 1, August 1959. So this was our first experiment. 6'15" But it was very unsatisfactory in a fundamental reason that there was road noise or vibration coming up from the hull. And it was one of these click decisions to say that it was entirely wrong to try and make the structure out of a monocog in the manner of an aeroplane or a motor car. And the right thing was to go for a frame. So this was our first actual definitive machine. You must forgive the cannibalisation which has taken place afterwards where we used this machine for, as you can see, for experimenting with different head angles and trails, but you can see the form. A tubular backbone going from above the wheel, the front wheel, down towards the rear wheel. The modern bracket or crank axle dependant from it, and the upright of the seat tube coming up from the crank axle. And this is the definitive F form mounted on the 16" wheel with high-pressure tyres, which became the definitive form of the Moulton Bike. 7'35"

Now looking at these machines here, they represent an intensive period of development. The form having been established, but development to get the thing finished and closed. In passing, you will note that from the models that we've looked at the weather protection was tried in this form. And you can see the shield and the rather hooded mudguard and the rear protection for the rear wheel, very well shrouded, and this theme of protection against weather we carried through with the help of Sergio Pininfarina my friend and famous body designer, who improved very much the shape of this cowl or weather protectipn from my stumbling efforts to get the simple shape to this pleasantly styled one. In the event, we didn't in fact go on with any form of weather protection. We felt that it was too cumbersome and too large from the point of view of stowing the machine. 8'58"

Now let us have a look therefore at what we did go on with in the last stages of development before we went on the stage of production. Now starting at the front, I've said that we felt it was very necessary to have, with these small wheels and high pressure tyre, some form of suspension. And the first one that we used in a serious way was this triangulated fork here, carrying the front spindle, and also making an abutment for the caliper brake underneath, and pivoted at the rear there with a very stiff tube here going up into the steering column. So as the wheel is turned the steering, as the handle bar is turned the steering is conveyed to this pivot through this stiff tube. The spring itself is simply a block of rubber which, I can press it down so, the suspension is attained by the rubber being deformed in compression in that way. 10'13"

Now one of the objectives of this form of suspension was the fact that it could be commonised with that at the rear. And if you look at the rear of the machine you will see a similar construction operating through a lever from pressings onto a rubber compression spring and with the similar position of the caliper brake underneath this triangulated construction. 10'43"

Now coming back again to the front, we found that though this gave a very silky ride and suspension, there was a fundamental disadvantage which drove our design into a different direction, namely that the mass of this concentrated so far behind the steering axis opposed the natural movement of the bicycle in producing its self-centring force, which is that when it leans into a bend the wheel should tend to turn in and thereby generate a centrifugal force which is the first act of stability. The mass of this thing opposed this and tended to move in the opposite

direction, and it gave a very unsatisfactory feel to the steering. So this concentration of mass had to go. 11'45" And we worked on a telescopic fork in which there was no mass here, concentration of mass here, but the spring was up inside the head post. And one of the problems was to obtain telescoping, meaning moving up and down in that way, and at the same time to maintain the guidance which is obviously essential in a steering system. And this first attempt was a very obvious one. It was in the manner of an aircraft undercarriage, namely the toggle link, which communicates the rotational movement from here to there, at the same time allowing the telescoping to take place, moved up and down in that way. 12'35"

So this was a solution which produced good steering and not bad suspension, but defective in the scale of a bicycle with its harsh usage, defective in having these exposed joints. That was therefore to go. Now just before we leave this machine, here is another feature which had arrived, namely the carrying handle had now become a structural member and also visually in order to strengthen the line of the machine, remembering that we had this open frame and I felt that it was necessary to have a masculine line to the thing in the manner of a cross-bar which we'd removed, so aesthetically this could be likened to a small cross-bar so that the boys wouldn't mind, wouldn't feel emasculated in riding an open frame bicycle. Structurally, we went straight through to this carrier here, actually piercing the seat post and had this considerable strut under there and no tie to support toe load from here. On the rear suspension, having got rid of the similarity between the front and the rear, we went to a single tube here and acting on a compression block in that manner, and we had removed the caliper brake from its vulnerable position from the point of view of rain going onto it when it was down there, to a better protected position there. So that is the penultimate development of the bicycle before it went on the stage of marketing. 14'33"

Now at last we come to the bicycle that went before the very surprised public in November, 1962, at the Bicycle Show, where we were overwhelmed by the interest and desire to buy this thing we had created over the last few years. Now you'll see, taking an

overall view how the definitive form has come. Front carrier. The open frame, male or female. The horizontal low cross-bar for structural reasons as well as to provide a support for the large rear boot here. And the support of the carrier beam is by a tie which was very soon added to by this strut here because we soon found that people were overloading this rear boot and we had trouble in this area here due to the inadequacy of this stiffness. So that strut was importantly put in immediately after production. 15'55"

Now let's look at what we did in the final count on the front and rear suspension on this first production model. 16'10" Here is a sectioned model of the frame I've just shown you and you can see, looking at the front, what we finally did. We maintained a spring up the middle of this telescope, which looks like, in fact, this, which is just a bit of rubber cord inside a coil spring which stabilises the rubber and organises movement, but essentially rubber, carrying 80% of the load, and a coil spring to organise the deflection of the rubber. The spring goes in there and the whole is a single telescopic unit in which the important function of the steering guidance is obtained by a splined nylon sleeve there, which belongs with the steering column, which engages with these metal splines which belongs to the fork. And the movement between one and the other provides the location of the fork and at the same time provides the guidance, in that way, accompanied by the movement up and down for suspension. In this way, which you can just see there, and at the same time allowing the steering to take place. A very neat solution which we have kept throughout the whole series of design. 17'55"

Then coming to the rear of the machine, rear suspension comprises a bonded rubber compression share element. Compression in that way. And shared between there and there in that manner. As you can see as I flex it. The whole of the rear fork is pivoted on a nylon bushed bearing which provides action without the need for lubrication. Here you see the strut which was put in demountably and fixed by a little yoke there, to support the excess load which could easily be put onto the carrier, which with only this tie made the whole of this seat post rotate about that axis there with disastrous results. This little tie, this little strut was immensely effective, being so far out from that point there, immensely effective in supporting a great load there without deformation there. 19'14"

So that was the machine which we went into production with and which started the revolution of the small wheel bicycle

which really showed that the classical machine, with its diamond frame and 26" wheel, need not rule supreme without any challenge.

19'38"