

Interview with Al Whelband at his home, July 1, 1983 and Al is informing me and giving me the set-up on the series of Avro Flying Flying Saucers, Avro Canada Flying Saucers, which started around 1952 and was terminated in the early 60's.

O.K. This is Al Whelband. I should really start off by giving my personal history. I don't want to give you a lot verbal diarrhea but I was born in England in Buckinghamshire in 1927, early '27. I attended primary school there and I went to the Royal Grammar School at High Wickham in Bucks until I got my senior metric and then I did some work in a technical school to learn how to do a little bit of drafting and I finally finished up the Martin Baker Aircraft Company in September 1943 where I did about a four and a half year apprenticeship in the Aircraft Design business. At which time, for the people who don't know Martin Baker's is a little family business, really, run by a Sir James Martin as he used to be, although he just died recently, was personally involved with all his employees and when I intimated that I would like to go to Canada to further my endeavors he suggested that a guy by the name of John Frost, who he knew fairly well from DeHavilland Aircraft in England, who was the project engineer on the DeHavilland 108 (which I think they called the "Swallow") some form of flying wing - we had, as a matter of fact, put the ejector seat in there and he said that "why don't you go see, in fact, he called him Jack Frost, that's how well he knew him - not too well - but anyway, he gave me a letter of introduction to John Frost and I came to Canada on August '47. I went straight to Morton and had an

interview with John Frost on the strength of this letter and he sat me the very same day and I started working on the design of the C100.

From that day on until John Frost left Canada I worked for John Frost exclusively when I was employed by AVO, which later became Avro Aircraft. I see by my notes here that I worked on the design of the C100 from August '47 until November '52. As you probably know the CF100 first flew in 1951 and I might say at this time that John Frost was an innovative designer, but he was a man of new ideas and new things and as soon as something became old hat and accepted and started getting involved in production he wasn't too interested and on that basis when the C100 first flew and went through it's first teething troubles and people started talking about making a production airplane out of it and selling it to the air force in large quantities I believe it was Sir, what the heck was the guy's name, it was, O.K. well, Sir Roy Dobson, in his best judgement decided he would send a team, or the nucleus of a team, to Canada to productionize the C100 and put it on the rails in a saleable form for the Canadian Air Force. So, he said at that time a guy by the name of Bob Linley a very good designer, I believe at that time several other people came over and the net result of that really was that John Frost, to a certain extent got sidelined as the chief designer of the C100 because Bob Linley kind of took over.

Now in the background to all of this we had Jim Chamberlain, who was a real technical _____, not a nuts and bolts man at all, purely technical and I must admit never very much of a friend of John Frost, although they worked together on the C100 and I know Jim Chamberlain's input in the C100 were invaluable. However, John Frost was an inno-

vative man and couldn't wait for all the new numbers to come through the computer. He had to see things work right away so they never really ever saw eye to eye in any form. And Jim Chamberlain, at this time, politically grew a lot of strength in _____ along with Bob Linley and Guest Hake and many of the people that Sir Roy Dobson sent to productionize the C100 formed a team of their own and John Frost to a certain extent was left out in the cold. And John Frost, the innovative man that he was, obviously they didn't want to get rid of him at that time, he was going to be useful in some capacity, they didn't know what. And at that time he didn't know what, but he sat down with his piece of paper and designed what he thought was a brand new concept, which turned out to be the startings of the AVRO car. The AVRO car was the termination, not necessarily deserved by any matter of means, but the termination of his seed thought that he had in the early, let's see now, early November of 195... early 1952. I would think probably during the summer of '52. And he really envisaged, now we'll depart from AVRO political intrigue and we'll now concentrate on John Frost and his team which formed almost jealously as a separate design bunch of boffins who were always hidden in a small corner somewhere within the company and right from the very start were beleaguered by very, very secret guards on the door, locked doors, special passes. We were not exactly ostracized but we played our own little tune in the corner of a very large company led by John Frost. John Frost was joined by Dezel. I don't remember the coming together of the two but during their whole life at AVRO they were an inseparable couple. Dezel has an aerodynamic background, John Frost had a nuts and bolts background -- to be perfectly honest -- although

I admired John Frost in a tremendous amount of ways, he was purely a nuts and bolts innovator and Dezel injected the necessary technical inputs to keep the thing technically on the rails.

O.K. So then I should really talk about the germ of the idea that John Frost had that started them off on this tangent of flying saucers. That is really a misnomer and a lot of people have written crazy things about people from outer space but this was no more, really, than a flying airplane of a different type. In his original idea, as he explained it to me when I first went to work with him on this group, was that if you can envisage a section through a normal jet engine with a compressor at the front, the center line being the axle, if you like, followed past the compressor by combustion chambers where the fuel is burned, followed again by a turbine which drove the compressor and finished up with a jet efflux at the back. He looked at this piece of paper like only John Frost could look at this piece of paper and decided that if you cut the paper on the center line of the axle and instead of the engine rotating about it's own axis it now rotated about an axis through the cut line so that the whole thing became many, many jet engines, if you like, in a circle. This then led to a flat plate, if you were, a saucer with a hole cut out in the middle where the air went in. Radiating from that were compressor blades in many, many rows. Radiating from the compressor blades again in many, many rows were combustion chambers. At the very end, or the tip of the saucer if you like, that I described to you, are turbine blades which drove the whole thing. Now, if you duplicate this and put another one on the bottom of the saucer that I've cut the hole in you

really have a germ of his idea or his idea of a huge, flat, round jet engine with all the jet coming out around the tip. John Frost explained this to me when he got most enthusiastic at the beginning and from some numbers him and Dezel had done went right, wrong, or indifferent, I'm not sure, made this engine which was three feet and approximately 30 feet in diameter, gave it approximately the horsepower of the Queen Mary, which I understand is around 250 thousand horsepower, and this set the whole thing on fire and John Frost and the whole team were extremely enthusiastic. We drew lots and lots of pictures. We all realized, including John Frost, there were many, many problems involved. John Frost was a man who didn't bother about the longsighted problems, he only bothered about the one that was today and we'd worry about tomorrow's problems tomorrow and he tackled this job by biting a little piece off every day and solving a problem every day and worrying about tomorrow tomorrow.

We worked along on this thing for perhaps six months to nine months to a year. We produced eventually an airplane picture which, by the nature of the beast, was basically circular and now we had a great problem because all this jet is coming out radially all the way around. And of course, it all has to be turned backwards to drive the airplane along. So, around this disc, if you like, he drew a spade shape, the idea being you could direct the jet backwards on either side and then, of course, from approximately the center line of the engine all the jet eflux could be directed directly backwards internally and it would now spill over but if over and under a control surface which would be buried in the eflux, which of course,

became a very, very powerful control and completely independent of the speed of the airplane, from zero to everything, the control forces would be approximately the same.

The next problem of course was how are you going to get this thing in the air. There was never any doubt in John Frost's or Dezel's mind or any one of us that the thing wouldn't fly when it was finished but we had to get it in the air and in those days the thinking was, well, we have to sit it on it's tail and we have to shoot it into the air. We had lot's of power to do it, it was VTOL I mean, it's power to weight ratio was something to believe if you could believe the two hundred and fifty thousand horsepower. The all out weight of the airplane, which was probably in the order of ten to twelve thousand pounds, it was a fantastic performer. So, this became known then as Project Y. And I do believe at that time that although I wasn't involved directly with any of the administration part of the operation, that some money was obtained from the Canadian government to do some basic research and produce a mock-up, which was full size. I can see it now. It was built in the flight test hangar at AVRO. It was behind very high walls and under very tight security and it sat at an angle of inclination to the vertical of about 20°. It sat on two tail wheels which were the corner apex's of this spade shaped airplane and it had a praying mantis type of appearance. I can remember at one time when this mock-up was basically finished General Montgomery coming to Canada for some other reason, obviously, but I think an awful lot of political enhancement was put on the project by the fact that he visited and was photographed. And I wish I

could get the pictures of him staring at this praying mantis, banging his stick against his leg and saying what a marvelous thing. He wished he had had it in the desert. However, that was all part of the political intrigue to get more and more money for this project.

O.K. Les was explaining to me just now that I perhaps didn't describe in enough detail how the eflux from the front part of the saucer got turned backwards. I think this was one of the main reasons why the airplane was designed as a spade shaped airplane with a point at the front and internal ducting leading to some almost like shark's teeth outlets around the sides where all the front part of the jet was turned backwards and eflux from the sides of the thing backwards. I did, I think, explain about the stuff from the center line back that went over the _____.

O.K. Now to continue, _____ also showed me a thing called an AVRO Canada Omega which some press man got on May 1, 1953. I don't really recognize it but I do see a difference in that the jet eflux on this airplane was really all collated from a compressor and all the eflux from the combustion chambers and through the turbine were dumped out the bottom of the airplane. I can only assume that this was some idea of John Frost's, he went through many of these ideas to obtain money and it may well be another one of his ideas to cut a little bit of the technical risk out of the airplane and perhaps sell it to the Canadian government as a smaller, less of a big bite project. As far as my knowledge is concerned, this airplane never really even got to the drawing board stage.

Now, to carry on from the spade shaped airplane, I think every

one in all the government circles who were the Mr. Monies thought that this was going to be a terribly big technical risk and a very expensive venture and they wanted a second opinion. On that basis John Frost and Dezel and John Dawbery, who was a very experienced mathematician and aerodynamicist who became a member of the team not too long before this, went to Farnborough for an extended period and Boscomb Down, I believe, and expounded their ideas to all the English boffins. The idea being that these boffins would then report back to the Canadian government and I do believe later on to the American government, on what their thinking of these crazy men's ideas were and how best, if at all, it should be pursued. I'm thinking historically back, being so closely associated with it at the time we didn't realize but I think the outcome of that whole thing was, yes, the British did think it was much too big a bite for anyone to take, especially Canada with her small financial resources. And that the thing eventually one day would become very successful but it was much too venturesome a technical problem for Canada to undertake at that time. So, then John Frost, not to be daunted, then went over the border. And I can remember him coming back compounding about General Pott of the U.S. Army and the U.S. Air Force who was set fire by these ideas and the yanks themselves then, did sort of a survey into, they all came up in strength, we showed them all our ideas. They expounded the whole lot and they came to a very similar judgement even though the Americans, with all their resources, that we were too far along the game. We were too far ahead of our time and what the Americans suggested in their

wisdom was, things should be cut down into smaller chunks and bitten off in smaller bites and we would eventually finish up with this airplane many years down the road, but we had to prove each piece as we went along. On this basis, O.K., I should backtrack just a little bit.

The airplane that was showed to General Montgomery, the spade shaped Project Y - John Frost was all the time worried about this praying mantis idea and the fact that the thing would be totally unstable when it first left the ground and we had all sorts of black boxes to contend with to keep the thing on the rails until it got airborne, started thinking about a flat riser. Now, I think you probably understand what I mean by a flat riser in that instead of pointing the thing up in the air and taking off we would sit flat and then we would hover the thing off the ground. And then transition into forward flight when we were airborne. Now, my knowledge as far as my knowledge was concerned, John Frost was the original concept, the original man that thought about ground cushioned machines at this time. In fact, I can remember Cockrel coming over from England before he ever got involved in ground cushioned vehicles to speak to John Frost cause he was also interested in this, and I honestly believe John Frost was the forerunner in the whole new ball game which were the ground effect machines, but we won't go into that too deeply now. However, now this jet eflex is coming out all the way around the saucer and the next thing to do first of all is to direct it all downwards. We direct it all downwards, of course the airplane lifts off the ground in a flat manner. Then, we

have to contrive to direct it all backwards in degrees until the airplane is foilborne, as we call it. A lot of work went into this and a lot of innovations came out of this. John Frost was tickled to death now because the airplane could be what he always wanted it to be, which was round. And this was where, really, up until this time no one ever talked about flying saucers. When the flat riser came along, which enabled us to have a completely round airplane, everybody immediately tagged onto the flying saucer idea. We did lots of tests. The Americans were now onboard. The Americans gave us freely of their wind tunnels, both in Boston and in Dayton and, I believe, other places, but later on, of course, the 40 by 80 wind tunnel at NASA Ames Research Center in California. That's a little later in the picture. However, yes, the Americans, as I mentioned before said, Let's bite it off in smaller chunks. The first chunk they bit off was a big one. They said, Well look, this engine is going to take a tremendous amount of multi-millions of dollars. And in those days multi-millions was like multi-billions today. They said, It's going to cost us too much to find out whether it's going to work. We'll agree with you that it will work one day. In the meantime we will provide you with a jet eflux of the tip of the circle in a totally different manner. How about going and buying a half dozen or dozen of whatever you need in the way of jet engines and pointing them radially outwards, making jet pipes that flatten out to form a periphery and then we will have a tip jet without the expense of designing the engine. And of course, naturally, John Frost jumped on the bandwagon, the only bandwagon that was left

to keep the thing going. O.K. boys, let's get some engines. And with that in mind, the Americans were very kind, went to England, spoke to Armstrong Sibley, ordered us some Viper engines. We sat down and designed. We produced one segment of this which I can well remember being tested, of a jet engine running into a fan shape which formed approximately a sixth or tenth of a circle and with a control on the end of it which shot the stuff downwards, outwards, upwards, backwards... in other words we designed a high temperature control on the back end of a jet engine. We pursued this for some time then the Americans reviewed it all again and said now this is getting expensive fellas. I think, let's think of another idea. Let's, I may mention that the whole thing sounds like and it really was in retrospect, a downhill retrogression from his original idea. But, however, by the nature of the beast, rather get some money to do something than to can the whole thing, John Frost constantly went along with the Americans and their ideas, how we can make this into smaller bites, put smaller amounts of money. Yes, I might mention and Les has just reminded me that the first engine that was discussed was an engine called the Gendavick which was made by Armstrong Sibley as a short life engine for a missile program and these were going to be made available to us but by the time the Americans in their wisdom had put all the paper work through necessary to buy these engines the Gendavick had become a long life engine which was called the AS Viper 5 which the Americans bought. I found out later that they bought more than they gave us. They bought some for themselves too and went off into their Ve___ programs with them as well. However, where did I get to now.

Maybe we should have a rethink first.

O.K. Well, we just had a little dissertation with Les to get our facts more oriented and organized in a logical fashion. I just finished explained how these radial Viper engines, which, and Les didn't quite understand, I'll explain again. The air went into the center of the circle and radiated outwards through these eight Viper engines and I think John Frost there again was a leader in the field of, everyone up to that time had thought that jet efluxes were terribly hot, very difficult to manage and he was the first inventor and pioneer, if you like, of changing the shapes of jet pipes to squash them up into shapes and change the direction of the air within the jet pipes. However, this was all done, this was all developed and I have in front of me now a report dated December 14, 1954 which really very well describes what I've been talking about in terms of the eight Viper Radial Flow Airplane, which we called Y2. This was the first one that was specially funded by the American government.

Now then, we did get to the stage of building one of these fan-tailed jet pipes as I will call them, with an engine on the front, which we ran - which we played with a controls which worked quite well, but my memory is a little bit hazy, I do believe that this is where the Americans came back and said this is still too damned expensive. We really have to find a way of proving this concept in a little cheaper manner. We now bought these engines, we have them. Can you think of an idea how we can use them and take some of the money out. And I think at that time, and I think correctly, John Frost said the best way to get the money out of this program is to stop playing around with the hot air as much, where we have to use

stainless steel and we have fatigue problems and we have all sorts of temperature problems and distortion problems and also problems of directing this extremely hot air with moveable controls, many, many faceted outlets and so on. We can take an awful lot of money if we can only use cold air instead of hot. So, although Y2 could well have been a very successful project and we did proof test some of the basic hardware i.e. one eighth of the airplane, full scale, running behind a jet engine, at that time it was decided that let's cut down one more notch and we will make a proposal for the Americans that we have, in fact, thought of an idea how we could use these engines that they bought, how we can take a lot of money out of the project, how we can get-all the time of course, we were compromising, all the time we were going downhill, all the time we were getting to an airplane which won't have as much thrust, which won't be as successful in the end, but however, the same old John Frost thing came through. Well, fellows, we've got to do something to keep these guys happy. I know it's not what we all want to do but it's at least working along the same lines. So, we then took and we found that six Viper engines not eight, six, could drive a compressor. And this became what eventually became Project 1794. Now all these numbers are mysterious to everyone including myself but I do believe they really are numbers which were dreamed up by the American various agencies, development, money agencies in the United States who could get money from who ever they could get it from, Army, Navy, Air Force, Research and Development, NASA or NACA as they called themselves in those days. Whoever you could get money from you went to them and they gave you the new number. So now we have instead of Y2 which was the first funding

from the United States, we now have Project 1794 which is six Viper engines and a very similar looking airplane except that these engines drive a compressor - a separate compressor completely. These engines are still radially disposed in the airplane however, now instead of outwards they now point inwards. The jet eflux from these six engines now go inwards and into a similar kind of an array that we had before but instead of shooting out the outside of the airplane they now went inwards and shot through a turbine which was attached to a compressor which is a double sided compressor and I guess in technical terms it's called a Lungstrom compressor. It has vertical blades like a radial engine which compress the air. So now we have six Vipers, I forget their exact power of thrust, but it really doesn't matter, driving through this turbine. The eflux after it went through the turbine we always used to refer to it as a dead man's breath because we tried to extract as much energy from it as we could and so all you had was a puff of hot air coming out with a very low speed which we then dumped out the bottom of the airplane. Now then, the hole in the airplane was now full of cold compressed air, compressed by this Lungstrom compressor and this column of cold air, under pressure was now radially sent outwards to the tip of the airplane. Now, we had a different ballgame. Now, we had a cold airplane. Now, we had controls that even people who didn't think as far ahead as we did in those days could understand that it was feasible to start pushing this air off in different directions with very conventional type of controls made of aluminum, made of light and easy to manufacture material and now we had an airplane which we thought the Americans would possibly

find was cheaper and would, although it wasn't doing all we wanted to do we still had a column of air going radially out around the circular vehicle. We still had controls on the tip of it and I might mention at this time that we went through many, many ways of changing the direction of this air - upwards, outwards, downwards, backwards and at this time, if not before, John Frost thought he had designed, thought he had discovered a phenomenon of air attaching itself to a curved surface and thereby being changed in direction with no other application. In other words, if you blow a sheet of air over a curved panel the air follows the curve of the panel and in this way we could then direct air. We thought we had a new concept. We later found that it was a man called Henry Coll^{w?}ander who had patents on this basic principle in France from several years before. However, jolly good luck, anyway, we used the Cowander surface to a degree in various ways of controlling this air. We used many other methods, but the net result was Project 1794 was funded. O.K. So now we have Project 1794, funded by the American government to basically do the scampings of the design for an airplane containing six Viper engines, driving a large compressor and using the cold air to propel and control this flat rising airplane. My understanding is that 1794 did just that. It was quite successful in it's, it was completed and the final reports were sent to the United States and then, my memory is very, being jogged all the time, but then I find another thing here which is PV704 6 Viper test rig. And this reminds me, which I think is the correct order of things. We have 1794 which paid for the basic concept design, provided all the drawings, provided all the necessary sales hardware for the Americans to then go back to their co-horts and discuss what next to do. And some agency,

whether it was Air Force, Navy, Army, NASA, I don't know. I wasn't involved in the administration part of things. I've said it before, I'll say it again. But, I think what happened was - along came this PV704 6 Viper Test Rig. And I think in there, Test Rig is the answer. And my memory is jogged to the effect that 704 was another lump of money which came when 1794 was completed which was no more than some money to provide the drawings of a projected airplane using this concept. And now another agency got involved and said O.K. we like the airplane, we like the concept. We now want to bite off a chunk of that and we want to bite off the machinery and we want to make sure that the machinery will work before we contract for a complete airplane. So, here comes PV704 which was based on the 1794 proposal. It was based on the 1794 airplane and it bit off the center mechanical chunk which were the six Viper engines, the Lungstrom compressor, the turbines to drive it and that was to be built and that was to be tested and that was to be mechanically proven and if that all mechanically proved correctly, as the saying goes, we will then put more money in to design the rest of the airplane and we will then make a prototype airplane. And then everyone gets very excited.

So here we go. 1794 - a lot of time is spent, a lot of money spent, a lot more people start to get involved. We built the complete center of this airplane. We built the structure with the fuel tanks, the integral fuel tanks which we used to fuel the airplane. We built the Lungstrom compressor with the help, I might say, I think I'm right, of some expertise from _____ engines. We built first of all, one of these segments with one Viper engine on it with it's own jet pipe

there again, flattened out again to drive this turbine. We ran this on a separate rig. We proved it out. We had a man out from Armstrong Siddely to help us run the engine and tell us all the quirks. We then built the complete center section of the whole circular airplane out of aluminum complete with it's intake and it's intake guide vanes, you name it. We built the Lungstrom compressor in it's entirety complete with it's turbines. I do believe, if my memory doesn't fail me that a lot of this stuff was far beyond the technical expertise of Canada at that time and I remember dealing with a company in California to do what they called microbrazing, which was a very, very high temperature braze used on nimonic type materials to weld the turbine blades into this assembly. I believe the tooling was made at AVRO's. The tooling was sent to California. These guys made up these hollow turbine blades and, you know in thinking about it, here we are in 1983, we were using very, very thin hollow metal blades fabricated and welded together - things that aren't even being used today. We were air cooling them with cold air which is the sort of things that Rolls Royce have only been talking about the last four or five years. And we were really, although we didn't know it at the time, far along the line in aircraft turbine design at that time. However, we built this thing. It was a tremendous undertaking. We were going into the unknown, if you like. We were a small bunch of guys. There were probably at that time, there, we probably built up to a team of perhaps twenty people. We had got ourselves a little shop all of our own with _____ Kels as the shop foreman, with a couple of sub-foremen - possibly up to a dozen men working in the shop. You have

to remember at this time that these guys weren't only building this, we had ongoing programs of wind tunnel model designs for various concepts. We were making and testing wind tunnels, as I've mentioned before in several United States agencies. However, we built this whole thing. We put it together. It was remotely controled. It was put together outside an old Orinda test cell behind whats now, or used to be called the Sheaffer building which was owned by the Sheaffer Pen Company for some time prior to AVRO's buying it. I can well remember being in the test section. I remember a guy by the name of Al Galbraith who was the chief electrician setting up his electric remotely operated throtttles for these Viper engines and all the instrumentation that was necessary to operate this thing - and sure enough, one day it ran. We ran it with one engine - we ran it with two engines - we ran it with three engines - it got pretty hairy. I remember John Frost building a quarter inch steel plate , if you like, bullet proof wall so that, with little windows in it so that we could review the thing. Everyone was scared to death. I remember we had a guy, I believe he came from Orinda, an expert in high turbine balancing. Everyone was worried about the balancing of the thing and I think probably he was right. We did have quite a few problems trying to balance it. As a matter of fact, it's very hazy in my mind now, but we never did get all of the six engines alight at one time. We, I don't remember the actual problem. It wasn't a failure, don't get me wrong. But it wasn't a howling success either because for some reason or other the thing seemed to taper off pretty quickly. The thing ran and we did all sorts of tests and the next thing we knew it had stopped. And whether the funding ran out, I think possibly that's what happened.

The funding ran out and I think in their best judgement the Americans were probably right again. We'd still bitten off possibly more than we could chew on at AVROs, and so I think what happened, the funding either was depleted or was stopped and this project then started having to look for some more funds. There, again, the Americans came back and said O.K. Fellows, you're not dead yet. We'll provide something that we know you can make. Let's go down another couple of notches. And, of course, it was always hard for John Frost to admit defeat and let's go down a couple of more notches. So, now we start to talk about the stuff we were supposed to talk about at the beginning of this program and that was the AVRO car.

I'd like to back up just a couple of notches here. I'm reading from 704 Project - I'm reading for the 6 Viper Rig - I'm reading for the, now we suddenly find a piece of paper which says 606A. And my memory serves me correctly now, I believe.

606A was a Program set up by a United States agency, don't ask me which one, to look into the whole concept. To look into the vertical take off airplanes and if you will notice when they mention 606A they nearly always say Systems 606A weapons system. I think this is an agency possible at Dayton, who were looking into the future needs of the Armed Services of the United States and they then took some of their own money and did their own study - Where shall we go from here? What do we need in the future? What have these people got that we can use? How can we best fund them to carry this program on? And I think the money that was spent on weapons systems 606A was basically spent by the Americans themselves to determine what to do now we have this six Viper, we might call it a monstrosity, some people did.

However, we had our wild charge at the thing on a big scale and weapons system 606A finally determined that what should happen is - we should go down a big notch as I mentioned a little while ago. They very sensibly digested a new concept which became the AVRO car. And I think that may have put it in the picture. I may be wrong but it seems to me to be quite logical. However, now we get into a whole new concept.

Now we get into a much smaller airplane. We get into an airplane about 18 or 19 feet in diameter - I don't remember the exact figures but I'm sure they are in the technical reports. It now has shrunk down to the pitiful size of a wheel in the middle, a compressor driven by a tip turbine, driven by three engines. And history says, and I well remember that the program has now got pretty low funding from the United States. And the Americans were very helpful to us. And they searched their coffers and they found they had some engines that were built under license in the United States from an original French design engine called a Pal and I think it was called the J69. It was a pitiful little engine, really, it had about 900 lbs. of thrust and they said, well what can you do - how many of these do you need to make the smallest possible vehicle to prove this concept? And after a certain amount of money was spent and there again, we were possibly spending 606A money on their behalf to decide what size of an airplane could use some of these engines to make a flying demonstration vehicle of a flying saucer. So, after all the chips were down we sat down and came up with a 3J69 engine, no longer radially disposed. But disposed sufficiently well to spray on a tip turbine of, I don't remember the diameter, but probably no more than about

6 or 7 feet in diameter, driving a very conventional single stage fan now. Here we have a fan of some, I think, 33 blades on the hub of a wheel driven by a tip turbine, compression very low pressure ratio, of course one stage, fairly large quantity of cold air into a big doughnut now, a fairly fat box - had to be to hold a couple of guys and some fuel. Then, taking this air - radiating it outwards and doing our thing on it again. And this became the AVRO car. And it really got into the hardware. Now, I guess we were getting smart. I guess we said, this is now within the realms of an engine company. Maybe we should have done it a long time earlier, however, Orindas came on board in a big way. Orindas undertook and were funded by the Americans through us to design and develop a tip driven fan of some 6 or 7 feet in diameter, single stage compressor which they did and they did very, very well. I think it produced a little bit more than 5 thousand lbs. of cold thrust from three engines which had 900 lbs. each. So you can see, it was done quite well. They built it. They tested it themselves. They designed and developed their own test rig. They ran it. They did what we call PFRT, which is previous to flight proving. I think 50 hours of running of various rpm's and various stops and starts and various temperature ratios, measured the outputs, did a very professional job on developing this fan. And in retrospect, when we find out how much money they actually took to develop this fan, and when much later I went down along with a lot of other people to the Ames Research Center to test the AVRO car in the 40 by 80 wind tunnel, we found that General Electric had, in fact, developed a fan later than this with something like three times as much money as we had needed to produce the complete AVRO car including it's fan and that did to

a certain extent become a quite successful fan. But funnily enough it had 33 blades, it had a tip driven turbine, and it was almost a direct copy of the Orinda one. However, that's digressing a little bit into a little political nit-nat, which I shouldn't do.

So, here we are now. We come along with the AVRO car. Now we're getting serious. We've got an airplane and we've got to make it less than 5 thousand lbs. all out weight including fuel, pilot, you name it. Very difficult. We got into unheard gauges of material. We were playing around with less than 20 thou thick aluminum. We were talking about rivets no bigger than 332 at 3/4" pitch. We were talking about blowing hot air through this lot through some very, very thin stainless steel boxes to keep it away from the aluminum. Apart from the development problems of the wheel itself which Orinda took away and did a very good job of, we had all the mechanical problems of fitting this into the airplane. And I might mention that the control system was inherent, and I should have mentioned this a long time ago, one of the major thrusts of John Frost's technical thrust was that the, when you had a disc running at high speed it was like a large gyroscope. And it had tremendous forces. And if you tried to upset the gyroscope it produced couples at 90° degree phasing through this. When you tried to topple the gyroscope the amount of energy that wants to keep it where it is can be used and this was used and even on the AVRO car the fan, if you like, was floating, in floating bearings. And it actually, the axis of the thing, the fan actually moved - due to processional loads. When you upset the airplane the rotor wanted to stay where it was and we used that energy to operate the control system for the AVRO car. And it was quite an important thing. It gave the airplane, as a

gyroscope it gave the airplane an awful lot of inherent stability that a normal aircraft doesn't have. I've digressed a long way on the technical side now but however, we got serious. In the end we built the components for, if not three complete airplanes, but we certainly built the components for three airplanes. The logic behind that was 1. build an AVROS, which eventually went on to a hovering rig at AVROS which eventually that one, I believe, went down to the United States to be tested in the 40 x 80 wind tunnel. The other one was left at AVROS to do investigative flight testing with, and I think there's quite a good documentation on film of Spud _____ flying this thing in the snow and having a thoroughly good time trying to fly the thing before it was even flight tested in the wind tunnel. We had two complete tests in the wind tunnel. I believe, if my memory serves me correctly, from the winter of 59 to 60 the thing spent a long time in the wind tunnel, if I remember, 5 weeks entry into the wind tunnel was unheard of in those days and we had five full weeks of testing. The think went through modification program during the following year and was tested again extensively in the winter of 1960-61, when certain problems developed in terms of stability we found the thing needed a tailplane. It went through various stages, anyway. We're not to cloud the issue with that. It went through quite a successful hovering program at AVRO and I might say that even if the AVRO car did nothing else it was probably the best ground effect machine that was ever designed. However, I've digressed too far now and I've gone too quickly. A fairly large team of people were built up. The design office got to possibly 20 or so people. The technical office got to probably almost the same number. The shop increased in numbers to

possible 20 to 30 people in the shop. We had a full size lofting department. We actually did all our own lofting. We had all our own tooling made. We stamped out all our own parts. We put these airplanes together and as an interesting sidelight, the thing was 18 feet in diameter or thereabouts. When the people at Ames very kindly said they wanted us to take it to the Ames Research Center to test it in their largest wind tunnel in the western world, and it still is, the 40 by 80, we found that it wouldn't go on a truck, it wouldn't go under any bridge, it wouldn't go on a train. It had been designed in such a way that having three engines it was made in three distinct segments and each one of these segments didn't break down to anything small enough to go under the bridges so eventually the thing was taken to Toronto in the dead of night, on the empty roads to the docks. It was put on a raft. It was taken across Lake Ontario through the Erie Canal to New York, transhipped to a destroyer deck, I believe of the United States Navy _____ Kels had a lovely time. He went with this thing and he went right down through the Panama Canal and up the other side to San Francisco down the San Francisco Bay was unloaded right next to the 40 x 80 wind tunnel at the bottom of San Francisco Bay. Of course the thing would never come back because it was so expensive to get it there, although the American Navy very kindly never sent a bill for that. I'm really digressing now, you know, the AVRO car program. I can only say that bad times hit us pretty soon because here we're coming along to black Friday and everyone knows what black Friday is, that was the day the Arrow was cancelled in February of 1959 and we were in the very fortunate, or if

you might like to say the unfortunate position of being the only people in the whole of that colossal _____ at Bolton there that had some money. And the whole AVRO program along with it's hundreds and almost yes, very many hundreds of technical personnel were found with nothing to do and here we were sitting with John Frost who had really been the outcast if you like, although it really isn't right. He'd been off to one side and shunted around from pillar to post with his little team of boffins doing these crazy things, suddenly became the focus of everyone including the president of the company and all the engineer and directors and here we had money and so, unfortunately in some respects, anyone who was anyone who AVROs deemed necessary to keep on their team or could afford to keep on their team was shunted onto this thing and I think really, to be honest about it, they drowned it with technicians who, quite a large majority of them were anti Frost. I don't think they really did a lot of good to the program in that they tried to reinvent the wheel all over again and tell us that everything was wrong and nothing was right. And of course it was going to cost millions of dollars to do what they wanted to do and the end result was that Fred Mitchell who was the, at that time, director of engineering of what was left of AVROs decided on his own bat that AVROs shouldn't be in the flying saucer business and he made a point during the summer holiday, I believe of 1959, 60, 61, of saying well, I have decided on behalf of AVRO Aircraft that we are no longer going to be in the flying saucer business and he got rid of John Frost and Dezel and most unfortunate breakup of the team. However, and it will be the subject of another book, there was a basic team left behind. There were all sorts of spin-offs from our program in the way of air bearings, which I do believe John Frost was one of the major inventors although

he never took claim to it, which we used extensively in our wind tunnel model certainly and even in the concepts in a lot of our airplanes. That along with another phenomenon which came to light as a spin-off from this program namely the _____ wing. And Don Whitley took that and ran with it and when DeHavillands finally purchased what was left of AVROs and inherited the technical people that were left, inherited Don Whitley and his group, who by that time I was onboard that at that time after John Frost had left it became the _____ wing group and has since progressed into flying an augments wing buffalo and are now into VTOL again with the augmenters being the main thrust of the VTOL system and it looks like it's still winning and still running along and not the end but maybe the beginning of a very sad tale of Canadian history in aviation.

- Q. Now I'd like you to give me a bit of information. You were saying about when the owl folded up, that a bunch of the guys that were sort of had mixed interest in the saucer became involved on your team and we've got a few sketches here.
- A. Yes, as you show me, you showed me two or three sketches here and there were many, many of these kind of sketches made and there were things like AVRO trucks and AVRO scouts whatever and these really were the outcome of a whole new gang of people moving in onto the project after the Arrow was canceled - all trying to do their best to put their ideas into what they thought the AVRO car needed in order to make it into a real airplane. And one problem we always did have, of course, was the transition from hovering to forward flight and there was always a lack of thrust, not because we knew it wasn't there, not because we knew we didn't want it, but because financial assistance wasn't available to do it. And this one

particular little thing, I'm looking at now, the AVRO scout circular wing shows a, what we used to call a stinger, but which was really an aft facing jet engine which was mounted on the upper surface of the back of the AVRO car to give it the necessary acceleration thrust that it needed to get into forward flight. That happens to be one, I've turned the page over now, yes, I've turned the pressure over now and I find all of a sudden one of the smart guys off the Arrow decided that circular platform wasn't the right way to go and I see an elliptical platform already coming up with the same idea as the AVRO car, AVRO scout that we had before but now he's throwing an elliptical wing and I know why he did it and there's good reasons for it but that would have been a no no in John Frost's books because the circular platform to him was all important as a hovering machine. Now then, I have a lot of these problems that came to light in the 40 x 80 wind tunnel and have been mentioned to a lot of people previous to this. The people who did a lot of serious aerodynamic thinking about the airplane was because the center of lift when the aircraft was hovering was naturally in the center of the circle and the center of a normal aerodynamic surface, of course, it normally occurs at the _____ and so you find that when you start into forward flight and the more que you get, or dynamic pressure you get you find that the center of pressure moves forward so that the effect of CG which stays in the middle of the airplane for hovering now would like to be shifted forward with the CP but it isn't so what effectively happens is as when you go forward you get a nose up pitching movement due to the shift of the center of pressure of

_____ forward due to forward speed and the center of gravity of the airplane remaining in the center. Now, don't think we haven't thought about it, and even in the Ames tunnel and even previous to the 40 x 80 tests we had flaps fitted to the back portion of the airplane which deflected the jet down to, given nose up pitching movement to counteract this.

I'm turning the page to another idea that one of the Arrow engineers had. O.K. This one here, what have we got here. We got two, a two engined airplane effectively what he has done. He's made a two engined airplane out of the three engines. We were saddled with three engines of about 900 lbs of thrust and now he's decided to spend a lot more money and buy to J85's which have 2500 lbs. each basic thrust which gave him 5,000 lbs. of basic thrust and if you put that through the fan you could probably turn the fan into a 10,000 lb. lifting machine and of course that would have made our problem easy, too. But we didn't have the luxury of this kind of power when we were doing the job. And of course you have to consider the fuel consumption of it as well in the amount of extra fuel you would have to carry and the all out weight of the airc... I mean, I could criticize these. I don't really want to. I notice he has also added a fin. While we added a fin in the 40 x 80 too and we also added a tail plane and he's moved the pilots together in the front, which was one of the army's requests, because it was quite foreign for them to be sitting far apart and not exactly facing forward in the original AVRO car.

I turn the page to another one called AVRO car development version with wing extensions which is no more than making the AVRO car

into a more conventional airplane and another way of getting away from the pitch problem and really, well. These are all, these are all ideas that were put forward by a bunch of very, very clever and very brainy guys but didn't realize, didn't realize the history of how the AVRO car developed and all the financial restraint and the political considerations given to keeping the airplane the way it was before the Arrow was canceled.

One little aside that I might mention very briefly in that when everything was super hush hush and the Americans were on board and the thing was going to win every war from now on for them and they thought that if we did build the AVRO car, which we did build one or two, or perhaps three of them, _____ they thought at one time that perhaps the thing was far so security conscious that it shouldn't be built in a populated area like Toronto where the Toronto Star could come with their speed graphics and take pictures of it every other day so, it was looked at and as a matter of fact, I made a trip with the Chief Security Officer from AVROs and the company lawyer to Gravenhurst Airport. In those days they called it Little Norway because apparently the Norwegian flyers were taught there during the war and we did visit this place and we did examine it as a potential manufacturing plant for an extension to AVROs as sort of a skunk works, if you like, but it really didn't catch fire. It really didn't come to any fruition. That's just a little aside I mentioned.

Now, do we want to go on to something else? Oh, yeah, almost on a comical note. I spent a good deal of my time after the AVRO car was all wound up and finished, long gone, working with Don Whitley

on the Augmenter Wing project, and we used the good graces of the 40 x 80 once again and we have on many occasions since, to test the Augmenter Wing in the 40 x 80 and on one occasion when I was down there they had had a Veteran's Day Parade or some kind of a Parade in the town of Mountain View and much to my amazement I found out that they had taken the old AVRO car which was on what they call the graveyard then, which is really the old scrap heap and a couple of energetic engineers had rescued the old thing and painted it green and stood a little Mars man in one of the cockpits and they'd actually towed this thing through the streets of Mountain View in a Veteran's Day Parade, which we all thought was kind of funny. Also, while I was down there, I would think probably in 68 or 69 I was called on by the people at Ames as an expert on the AVRO car, I guess I was the only one on board at that time, to go and explain to them how the thing could be efficiently, where it could be efficiently cut so that it could be transported to the museum, the Smithsonian Institute in Washington and I did at that time tell them how to cut the thing up and also suggest how they did it and I believe, in fact, they did do it and they did, in fact, send it to the Smithsonian Institute and I believe that's where it is today. Whether or not it's been completely refurbished and put on display yet, I don't know. But, that's all I really know about that.