PROF. V. RADHAKRISHNAN

Prof. V. Radhakrishnan was born on 18th May 1929. He was the son of Prof. C. V. Raman and Mrs. Lokasundari Raman. After getting his B.Sc (Honours) degree from the Mysore University and working as a research scholar in Indian Institute of Science, Bangalore, for a short time, he went to the Chalmers University of Technology, Gothenburg, Sweden, and worked as Research Associate in the field of Radio Astronomy from 1955 to 1958. From 1959-1964 he was a senior research fellow in Caltech, Pasadena, USA, in Radio Astronomy. He then moved to the Division of Radio physics, CSIRO, Sydney, Australia, where he worked as a Principal Research Scientist till 1971. The next one year was spent by him in the Observatoire Meudon, in Paris. From 1972 he was the Director of the Raman Research Institute in Bangalore. He revisited Caltech from September 1980 to March 1981 as Sherman Fairchild distinguished scholar. From April to September 1989 he was Jublieum's Professor in the Chalmers University of Technology in Gothenburg, Sweden. He was a Fellow of the Indian Academy of Science in Bangalore and was a serving member of its council from 1971. He had wide ranging interest in Electronics, Astronomy, Astrophysics and Aviation. In addition he was keenly interested in sailing craft. He was married to Francoise-Dominique nee Barnard and had a child.

FLYING SLOWLY

V. RADHAKRISHNAN

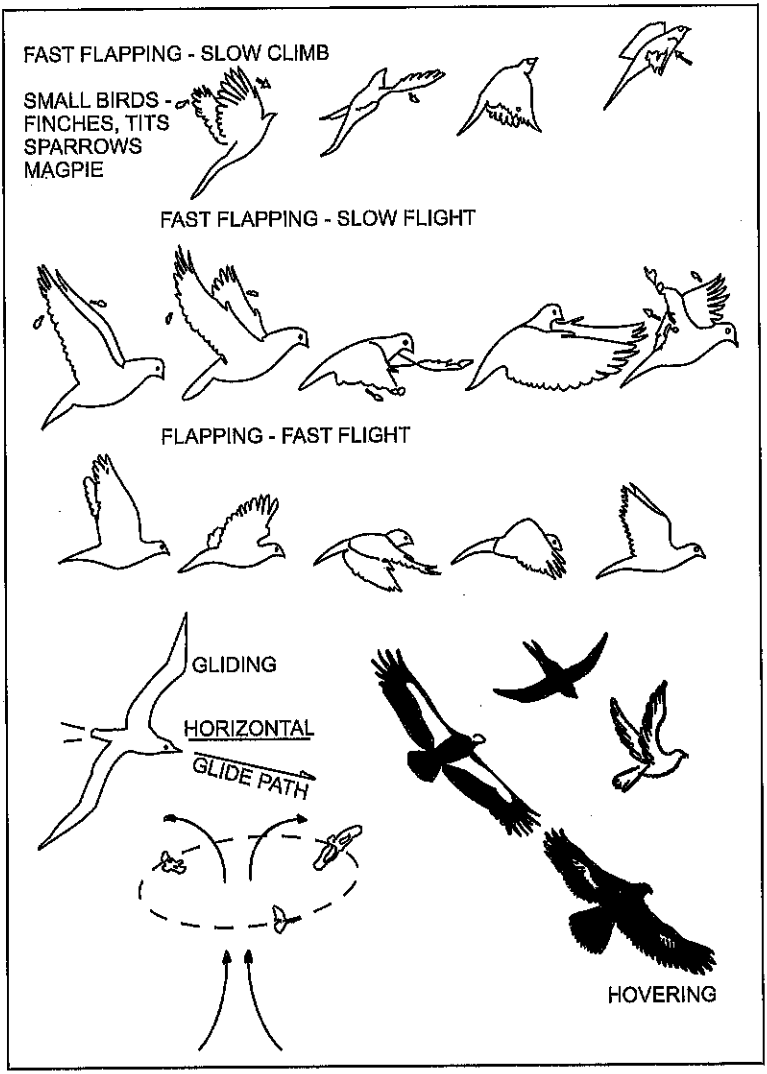
I am sure that every human being has at some time or other wished he could swim like a fish and fly like a bird. Swimming, even if not quite like a fish, is relatively easily achieved almost anywhere in the world but flying is another matter. What I would like to talk about today are some interesting aspects of how man took to the air in the first place, their connection with recent developments in low speed aviation in the world, and also some personal experiences related to activities in India.

For all those who yearned to fly, like the pioneers in aviation, it was the birds that inspired them. But birds come in all sizes and shapes, and they fly in so many different ways. For example, the hovering of a humming bird sipping nectar from a flower while flapping its wings fifty times a second is very different to the stately cruising over the ocean of an albatross with outstretched wings locked open.

There is nothing in Nature that man cannot learn from, but the lessons are not always easy and straightforward as we shall see. I shall divide the early experimenters in aviation crudely into two classes. The first looked for lessons to the flapping birds as there are no birds which do not flap at some time or other. But nobody ever managed to build a flapping machine with which one could take off from the ground, leave alone fly. It took a very long time to appreciate the extremely complicated action of a bird's wing in 'flapping' which was revealed only by modern ultra high-speed photography. So it is understandable that those adventurers who tied a couple of "wings" to their arms and tried to flap them up and down just fell on their faces.

Prof. Satish Dhawan, former Chairman of the Indian Space Research Organisation (ISRO) has made a deep study of bird flight and I refer anyone who wants to know more to his book* from which the illustration has been taken. The smart pioneers of aviation were those who were inspired by another kind of bird, also shown in the same illustration. These are what I would call soaring birds, which include vultures, kites and other large birds, who rarely flap their wings, but just go round and round effortlessly and apparently stay up forever. In due course, it became clear that they were being held up by rising currents of hot air, which are also shown in the same picture. The birds sense these columns of rising air and circle round their centre's to stay in them.

* 'Bird's Flight' (S. Dhawan), Special Publication No. SP 9019 October 1990. National Aeronautical Laboratory, Bangalore.



TYPE OF BIRD FLIGHT - flapping, gliding and hovering
(Bird's Flight- S. Dhawan)

talk however, the essence of these findings can be stated in the following deceptively simple form.

Aerofoils are objects shaped similar to bird's wings; when moved through the air at an appropriate angle they experience a force perpendicular to the direction of motion (lift) which can be many times (say 10 to 50) larger than the force in the line of motion (drag). This ratio is called the lift to drag ratio (L/D) of the wing and is a measure of its aerodynamic quality, the larger the ratio the better the wing. For a bird gliding down in still air without flapping its wings, the inverse of this ratio also gives the slope angle of the glide.

Now the smart pioneers, as I said, spent their time watching the big birds, building gliding machines and learning to glide. And amongst the greatest and most celebrated of them were the Wright brothers. In fact, they spent years practicing with their glider to understand how one can glide down safely before attempting to install a motor and propeller on it for powered flight. One other crucial thing that the Wright brothers did was to add something that enabled control of the glider as it came down. The invention and perfection of this control system led to their final success in achieving the world's first manned, powered and controlled flight of a heavier-than-air craft. What they added were small control surfaces called ailerons, rudder and elevator. All of these were connected to cables or other mechanical means by which the pilot could move them and so control the aircraft. This scheme is absolutely basic, and all planes that you see today from little trainers to the big jumbo jets are controlled this way. It is called three-axis control, and the reason I draw attention to it will become clear as we go along.

Aeronautics has been advancing for a century in spectacular fashion. Apart from its vital role in military matters, the transport of people and cargo by air has become an essential part of everyday life in the more developed countries. Even in India, there is a tiny but significant fraction of the population whose life and work styles could not survive without air travel. But in spite of the overwhelming influence of aviation, there was something missing in the world scene and which suddenly appeared as a minor

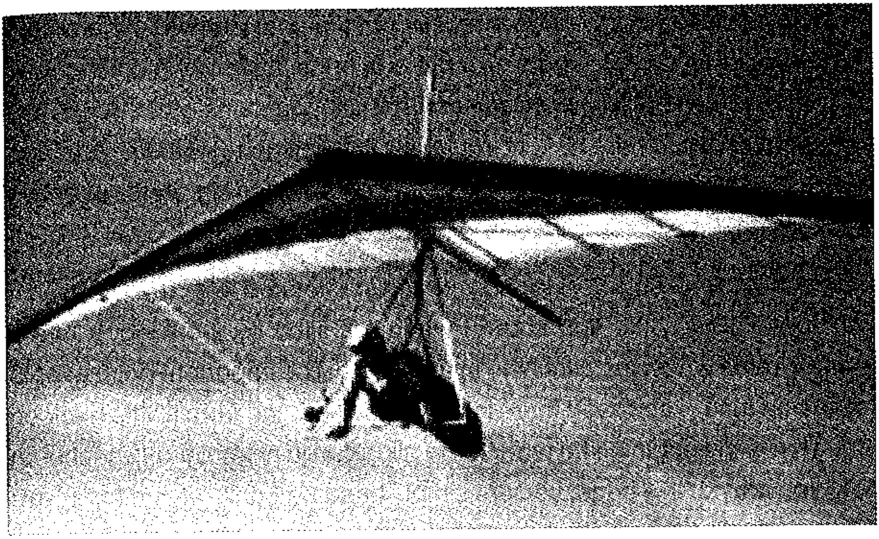


FIGURE 2 A modern Hang Glider

that sacrifices must be made. Lilienthal's and all of those other early gliders were controlled by shifting your weight with respect to the centre of effort of the wing. In other words, all that the pilot did was to move his body with respect to the contraption which could have been a sail or a box-kite or whatever. One did not manipulate any parts of it as in fact the Wright brothers did in their three-axis system. The modern hang glider also works on this early principle of weight-shift and does not have any controllable aerodynamic surfaces. And this happened in the middle of the jet age when you would have thought that no one in his senses would advocate, or build, or fly a machine which had no controllable elements.

The trigger for the development of modern hang gliders was an idea of a man called Rogallo who worked for NASA. He thought up what he felt was a very clever kite system. But nobody paid any attention to him, and finally he and his wife went and took out a patent. Much later, NASA paid him an enormous fortune because they thought they would use his device to bring spacecraft down instead of the parachutes that were normally used. Apparently NASA spent a lot of money before finally scrapping the idea as unworkable. The drawing from his patent looks incomprehensible and I or the other to turn it, the wing loading on different parts of the sail changes and the sail modifies itself in such a way to both initiate a turn and also to stabilize it. It coordinates roll and yaw by itself like a bird, something that conventional airplane pilots must do with the controls.

It is the simplicity and affordability of hang gliders which made the sport spread like wild fire in the US, Europe and Australia and created enormous numbers of a new class of aviator. The only comparable revolution was the invention of the wind surfer which was to the yacht what the hang glider was to the airplane. It is the craft sailed by the greatest number of sailors in the world today and it is for exactly the same reasons namely simplicity, portability and a very low price. Remarkably, the materials used - aluminium alloy or carbon fibre and stabilized sail cloth - are the same, as is the fluid mechanics which describes their performance.

The stalling speed of free flying hang gliders can be as low as 20 kms per hour and typical speeds 30-40 kms per hour. They are very safe and maneuverable in calm weather or steady winds but they are not meant to be used in gusty or turbulent conditions. One learns to fly these gliders by running down gentle slopes with them. With the right kind of instruction, and people to catch you when you fall, you go from gentler to steeper and steeper slopes and you get airborne for longer and longer times, and gradually you learn to control the device. If you persevere long enough you should get to the stage when you can jump off a cliff, catch a thermal and soar for an hour or two or till you get cold and tired.

Just as in wind surfing, you need to be very fit, or should have learnt to operate these sports, so I don't fly free flying hang gliders, but I did get a ride once on a glider big enough for two people to hang from. We jumped off a steep cliff on Nandi Hills, near Bangalore, and the flight lasted for only two or three minutes. But after this experience I decided that this was something that should be encouraged in our country, where other types of flying are either prohibitively expensive or inaccessible or both.

Towards this end one set up is a series of projects funded by the Aeronautics Research and Development Board of the Ministry of Defence. I

Brothers, with which one could take off, cruise around and land with complete control on any open field. Dozens of such designs were produced in the last fifteen years or so, particularly in Europe and manufactured in large numbers. This next and major step was a more than interesting one for me because I could now participate instead of just encouraging others. We too got into the game and three such models of "powered hang gliders" were produced since 1987 and several tens of them can be found all over the country today. The smallest were single seaters powered by the 250cc YEZDI Road King engine and the biggest long-range two-seater cruising machines were powered by imported 500cc Rotax Aero engines.

A couple of years ago we decided to do a little tour to really check out the reliability of these machines in cross country flight. We covered a 1000 kms. in a week and at the end it wasn't clear whether it was the machines we were testing or the endurance of the pilots. Unlike in conventional aircraft, one is exposed to the weather, and worse, in weight-shift machines one has to exert considerable force to control the craft when the air is turbulent. An extended flight in non-ideal conditions can be exhausting and one is grateful to be down and safe on the ground again. On the other hand, when the weather is right, there is no aircraft which can compare with the hang glider in imparting the sheer joy of flying. One of my friends who was a Chief Test Pilot and has spent the last forty years piloting every type of aircraft form trainers to jet fighters and helicopters to heavy transports claims that what he enjoys flying most are the hang gliders developed in the project. A joy-ride in such a machine, open as it is with no cabin to make you feel cooped-up, is an unforgettable experience not to be missed if you have the chance. Apart from the fun of sport flying, powered hang gliders have found use in reconnaissance, wild life surveys, aerial photography specially of urban areas, and agricultural spraying, the last particularly in Russia.

The project has provided a lot of fun and excitement. But I would be giving a very false impression if I did not mention at least some of the many difficulties encountered along the way. The design and manufacture of