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Ramaseshan's Chitra connection*

I met Ramaseshan for the first time in 1972 in the old CSIR guest house in Delhi. I had then returned to India from the US after many years and made an uncertain start in the Safdarjung Hospital as a cardiac surgeon. I was asked to meet him by Nayudamma who took note of my plea for developing biomaterials and medical devices technology in India. Rigid compartmentalization is the bane of science and I had long recognized, not two, but many cultures among scientists and intellectuals. The meeting with Ramaseshan came as a breath of fresh air because here was a master physicist who not only understood the problems of introducing materials into a living system but even shared the excitement of developing an artificial valve which had to open and close 100,000 times a day for a minimum period of 10 years before getting approval for implantation! We hit it off immediately and our contacts grew even though I could achieve little during my year's stay in Safdarjung Hospital. My next stop was the IIT, Chennai where Arcot Ramachandran offered me a Visiting Professorship in the Division of Biomedical Engineering with permission to operate in the Railway Hospital, Perambur thrice a week. My assignment in the IIT included teaching a course in physiology, contributing to seminars and interacting with M.S. students whose projects covered almost everything in medical sciences. I was however disappointed that R&D received low priority in the IIT scheme of things; a student could spend three or four years, for example, on the modelling of a valve for his Ph.D. without getting any closer to making a prototype. As the students were bright and enthusiastic there was no reason why each project could not have been chosen and planned with technology transfer in view. I remember discussing these issues more than once with Ramaseshan who did not dismiss my concerns as scientists generally tend to do. Needless to say, the valve project made no progress during my IIT interlude.

Like in the affairs of men, there is a tide in the life of ideas and the upswing for the valve project coincided with my move to the Chitra Institute, Trivandrum in 1974. Side by side with the commissioning of a speciality hospital, a project proposal for the development of PVC and titanium for medical applications was approved, among the first few, by the SERC for funding. My co-investigators were Ramaseshan in the NAL and Gowarikar in the VSSC. The project gave me an opportunity to bring two biomedical engineers including Bhuvaneshwar who had been a keen student in the IIT, as Research Fellows to Chitra and create a rudimentary facility for R&D. Looking back, it is remarkable that our tiny group could develop a pulse dup-

*Dedicated to Prof. S. Ramaseshan on his 80th birthday.

licator, test the samples of imported valves and publish a paper in those far-off days! A Research Fellow worked under Ramaseshan in the NAL for fabricating a valve housing of titanium, which was shown to be feasible.

Why develop a prosthetic heart valve which is available in the market? Why re-invent the wheel? The short answer to these questions is the desperate need of poor patients who are priced out by the imported valves. Nothing could be more painful or more unfair than the denial of a surgical procedure to a patient on the ground that a life-saving device is beyond his or her means. There were other reasons too. The technology of the heart valve is complex and demands high level inputs from materials science, engineering and cardiac surgery. It is the very complexity which limits the development and successful production of valvular substitutes to no more than two or three countries in the world. The mastery of the valve technology would imply the growth of self-confidence and the creation of a self-regenerating base of R&D which would make it possible for the country to develop any medical device of importance for our health services. We dreamt that India would cease to be a perpetual borrower of medical technology and would have something to lend in return!

The valve project picked up momentum when a new campus for biomedical technology was acquired by the Chitra Institute. From a humble start in an out-house, Bhuvaneshwar built an excellent laboratory where instruments for testing the performance of materials and devices were designed and made; Neelakantan Nair organized a Tool Room which could fabricate metallic components of the valve to desired size and design; Arthur Vijayan Lal, a veterinary surgeon, made ready an animal care facility and procedure rooms where heart valve replacement could be done in sheep with predictable survival; our colleagues in pathology, toxicology and other divisions extended support whenever necessary. To manage the multidisciplinary team, the newly acquired campus needed a leader with an uncommon combination of abilities. My first choice turned out to be wrong and I turned to Ramaseshan for help. It was on his initiative that A. V. Ramani left the NAL and joined the Biomedical Wing of the Chitra Institute to preside over a decade of technologic growth. The valve project had Bhuvaneshwar as the principal investigator with Ramani and colleagues providing constant support through innovative suggestions, trouble-shooting and close monitoring.

The real test of any team lies in how well they manage crises which are not uncommon in the development of complex technologies. We had more than the usual share of misfortunes – and the triumph over setbacks was facilitated by Ramaseshan who was a guardian angel for the project. The successful model in the market is the third in our developmental series and puts a veil over models 1 and 2 which failed.

A prosthetic valve has three parts – a metallic housing, a disc or ball which functions as an occluder and a sewing ring of plastic fabric fitted around the housing for surgical fixation. Our model 1 featured titanium for fabricating the housing, polyacetal (Delrin) for a disc and polyester for a sewing ring. The major and minor struts between which the disc was suspended had been electron beam welded in the valve housing. To our dismay, the model died quickly because the major strut fractured at the weld after a mere 100,000 cycles in Bhuvaneshwar's wear tester when our target was 380 million cycles! It was Ramaseshan and Valluri who arranged for a study of the strut fracture at the NAL, which showed that weld embrittlement had caused the failure. It did not escape our notice that around the same time a reputed manufacturer abroad had given up welding in favour of an integrally machined housing. Ramani took the lead in switching the housing of the Chitra valve from welded to the integrally machined mode. On the lighter side, it used to puzzle me why the titanium housing was showing wear in the wear tester while the soft polyacetal disc seemed immune! It was the opposite of what one expected in materials science or human relations, for that matter. Failing to find a physical explanation, I remembered the famous verse in *Mahabharata* 'The gentle overcomes the hard; the gentle overcomes the not so-hard; there is nothing the gentle cannot do; therefore the gentle is the stronger'. My speculations came to an end when Ramaseshan took a close look at our wear tester and made an accurate diagnosis. The wear chamber was made of mild steel and the rust particles formed in the fluid medium (water) had got embedded on the plastic disc; every time the disc tilted, the rust-embedded surface abraded the surface of titanium like a sandpaper. The problem was solved by fabricating the wear tester from stainless steel and adding an anti-rust agent to the fluid medium in the chamber.

Model 2 inspired high hope because the valve housing was integrally machined from Hayne's alloy and the disc was made of single crystal sapphire, which has many attractive properties such as inertness, hardness, mirror finish, etc. It went through every stage of development successfully over a three-year period including implantation in the mitral position in sheep. In fact, we decided to seek the approval of the Institutional Ethics Committee for its clinical trial in early 1990. But disaster struck when one of the six sheep with the valve in position suddenly dropped dead after several months and a necropsy showed that the sapphire disc had fractured. We knew at once that not only the sheep but model 2 was dead and our sustained effort of years lay in utter ruin! It was a major crisis when friendly and not-so-friendly critics and the media mounted a spirited attack on the valve project. Once again, our crisis management group held long sessions with Ramaseshan who suggested a series of five possible plastic candidates instead of a rigid material for fabricating the disc. We took the help of NCL under Mashelkar for identifying ultra-high-molecular-weight polyethylene from the candidate list for making the occluder for the successful model 3.

Another benefit gained from the adversity was the adoption of sub-assembly tests for adhesive wear, abrasive wear, etc. – before testing the full model – a highly economic procedure in terms of cost and time. Ramaseshan played a crucial role in the introduction of this procedure. When the Chitra–TTK valve was successfully implanted in a patient in 1991, he took editorial note of the event in *Current Science* and gave us a much-needed shot of encouragement. The Chitra–TTK valve never looked back and has now been implanted in 10,000 patients in India. Its market continues to grow to the gratification of those who laboured long in the Chitra vineyard and especially of Ramaseshan.

Ramaseshan's contributions to technology development at the Chitra Institute were not limited to the Chitra valve. An R&D group in India faces a serious, but poorly recognized problem of validation in the transfer of technology. A prototype which works in the laboratory may not work too well during pilot production, which is followed by the R&D group and industry blaming each other to their mutual detriment. In the eighties, long before incubators became fashionable, the Chitra Institute set up a facility known as 'Techno-prove' where the R&D group and engineers deputed by the industry worked together on the basis of an MOU under GMP conditions to produce a few thousands of a given device over a 2–3 year period. The Techno-prove ensured the success of the transfer of technology of the blood bag, oxygenator and the Chitra–TTK valve and continues to be in active use for the service of the Institute and industry. The Techno-prove was a brainchild of Ramaseshan and its construction was supported by industry. He was the first Chairman of the Technology Transfer Committee of the Chitra Institute and played a major role in bridging the gap between the Chitra laboratory and industry. He did not hesitate to don the hat of the Chairman of a joint sector company which manufactured the blood bag developed by the Chitra Institute – he was as committed as the rest of us to the scientific and commercial success of Chitra technologies.

As I recall my long and precious association with Ramaseshan, memories and images crowd in my mind. He is a quintessential scientist but much more; a technologist with a sharp eye on practicality; a colleague who cheers and inspires his team; a speaker who moves his audience and even holds them spellbound when speaking on Raman or Ramanujan; a connoisseur of literary style; to all these shining qualities, the gods gave him a keen sense of humour to the regalement of his friends. It is curious that we hardly ever touched upon questions relating to faith or religion even though our free-wheeling discussions covered everything from archeometallurgy to zeolites! Nevertheless I am persuaded that his credo would be of a piece with the *summum bonum* of human existence – truth, happiness and beauty (Satyam, Sivam, Sundaram).

It is a privilege to salute Ramaseshan on his 80th birthday.

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