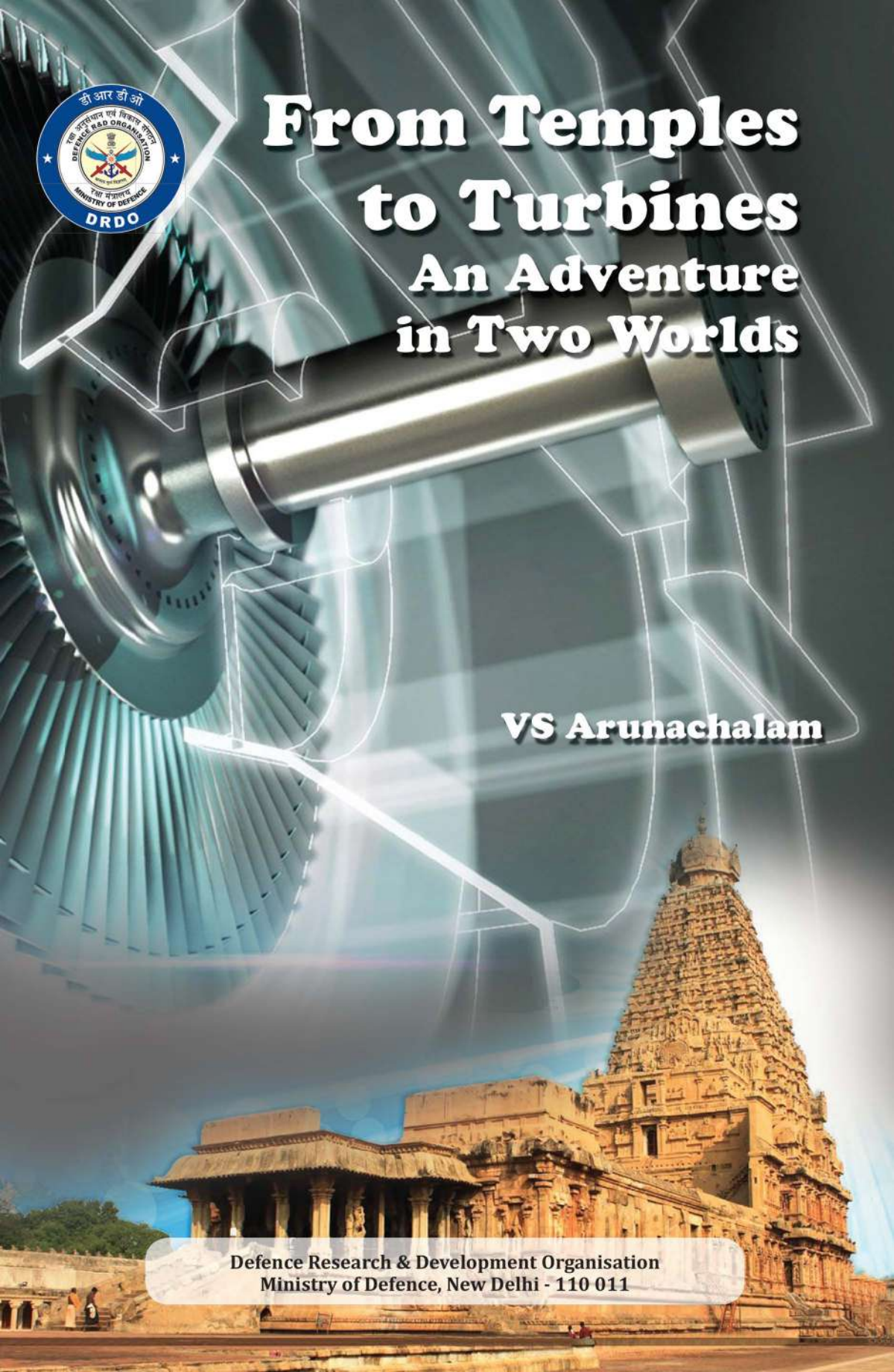

From Temples to Turbines

An Adventure in Two Worlds

VS Arunachalam

Defence Research & Development Organisation
Ministry of Defence, New Delhi - 110 011

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Dr VS Arunachalam
Former Scientific Advisor to Defence Minister,
Secretary DD(R&D) & DG DRDO

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2019

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FROM TEMPLES TO TURBINES
AN ADVENTURE IN TWO WORLDS

VS Arunachalam

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DEDICATION

Even though I was tempted to label this volume as my autobiography, I have resisted it. Instead, for this volume technology is the hero pursuing knowledge in various forms and providing continuity to the stories: a technology for making idols becomes the technology for making advanced turbine blades; thin diminutive glass fibre becomes the sole carrier for electronic communications. The excitement of such discoveries alone is as fresh to human mind as discovering a new continent. Thus, this has become my story of discovering and transforming knowledge. The dedication should therefore be to technologies and their practitioners.

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Preface

Science enriches society through technology. How does a society develop technologies and what ingredients are necessary for such integrations? These are the problems I discuss in this text. Instead of building a formal structure of technology, I have discussed my experience of four decades in integrating science and technology as anecdotes. Most of these are drawn from defence research organisations as they are rich in tales, from a mechanic developing diminutive magnets that revolutionised the design of a machine gun to an impressive consortium of scientists and engineers designing and building a modern fighter aircraft. There are also stories of Indian leaders in science and to hear of their achievements; for history gets written through such anecdotes.

Bengaluru, July 2019 VS Arunachalam

Acknowledgments

On the home front, Meena, my wife, is a willing partner in my life's journey sharing the successes and challenges along with our children Raghu, Malavika and Ramu. To them, I say many thanks.

For many years, my dateless diary was in a bookshelf gathering dust. A book had been on my mind but I was too preoccupied to take the next step and write such a book. It was then that my secretary at CSTEP, Ms Roopa, stepped forward to transpose and transcribe my experiences into coherent stories. To her, my special thanks.

Dr Gopal Rao, Editor, MRS Bulletin (the flag-bearer of the International Materials Research Society) and our editing team at CSTEP have painstakingly gone through the draft versions and have given valuable suggestions. Many thanks to them as well.

Dr R Krishnan has been a close colleague for over four decades. Many of his suggestions in editing this book were precious. I am grateful to him.

VS Arunachalam

INTRODUCTION

In the 1960s, India was passing through an existential crisis. The enemy at the North Gate was threatening to move further down the land; the drought continued its endemic grip on the agricultural lands and the country was almost bankrupt, with few lenders willing to provide support. Even some well-meaning friends of India were beginning to worry whether the country would remain stable against the many challenges it was then facing. In 1964, a Trinidad-born writer of Indian descent published a series of articles in a Western newspaper arguing that India, as a free and democratic society, was incapable of building a prosperous nation and it would be condemned to remain a poor and weak society with all its prejudices crippling growth. He saw no hope for India.

I was then working as an engineering graduate student at a British University, aware of India's growing prowess in science and technology and sustained by a belief this asset when disseminated throughout the country would help correct all the deprivations and usher in an equitable society. Didn't the Industrial Revolution bring in prosperity to Britain, and wasn't Lenin's promotion of electricity a cure-all for the problems stunting the growth of Soviet Union, ran my argument.

Even in the 1960s, Indians were beginning to see changes in the country, engineered by modest growth of industrialisation–outstanding educational institutions were being established, as were a few scientific laboratories. Already, Homi Bhabha was talking about thorium-based nuclear reactors that would harness the unlimited resource of beach sands as nuclear fuel, and MS Swaminathan and his collaborators were transforming agricultural lands into high-yielding wheat fields–begging bowls were being replaced by ever-growing bread baskets. All of these would need to wait for a few years more to bear fruit, a few years that VS Naipaul in his *An Area of Darkness*[1] was not willing to give.

[1] '*An Area of Darkness*' by VS Naipaul, published by Andre Deutsch (1964)

If I was blinded by the possibilities offered by science, the then Prime Minister Jawaharlal Nehru was persuaded even more. He nurtured the nation's science sector as his exclusive constituency, opening laboratories, attending Science Congresses and building personal relationships with scientists all over India and from many parts of the world. He even found time to contribute a persuasive editorial for a monograph on the consequences of nuclear explosions.

I could not easily accept Naipaul's argument about India's maladies and wrote a rejoinder to that newspaper, complaining about his blinkered assessment of India. In the rejoinder, I cited technologies that India was nurturing to build a modern state and eradicate the deprivations that the writer talked about. My letter did not get published but I got a response from the editor willing to consider an Indian story of growth if I was willing to write a piece citing the changes the new technologies were bringing to the country. A friend also advised me to keep a diary recording the progress that technologies were making in the country.

But, the country was slow to catch up with technology. We expected "modernising India" would occur rapidly and were disappointed by the slowness of change. It appeared that Western and other Asian nations capitalised on technologies far more easily, and they also protected that knowledge for trade and for building military hardware. It took India some years to realise that successes in science and technology were not automatically cashed; often, such innovations had to go through painful intermediate processes to build the auxiliary infrastructure of humans and machines and also generate the necessary economic viability and political acceptability. This was the interface that Western nations seemed to understand better. Russians and Chinese were forced to go through this phase through the heart-wrenching routes of the Gulags and Cultural Revolutions that imposed numerous deprivations on their citizens. Mercifully, India escaped such tragic interventions that killed millions of people.

PMS Blackett, A Nobel Prize winner, and a personal friend of India's first Prime Minister Nehru, was not confident of India's ambitious plans of industrialisation. While he was persuaded by the necessity to build some modest amount of military hardware, he argued that India's industrial infrastructure and experience were inadequate to build advanced military systems such as aircraft, radar, combat vehicles and missiles. For many years, our defence sector took this advice seriously importing major hardware and even spare parts.

We broke these self-imposed embargoes only in the 1970s, venturing to design and build major military hardware.

This transition was enthusiastically supported by the political leadership, who realised that for a country to be truly independent, unencumbered by arms control acts and dependence on imports of military hardware, India needed to be self-sufficient in building advanced technologies that would enable advanced systems for the military. The costs incurred in building such systems were truly prohibitive and forced the country into competition with others who had been in this game for decades. Such investments also diverted the nation's resources from people's needs to military requirements, a diversion that democracies found it difficult to accept. The advantage was that locally built military hardware created a robust industrial base of humans and machines and enabled India's self-reliance.

A veritable flood of new projects was initiated by Defence Research and Development Organisation (DRDO) in the 1970s, along with the building of the required infrastructure. These projects were ambitious, expensive and technically challenging. An immediate consequence was comments from India's neighbours who observed that India was building its military for a superpower status. They were surprised that India was able to support four or five major force-multiplier systems (military speak to describe complex advanced technology systems), ranging from battle tanks to nuclear powered submarines, without diverting large portions of the nation's financial and human resources from the civilian sectors. If India was able to manage this diversion without destroying its social and economic fabric, it is due to its leadership who prioritised military needs over the nation's societal needs. DRDO increased its budget by almost ten times during those years and began working on major projects.

I was then the Director of a DRDO laboratory, and later became Scientific Advisor to the Defence Minister with a grandstand view of all the projects, and exposing me to many successes and a few failures. I thus have many stories to tell, from building combat vehicles to panoramic sonar for the Navy. In this volume, I have limited myself to just a few of these; the choice was purely personal. In some, the design was almost complete and there were a few technical challenges, only political decisions to be made. In others, there were problems of national security and secrecy. Thus my version is not a full-fledged diary of all such projects, rather, a few that I was fully aware of the details and which I could disclose without compromising on security and technical

secrecy. I shall therefore merely mention a few outstanding contributions which are state-of-the-art in technology.

In an organisation of the size and scope of DRDO, you come across thousands of scientists and engineers who owned the projects, and I was fortunate to have met them, sharing their joys and failures. I have worked with five Prime Ministers and over a dozen defence ministers of India. The passion for science and technology within the organisation was infectious and you do not remain the same person after this exposure. I am grateful for the opportunities that made this possible.

Many scientists, along with their scientific expertise, are compulsive story tellers as well. The human side, however, is rare in Indian storytelling. There is no Double Helix by James Watson here. Even the story of the life and work of the mathematician Ramanujan came out much later, authored by an Indian librarian and an American science writer. Such silence is now fading with the publication of several books on Indian physicists such as CV Raman and KS Krishnan authored by the fellows of the Indian Academy of Science and other educational institutions.

It has been years since I left the defence organisation and my work currently is to understand the mechanisms that make technologies visible to people. The pristine atmosphere of CSTEP, an acronym for the Center for Study of Science, Technology and Policy, which I setup a decade ago, inspires me and allows me to address such esoteric questions. CSTEP has chosen Energy as its main theme for the past few years and has built an impressive array of tools and experience. Our researchers at CSTEP are also moving to work in other areas such as Air Pollution, Climate Change, Transportation and Artificial Intelligence (AI). Especially in AI, we are exploring opportunities inherent in human development and wellbeing.

In my professional journey, I worked with a large number of scientists and engineers from numerous laboratories and universities in India and abroad. I owe them many thanks for teaching me not only science but also made me understand the beauty of this pursuit.

CHAPTER 1

The Prize

The purpose of the award is to recognise outstanding Indian work in science and technology.
(Criteria for the Award of the Shanti Swarup Bhatnagar Prize)

Shanti Swarup Bhatnagar Award being conferred by Prime Minister Indira Gandhi

This should have really been my day. Ever since the announcement of the Bhatnagar Prize three months earlier, I was looking forward to the function where Prime Minister Indira Gandhi would present me with a plaque and a cheque for twenty five thousand rupees, a respectable sum in the 1980s. I had never met an Indian Prime Minister before and wasn't even sure of the protocol

that I needed to conform to while receiving the award. Should I shake hands with her, or should a namaste be adequate? One obvious route would be to just strictly follow the code observed by other awardees. I learnt that my turn to receive the Engineering Science prize would come after the Physics, Chemistry and Mathematics prizes were awarded. Prof N Mukunda, the Physics prize winner and a fellow trainee in the Atomic Energy training school, was always appropriate, and I decided to copy his response while receiving the prize.

I got news of the Bhatnagar Prize while vacationing with my family in Kerala in the summer of 1980. We were getting ready for a day-trip to Kanyakumari, where the vast Indian land mass, after traversing hundreds of miles from the Himalayas, transforms to a diminutive rock and embraces the Indian Ocean.

What a wonderful time and place to hear of this recognition! On my return to Hyderabad, there were a bunch of congratulatory letters and telegrams awaiting me. Hiding within that bundle was a handwritten postcard. I recognised the Tamil handwriting immediately. It was from a family friend then living in my village, Vallampadugai in Tamil Nadu, just a few miles south of the temple town of Chidambaram. She had known me from my childhood and continued to maintain sporadic contact with our family. She was overseeing the cultivation of a tiny bit of agricultural land we still had left in the village.

DRDO Lifetime Achievement Award being conferred by Defence Minister Manohar Parrikar in 2014

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About the Book

Science enriches society through technology. How does a society develop technologies and what ingredients are necessary for such integrations? This is the problem Dr VS Arunachalam discusses in this text. Instead of building a formal structure of technology, Dr Arunachalam discusses his experience of four decades in integrating science and technology as anecdotes. Most of these are drawn from defence research organizations as they are rich in tales, from a mechanic developing diminutive magnets that revolutionized the design of a machine gun to an impressive consortium of scientists and engineers designing and building a modern fighter aircraft. There are also stories of Indian leaders in science and to hear of their achievements; for history gets written through such anecdotes.

About the Author

Dr VS Arunachalam graduated in Physics and Materials Science and Engineering in Mysore, Sagar, and at North Wales where he obtained his PhD. He was selected as a trainee at the Atomic Energy Establishments and was a research scientist at the Metallurgy Division there before becoming a Director at the Defence Metallurgical Research Laboratory in Hyderabad. He was selected as Scientific Advisor to Defence Minister; Secretary, Department of Defence Research and Development (DRDO). Concurrently, he was also appointed as Director General of Defence Research and Development. During his tenure DRDO grew many folds from building indigenous missiles to advanced radars, with a number of scientists and engineers impressively increasing. He has been recognized for his achievements by the government with Padma Vibhushan and Padma Bhushan National Awards, Shanthi Swarup Bhatnagar Award for Engineering and DRDO's Lifetime Achievements Award in 2014. He is recipient of honorary doctorates and fellowships of learned societies. He was also a visiting professor at the University of Warwick. He has also contributed working as Editor for Materials Research Society and has co-edited special issues on Energy issues and Materials. He is Founder Chairman of the Center for Study of Science, Technology & Policy, a Think-Tank with a focus on technology in Bengaluru.

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