SECURITY, CONFLICT AND COOPERATION IN THE CONTEMPORARY WORLD

The Development of Nuclear Propulsion in the Royal Navy, 1946–1975

GARETH MICHAEL JONES

palgrave macmillan

Security, Conflict and Cooperation in the Contemporary World

The Palgrave Macmillan series, Security, Conflict and Cooperation in the Contemporary World aims to make a significant contribution to academic and policy debates on international history, war and diplomacy since 1900. It evolved from the series Global Conflict and Security edited by Professor Saki Ruth Dockrill. The current series welcomes proposals that offer innovative historical perspectives, based on archival evidence and promoting an empirical understanding of economic and political cooperation, conflict and security, peace-making, diplomacy, humanitarian intervention, nation-building, intelligence, terrorism, the influence of ideology and religion on international relations, as well as the work of international organisations and non-governmental organisations.

Gareth Michael Jones

The Development of Nuclear Propulsion in the Royal Navy, 1946–1975

palgrave
macmillan

Gareth Michael Jones
Ugborough, Devon, UK

ISSN 2731-6807 ISSN 2731-6815 (electronic)
Security, Conflict and Cooperation in the Contemporary World
ISBN 978-3-031-05128-9 ISBN 978-3-031-05129-6 (eBook)
https://doi.org/10.1007/978-3-031-05129-6

Cover credit: Keystone Press / Alamy Stock Photo

This Palgrave Macmillan imprint is published by the registered company Springer Nature Switzerland AG.
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

Preface

The Royal Navy's first submarine, *Holland 1*, was launched in 1901. In that same year H. G. Wells wrote: '…my imagination, in spite even of spurring, refuses to see any sort of submarine doing anything but suffocate its crew and floundering at sea'.[1] *Holland 1* was powered on the surface by a petrol engine, and was a submarine with very little freeboard. When dived, she was propelled by lead acid batteries driving an electric motor. With no air purification systems to support the crew of eight men, white mice were carried onboard to warn against poisonous fumes. It is not difficult, therefore, to understand Wells' imagination visualising anything other than disaster. However, his contemporary author, Jules Verne, saw things differently, especially in Captain Nemo's *Nautilus*. Whilst taking Professor Aronnax on a tour of the *Nautilus*, Nemo tells his captive that the submarine is powered by "Bunsen's contrivances" and that: '…the dynamic power of my engines is almost infinite'.[2] *Holland 1* was a submersible that transited on the surface and dived to attack its target. Verne's vision in that of the *Nautilus* is of a true submarine diving to great depths and travelling at great speed. Verne's vision of 1873 eventually became a reality eighty-two years later in 1955, when the nuclear-powered submarine, USS *Nautilus*, sailed on her maiden sea trials. This is a book

[1] H G Wells, *Anticipations of the Reaction of Mechanical and Scientific Progress upon Human Life and Thought* (Chapman and Hall, London, 1901) Quoted in, https://en.wikipedia.org/wiki/Anticipations

[2] Jules Verne, *Twenty Thousand Leagues Under the Sea* (Butler Brothers, New York and Chicago, 1887) p. 78. https://www.google.co.uk/books/edition/Twenty_Thousand_Leagues_Under_the_Sea

which investigates the Royal Navy's journey in the third quarter of the last century to achieve the true submarine, able to sail the ocean depths free from the constraints of the atmosphere, through the Naval Nuclear Propulsion Programme; the development of nuclear propulsion for its submarine fleet; and thereby its ability to effectively counter the Soviet submarine threat of the Cold War and carry the nation's nuclear deterrent.

Ugborough, UK Gareth Michael Jones

It is an immense privilege, both to have been so closely involved with the UK's nuclear submarine programme and to have been invited to pen an introduction to this fascinating record of the development of nuclear propulsion through to 1975—the year before I joined the Royal Navy.

Having spent almost the entirety of my career either in or closely associated with the Submarine Service, although I had a general understanding of the circumstances leading to the advent of the UK's first nuclear submarine, HMS Dreadnought, I had little appreciation of the details underpinning the ebb and flow of events that defined this journey.

'Taff' Jones' research has helped to bring to life a timely narrative, recording the importance of vision, leadership, the demand for technical excellence, the relationship between the US and the UK and the all important component of 'people'—their characters, their motivations and the historical environment in which those involved played out their roles. While exploring the difficulties encountered on the journey through the early years of the programme, it is ultimately an account of success, the foundation on which the effectiveness of today's Royal Naval submarines has been built.

As the search for further technological improvements continues, the lessons learnt along the way remain as relevant today as when first encountered—a feature recognised by Churchill in stating that 'the further you look back the more you can see into the future'. While the nuclear submarine represents a highly potent war-fighting capability, it must continue to enshrine a balance of safety, quality and reliability executed through a cadre of competent designers, manufacturers, maintainers and operators who, together, are entrusted with the effective stewardship of this technology.

Despite the hugely attractive advantage that this nuclear-powered underwater capability represents, it is no coincidence that there are so few nations that have proved to have the necessary willpower, technological base and competences necessary to establish and sustain such a complex programme. For the UK, this represents both national and international endeavours that demand enduring clarity of the goal and agreement of its 'worth'; aligned prioritisation of effort; appropriate funding; honesty and realism; and, above all, competent people working in a structured organisation that enjoys inspired, effective and accountable leadership.

This review of the evolution of the UK's nuclear submarine programme is both a timely reminder of the early steps that were undertaken on the journey and an illustration of the focused effort it will take to deliver continued success by those to whom the baton of effective stewardship has been passed. Rear Admiral Steve Lloyd CBE (Retired Marine Engineer Submarines).

Acknowledgements

To write a nuclear history is a difficult undertaking due to the secrecy surrounding the subject matter. It would have been more difficult without the introduction to many people involved in the nascent days of the Royal Navy's Naval Nuclear Propulsion Programme who gave generously of their time and, on occasions, hospitality. First and foremost, I offer my sincere gratitude to Rear Admiral Steve Lloyd CBE, who listened to my initial thoughts and supported my research from the start. Rear Admiral Lloyd subsequently introduced me to Vice Admiral Sir Robert Hill who in turn introduced me to Rear Admiral Peter (Spam) Hammersley, Captain Colin Farley-Sutton RN Ret'd, Captain John Jacobsen RN Ret'd and Commander Roger Berry RN Ret'd; I was later introduced to former CPO W. (Baz) Bowyer. I thank them all for answering my numerous correspondences, for their advice and their unfailing support for my research.

My sincere gratitude goes to Commodore Mark Adams RN, Director Nuclear Propulsion (DNP), for his support and granting me privileged access to unreleased files held at his offices at MoD Abbey Wood. Members of DNP's staff meriting an expression of gratitude include DNP's former Secretary, Mrs Sandy Grinnall for organising my visits and finding me a desk to work from, Ms Aimee Pugh for dealing with subsequent queries and Mr Paul Bolt, DNP's Security Information Policy Manager, for his advice. My supervisor and Director of Studies, Dr Harry Bennett has my deep gratitude for his light touch, wide knowledge of naval history and gratefully received advice and support. I also offer my deep gratitude to Dr Elaine Murphy for her encouragement, support and advice.

Final thanks go to all my friends for their support but especially my "student widow" wife, Philomena, for her love, encouragement and understanding over the past six years.

Dramatis Personae

Ackers, Wallace A.,	Director, Tube Alloys
Alexander, A. V.	First Lord of the Admiralty, 1940–46; Minister of Defence, 1946–50
Anderson, Sir John,	Chancellor of the Exchequer, 1943–45
Baker, Rowland, RCNC	Technical Chief Executive DPT
Barman, H. L.,	Rolls-Royce Ltd, Senior Chief Executive
Berry, Roger, Commander	Harwell & DLE, Groton USA
Buckley, J. W., Major	Metropolitan-Vickers Ltd
Burke, Arleigh, Admiral USN	Chief of Naval Operations, 1955–61
Brundrett, Sir Frederick,	Chairman DRPC
Caccia, Sir Harold	British Ambassador to Washington
Carroll, Dr John A.,	Deputy Controller, 1946–58
Cilcennan, Viscount	First Lord of the Admiralty, 1951–56
Cockcroft, Sir John,	Harwell, AERE Director
Cotman, D. A., Captain	DLE, Pittsburgh USA
Daniel, Sir Charles, Vice Admiral	Controller of the Navy, 1945–49
Daniel, R. J., RCNC	Chief Constructor DPT, 1960
Denny, Sir Michael, Admiral	Controller of the Navy, 1949–53
Diamond, Jack, RNSS	Head of Naval Section Harwell, 1946–53
Dunphie, Charles, Major General	Vickers-Armstrongs, Chairman
Dunworth, J. V.,	Harwell, Head Nuclear Physics Division
Edwards, Prof. J., RNSS	Harwell then Greenwich, 1957–
Edwards, Sir Ralph, Admiral	Controller of the Navy, 1953–56

Eisenhower, Dwight D.,	President USA, 1953–61
Elkins, R. F., Vice Admiral	(BJSM) Washington, 1957–58
Farley-Sutton, Colin,	Captain, Dreadnought Project Team
Finniston, H. M.,	Harwell, Head of Metallurgy
Goodlet, B. L.,	Harwell, Engineering R&D Division
Gordon, Robert,	Westinghouse
Hall, Viscount	First Lord of the Admiralty, 1946–51
Hammersley, Peter, Rear Admiral	HMS *Dreadnought*
Harrison-Smith, S., Captain	Head of Naval Section, 1954–58
Hawkins, R. S., Rear Admiral	Director General Ships
Head, Anthony	Minister of Defence, 1956–57
Heathcoat-Amory, Derick	Chancellor of the Exchequer, 1958–60
Hedger, H. E.,	Admiralty, Asst. Director of Contracts
Heslop, J. A. B.,	Admiralty, Seconded to AERE
Hinton, Sir Christopher,	Risley, Industrial Group Director
Hives, Lord	Rolls-Royce Ltd, Chairman
Hudspith, H. C.,	UKAEA, Finance
Jacobsen, John, Captain	HMS *Valiant*
Kingcombe, Sir John,	Vice Admiral, Engineer-in-Chief, 1945–47
Lang, Sir John,	Secretary of the Admiralty, 1947–61
Le Fanu, Sir Michael,	Admiral, Controller of the Navy, 1961–65
Mackay, J. M.,	Admiralty, Under Secretary Finance
MacLean, I. G., Rear Admiral	Deputy E-in-C 1953–55
Macmillan, Harold	Prime Minister, 1957–63
Mason, Sir Frank T., Vice Admiral	Engineer-in-Chief, 1953–56
Mawer, F. H.,	Admiralty, General Finance Branch
McKinnell,	Admiralty, General Finance Branch
McMahon, Brien, US Senator	Sponsor of US Atomic Energy Act, 1946
Mountbatten, Earl, Admiral of the Fleet	First Sea Lord, 1951–55
Orem, H. J.,	HM Treasury
Owen, W. L.,	Risley, Industrial Group Deputy Director
Peirson, D. E. H.,	UKAEA, Secretary
Penney, Sir William,	UKAEA, Aldermaston Director
Plowden, Lord	UKAEA Chairman
Portal, Lord	(MoS) Controller of Atomic Energy
Powell, Sir Richard P.,	(MoD) Permanent Secretary
Price, B. Terence,	Harwell, AERE Physicist

Pritchard, A. A.,	Admiralty, Material Division
Radice, I. D.,	HM Treasury
Rebbeck, Sir Edward, Rear Admiral	Vickers-Armstrongs Group
Reid, Sir Peter, Admiral	Controller of the Navy, 1956–61
Rickover, Hyman G., Admiral USN	Nuclear Programme 1946–82
Ridley, W. T. C., Captain	Dreadnought Project Team
Rydill, L. J., RCNC	HMS *Dreadnought* designer
Samuel, H. W.,	Admiralty, Under Secretary Finance
Sandys, Duncan,	Minister of Defence, 1957–59
Sarell, R. I. A., Captain	E-in-C's Department
Schonland, Dr Basil F. J.,	Harwell, AERE Deputy Director
Selkirk, Earl of	First Lord of the Admiralty, 1957–59
Serpell, D. R.,	HM Treasury
Sims, Sir Alfred J., RCNC	Director General Ships, 1958–67
Stewart, J. C. C.,	Risley, Industrial Group
Strath, Sir William,	UKAEA, Managing Director, 1955–59
Synott, P. N. N.,	Admiralty, Under Secretary Finance
Thorneycroft, Peter,	Chancellor of the Exchequer, 1957–58
Tizard, Sir Henry,	Chairman DRPC, 1950–
Tongue, H.,	Harwell, AERE Chief Engineer
Verity, C. E. H.,	Foster Wheeler Ltd
Weeks, Sir Ronald,	Vickers-Armstrongs Group, Chairman
White, E. A.,	Risley, Industrial Group (H&S Branch)
Willis, J. A. V.,	UKAEA representative, Washington DC
Wilson, G. A. M., Rear Admiral	(RANP), 1957–59
Yapp, R. P. H.,	Vickers-Armstrongs
Zuckerman, Sir Solly,	Government Scientific Advisor

Chronology

1939, 17 Dec. (Germany) Discovery of fission of uranium by Otto Hahn
1940, Mar. (UK) Frisch-Peierls Memorandum
1941, 15 Jul. (UK) MAUD Committee Report on nuclear fission released
1942, 2 Dec. (US) First controlled nuclear chain reaction in the Chicago Pile
1943, (UK) Secondment of Prof. Mark Oliphant and other RNSS staff to the Tube Alloys Project
1945, Nov. (UK) Atomic Energy Research Establishment, Harwell founded
1946, 1 Jan. (UK) Secondment of Jack Diamond as head of the Naval Section at Harwell
1946, 18 Feb. (UK) Rear Admiral Charles Daniel's paper on nuclear propulsion
1946, 10 Apr. (US) Paper by A. M. Weinberg in the US identifying the Pressurised Water Reactor as best suited for use in a submarine
1946, Jun. (US) Captain H. G. Rickover USN appointed to Oak Ridge National Laboratory to head USN team to investigate nuclear propulsion
1948, 14 Nov. (UK) Formation of Enriched Reactor Group for submarine prototype
1950, 6 Sep. (UK) Contract awarded to Metropolitan-Vickers to confirm the feasibility of a nuclear submarine based on the Mark I Enriched Reactor
1951, Jul. (US) USS *Nautilus* authorised by the US Congress
1952, May (UK) Conclusion that the Enriched Reactor would be too large for a submarine

1953, Jun. (UK) RN Nuclear Submarine Project placed in Class II of defence projects
1953, 30 Mar. (US) US Navy's Submarine Thermal Reactor (STR 1) went critical first time at Arco in the Idaho desert
1954, 21 Jan. (US) USS *Nautilus*, first nuclear-powered submarine launched
1954, May (UK) Naval Section increased, Captain S. Harrison-Smith appointed as head
1954, 1 Aug. (UK) Formation of the United Kingdom Atomic Energy Authority taking over from Ministry of Supply
1955, 17 Jan. (US) USS *Nautilus*, sailed on maiden sea trials
1955, 8 Dec. (UK) Proposal for 15,000–20,000 SHP nuclear power plant submitted
1956, 6 Jan. (UK) Treasury approval for HMS *Dreadnought* and Dounreay Submarine Prototype authorised
1957, 7 Nov. (UK) Neptune zero energy reactor went critical first time
1958, 14 Jan. (UK) Rickover's offer to purchase USN reactor of S3W type made
1958, Jun. (UK) US informed UK would like to purchase S5W and full machinery set
1958, 3 Jul. (UK/US) Mutual Defence Agreement signed
1958, 22 Oct. (UK) First RN Nuclear Course at HMS *Collingwood*, Fareham
1959, Jan. (UK) Department of Nuclear Science & Technology formed at RNC Greenwich
1960, 21 Oct. (UK) HMS *Dreadnought* launched
1962, 12 Nov. (UK) HMS *Dreadnought*'s reactor went critical first time
1962, 12 Dec. (UK) HMS *Dreadnought* sailed on maiden sea trials
1963, Sep. (UK) Dounreay problems with primary circuit
1963, Nov. (UK/US) Westinghouse/Rolls Royce contract expired
1965, 7 Jan. (UK) PWR 1 Core A went critical first time
1968, 15 Jun. (UK) HMS *Resolution* sailed on first UK Polaris deterrent patrol
1968, Aug. (UK) PWR 1 Core B went critical first time
1974, 16 Dec. (UK) PWR 1 Core Z went critical first time

Technical Definitions

All definitions sourced from Walker, Peter M. B., ed., *Chambers Dictionary of Science and Technology* (Edinburgh, Chamber Harrap Publishers Ltd, 2000).

Austenitic Steel: Steel containing sufficient amounts of nickel, nickel and chromium or manganese to retain austenite at atmospheric temperature, e.g. austenitic stainless steel of Hadfield's manganese steel.

Burn-up: Amount of fissile material burned up as a percentage of total fissile material originally present or fuel element performance—Heat released from a given amount of fuel GW/MW per tonne.

Cermet: Ceramic articles bonded with metal. Composite materials combining the hardness and high temperature characteristics of ceramics with the mechanical properties of metal, e.g. cemented carbides and certain reactor fuels.

Criticality: State in nuclear reactor when multiplication factor for neutron flux reaches unity and an external neutron supply is no longer required to maintain power level, i.e. the chain reaction is self-sustaining.

Enriched Uranium: Uranium in which the proportion of the fissile isotope, uranium-235, has been increased above its natural abundance.

Fast Reactor: One without a moderator in which a chain reaction is maintained almost entirely by fast fission.

Hafnium (Hf): A metallic element, it occurs in minerals containing zirconium, to which it is chemically similar, but with a higher neutron capture cross section. This makes it a troublesome impurity in the zirconium alloys used as fuel cladding.

Intermediate Reactor: One designed so that the majority of fissions will be produced by the absorption of intermediate neutrons.

Nuclear Breeder: A nuclear reactor in which in each generation there is more fissionable material produced than is used up in fission.

Pile: 'Original name for a reactor made from the pile of graphite blocks which formed the moderator of the original nuclear reactor which first went critical on the 2 December 1942 in Chicago, Illinois, US'.

Reactor Poisons: 'Other elements, especially those present as fission products, also capture neutrons very effectively. Of these xenon-135 and samarium-149 capture neutrons about a million more times effectively than elements in moderators, so very little of these elements can shut down a reactor or poison it. The gas xenon-135 readily fissions to form less damaging products in a reactor running at full power but can cause considerable problems for a reactor starting up or running at lower power for a considerable time'.

Scram: General term for emergency shut down of a plant, especially of a reactor when the safety rods are automatically and rapidly inserted to stop the fission process.

Sponge: Porous metal formed by chemical reduction or decomposition process without fusion.

Thermal Reactor: One for which the fission chain reaction is propagated by thermal neutrons and therefore contains a moderator.

The Reactor Problem: With reference to Moderators, Reactor Poisons, Control and Reactivity. 'These effects and others like the proportion of neutrons which escape the core, contribute to the *reactor problem*, whose solution determines whether a design can sustain a chain reaction without risk of meltdown. They all depend not only on the fuel, the moderator and the coolant, but also on the positions and shapes of the components. Calculating the effects of various arrangements is no easy task. Much calculation and experiment were needed to determine the most suitable materials and their disposition in the early years of the nuclear age and so solve the reactor problem. That is in ensuring that just one neutron can survive to continue the chain, no more and no less.'

Zirconium (Zr): A metallic element, the principal ores are zircon ($ZrSiO_4$), which is a very common mineral of igneous rocks and concentrated in beach sands. When purified from hafnium, its low neutron absorption and its retention of mechanical properties at high temperature make it useful for the construction of nuclear reactors.

Praise for *The Development of Nuclear Propulsion in the Royal Navy, 1946–1975*

"The nuclear enterprise, and its success or failure, was fundamental to the UK, and also the USA, maintaining the edge in the Cold War under the sea. It is a devilishly complex subject, full of twists and turns, but Gareth Jones manage to tell the story in a lucid fashion. He unravels the complexities and provides deep understanding of the technological, political, industrial and key personalities. It is a ripping yarn that anyone seeking to truly comprehend the great submarine rivalry between the Soviet Union and NATO should read."

—Iain Ballantyne, *author of 'Hunter Killers' and 'The Deadly Trade' and editor of Warships: International Fleet Review*

"The development of nuclear-powered propulsion for the Royal Navy's submarines marked a vital leap forward in the capabilities of the Senior Service. Indeed, it was an essential development if the Royal Navy was to remain in the premier league of world navies in the midst of a Cold War arms race. This book, for the first time, examines and analyses the complexities, technical, personal and diplomatic, the intrigues and twists and turns, which lay at the heart of the development of the Royal Navy's Nuclear Propulsion Programme. It was a human story as well as a technical one, that sheds new light on Anglo-American defence relations in the post-war period. For naval and diplomatic historians, this is a good book and an important one."

—Dr Harry Bennet, *Associate Professor of History, University of Plymouth*

"Taff has opened wide an important window into a notoriously closed subject. Naval history and dogged research at its best."

—Dr Sam Willis, *Broadcaster, Author and editor of Navy Records Online*

"The post-war advent of 'nuclear' was a universal game-changer. For the Royal Navy, it led to the development of a nuclear-powered propulsion programme which transformed our capability and ambition. It enabled the Submarine Service to operate almost at will in the harshest of environments for long periods of time, and to compete against a foe blessed with mass. That we prevailed in the Cold War is down to professionalism and technical superiority. It was nuclear propulsion that enabled success. Whilst this important book should appear on every "Back Aftie's" book-shelf, it will also hold a great appeal to those 'passengers' in nuclear submarines – including the author and me - who spent many years of their lives submerged but 'forward of the tunnel."

—Commodore Mike Walliker CBE, *former Submarine Commanding Officer, HMS Tireless and HMS Astute*

Contents

List of Figures

CHAPTER 1

Introduction

With the delivery of the *Frisch-Peierls Memorandum* to the British Government in March 1940 and the subsequent formation of the Tube Alloys Project, later subsumed into the Manhattan Project, the Allies' focus during World War II was on the design and construction of an atomic bomb. There was great concern that Nazi Germany was developing its own atomic weapons programme and the Allies own efforts were paramount to winning the war. However, because of the demands of World War II and the success of the Manhattan Project, it has long been forgotten that one of the first applications envisaged for nuclear fission was submarine propulsion. In the immediate aftermath of World War II nuclear-submarine propulsion programmes were instigated in the US, the Soviet Union and, here, in the UK.

On 2 December 1942, in an abandoned racket court under the stands of Stagg Field sports ground at the University of Chicago, Illinois, the first controlled self-sustaining nuclear chain reaction occurred in a reactor designated CP-1 (Chicago Pile 1). Subsequent early nuclear reactors (originally known as atomic piles) were developed to produce plutonium for atomic bombs, radio-isotopes for research and medical purposes, and for nuclear physics research. None of these reactors utilised the heat generated as a source of power. Calder Hall in the UK is generally

G. M. Jones, *The Development of Nuclear Propulsion in the Royal Navy, 1946–1975*, Security, Conflict and Cooperation in the Contemporary World,
https://doi.org/10.1007/978-3-031-05129-6_1

acknowledged as the first reactor in the world to produce power for commercial purposes in October 1956; however, its primary purpose was to produce plutonium for Britain's atomic bombs. The first purpose-built commercial reactor to produce power for electricity was the pressurised water reactor constructed at Shippingport, Pennsylvania, which went critical in December 1957. Nevertheless, the first nuclear reactor in the world to produce power that could be utilised was a prototype pressurised water reactor built at Arco in the Idaho Desert, which initially went critical in March 1953 and, after further testing, produced steam to a turbine in May. This event paved the way for a production model to be fitted into a submarine under construction at the General Dynamics Electric Boat yard at Groton, Connecticut.

The pressurised water reactor uses enriched uranium to produce heat, the water is pressurised to stop it boiling. Pumps circulate the heated water through the reactor core from where it passes through a heat exchanger in a continuous loop; the heat exchanger produces steam which is supplied to turbo-generators to produce electricity and, in the case of submarines, turbines to propel the vessel. Once the steam has condensed, it is extracted and fed back to the heat exchanger to repeat the process in a closed cycle. Although the engineering hurdles were formidable, the pressurised water reactor was selected as the best model to pursue due its compact design, simplicity of operation and the safety characteristic of its negative temperature coefficient, a description of which is given in Chap. 2. See also Fig. 1.1 for an outline of a basic pressurised water reactor propulsion plant.

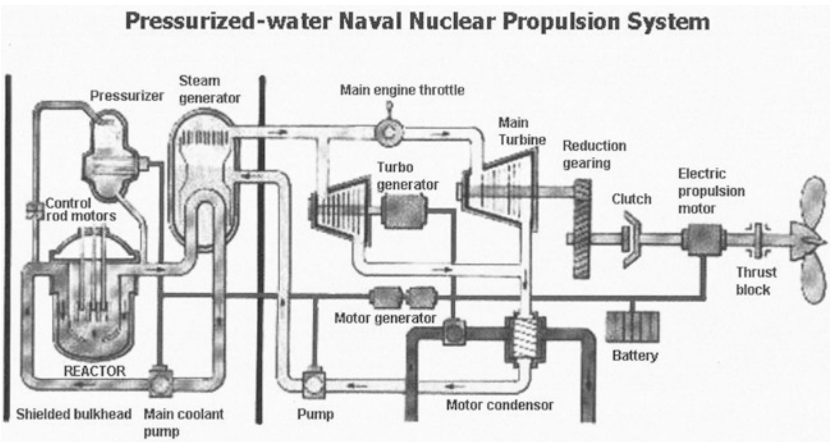

Fig. 1.1 Pressurised-water naval nuclear propulsion system

The world's first nuclear-powered submarine, the USS *Nautilus*, was launched 21 January 1954 by Mamie Eisenhower, wife of the then US president. The following year, 17 January, the USS *Nautilus* slipped down the River Thames leaving Groton, Connecticut, for her maiden sea trials. At 11:33, her Commanding Officer, Commander Eugene P. Wilkinson USN, sent the famous signal: 'Underway on nuclear power'.[1] In the intervening sixty-five years, only five other nations with the economic means have developed the technical capability to undertake the construction, operation and maintenance of nuclear-powered submarines: Russia (*Leninsky Komsomol*, SSN launched August 1957), Britain (*Dreadnought*, SSN launched October 1960), France (*Le Redoutable*, SSBN launched March 1967), China (*Long March 1*, SSN reportedly launched 1970) and India (*Arihant*, SSBN launched July 2009).[2] To gain experience of nuclear-powered submarines the Indian Navy leased a Soviet *Charlie* SSGN class submarine between 1987 and 1991, in commission with the Indian Navy it was named *Chakra*. As an integral part of a balanced blue-water navy, the nuclear-powered submarine enables these countries to project their political and military power in ways not possible by conventional means. To date, Britain has built twenty-four nuclear-powered submarines (SSN) and eight nuclear-powered and nuclear-armed submarines (SSBN) that carry the nation's deterrent.[3] Currently, the Royal Navy has three *Astute* class SSNs and four new *Dreadnought* class SSBNs either in build or on order. The first Royal Navy nuclear-powered submarine, HMS *Dreadnought*, was powered by a nuclear propulsion plant purchased from the US. Royal Navy submarines since *Dreadnought* have been powered by nuclear propulsion plants designed and built by Rolls-Royce and Associates at their Raynesway plant at Derby.[4] Since 15 January 1999, the company has been known as Rolls-Royce Marine Power Operations Ltd.

Sir Leonard Owen, who, in 1954 on the formation of the United Kingdom Atomic Energy Authority's (UKAEA), was appointed as its first Director of Engineering, wrote that at the time of setting up Britain's nuclear organisation: '…there were few scientists or engineers in Britain who were familiar with atomic energy'. Indeed, Owen noted that of the

[1] Norman Polmar and Thomas B. Allen, *Rickover* (New York, Simon and Schuster, 1982), p. 165.

[2] https://en.wikipedia.org/wiki/list_of_nuclear_submarines [Accessed 15 January 2021].

[3] NATO Acronyms: Ship Submersible Nuclear (SSN) and Ship Submersible Ballistic Nuclear (SSBN).

[4] For further details of nuclear-powered Royal Navy submarines, see Appendix.

twelve personnel starting at the UKAEA's Industrial Group at Risley, Lancashire, '…only one person knew anything about atomic energy. He was Dennis Ginns, an engineer who was home on sick leave from Chalk River'.[5] In private industry as well as the Royal Navy, the number of scientists and engineers working on nuclear matters was likely to have been negligible. The initial thrust of research and development in nuclear power was directed towards its civil application in support of the development of the atomic bomb and, later, electrical generation for the national grid. Yet it is a reflection of the political will on both sides of the Parliamentary divide, and of the scientific and engineering prowess that Britain was (is) capable of, that from these beginnings within the space of fifteen years Britain was in a position to launch its first nuclear-powered submarine, HMS *Dreadnought*. The primary aim of this book is to research, investigate and analyse the introduction of nuclear propulsion into the Royal Navy's submarine fleet, because arguably, it is part of the legacy of those political, naval and engineering decisions, made over sixty years ago, that allow Britain to "punch above its weight" on the world stage long after its Empire has ceased to exist (Image 1.1).

Overview

With economic decline setting in after World War II in Britain, and the acceptance of the right of an indigenous population to self-determination, there was a growing realisation in government that the Empire was morally, and financially, untenable. The granting of independence to the former colonies meant that there was no longer a requirement for Britain to maintain the expensive naval bases, air stations and army garrisons that were needed to defend and police these overseas territories. Many of these military assets were handed over to the new governing powers for the use of their fledgling services. Arguably, successive British Governments wanted to maintain some presence in the regions they vacated, partly in order to influence the democratic governance of their former colonies. Mainly, however, the British Government's objective was to prevent Soviet influence from filling the political vacuum of their departure and gaining

[5] Leonard Owen, 'Nuclear Engineering in the United Kingdom – the First Ten Years', *Journal of British Nuclear Energy*, (Jan., 1963), 23–32 (p. 23). Note: Chalk River, Canada, was the site of the Tube Alloys Project, the UK project to develop an atomic bomb, it later became part of the Manhattan Project.

Image 1.1 HMS/m *Dreadnought* entering Gibraltar

a presence in these regions. This was especially so in areas where major trade routes passed geographical choke-points such as the Straits of Hormuz into the Persian Gulf and the Bab El Mandeb Straits into the Red Sea. Economically and politically, it can be argued that the easiest means of maintaining a presence in a foreign region is through naval power. Unlike an air base or an army garrison stationed in a foreign country, the warship is sovereign territory and it is manoeuvrable. Diplomatic clearance from a foreign government is not required to utilise this asset and it can be positioned in areas to react to situations where it may be of greatest strategic influence. Unlike the conventionally powered surface warship, the nuclear-powered submarine requires no fuelling facilities when deployed, so it does not need to call into port or to have a Royal Fleet Auxiliary deployed with it. The nuclear-powered submarine can operate autonomously from other military and political considerations that would constrain a surface warship, which makes it a very potent unit to have at a government's disposal.

In the period after World War II up to the present day, British political and military influence has been maintained in some areas by a visible maritime presence. Initially this was achieved by aircraft carriers in the Mediterranean and the Far East and by dedicated warships in other areas deemed of importance to governments, such as the *Beira* Patrol which, between 1966 and 1976, enforced UN sanctions, in particular the oil embargo against Southern Rhodesia, at an estimated cost of some £100 million.[6] More recently, warships have been given designated patrol areas to project British influence, for instance, the *Armilla* Patrol which was instigated at the start of the Iran/Iraq war in 1980 to ensure safe passage of merchant shipping through the Straits of Hormuz. From the late 1960s however, although Britain has struggled to maintain its political and military influence, and its maritime presence has become less visible. This became more apparent in the late 1960s and early 1970s with the British Government focussed on joining the European Economic Community resulting in descending importance of the Commonwealth and Britain's worldwide authority. Britain does, however, continue to support NATO and maintain its seat as a permanent member of the UN Security Council. Significantly, Britain provides substantial submarine-focussed support to its NATO allies, the most explicit example being the nuclear deterrent patrols of the Polaris/Trident armed submarines. Also of note was the Callaghan Government's decision in the late 1970s to despatch HMS *Dreadnought* to the South Atlantic to deter possible Argentine aggression towards the Falkland Islands.[7] To this day, the nuclear-powered submarine allows Britain to maintain and exercise its political and military role on the world stage.

A typical World War II submarine, such as the German Type VIIC, displaced around 870 tons submerged, while many modern nuclear-powered submarines displace more than 5000 tons submerged.[8] The nuclear power propulsion plant has not only increased the sustained speed of the modern-day submarine, it has increased its endurance. Nuclear

[6] William Minter and Elizabeth Schmidt, 'When Sanctions Worked: The Case of Rhodesia re-examined', *African Affairs*, Vol. 87, No. 347, (Apr., 1988), 207–37 (p. 216).

[7] http://www.theguardian.com/uk/2005/jun/01/argentina.military [Accessed 3 December 2015].

[8] J. F. Starks, 'German "U"-Boat Design and Production', *Transactions of the Institution of Naval Architects,* (1948), 291–315 (p. 298).