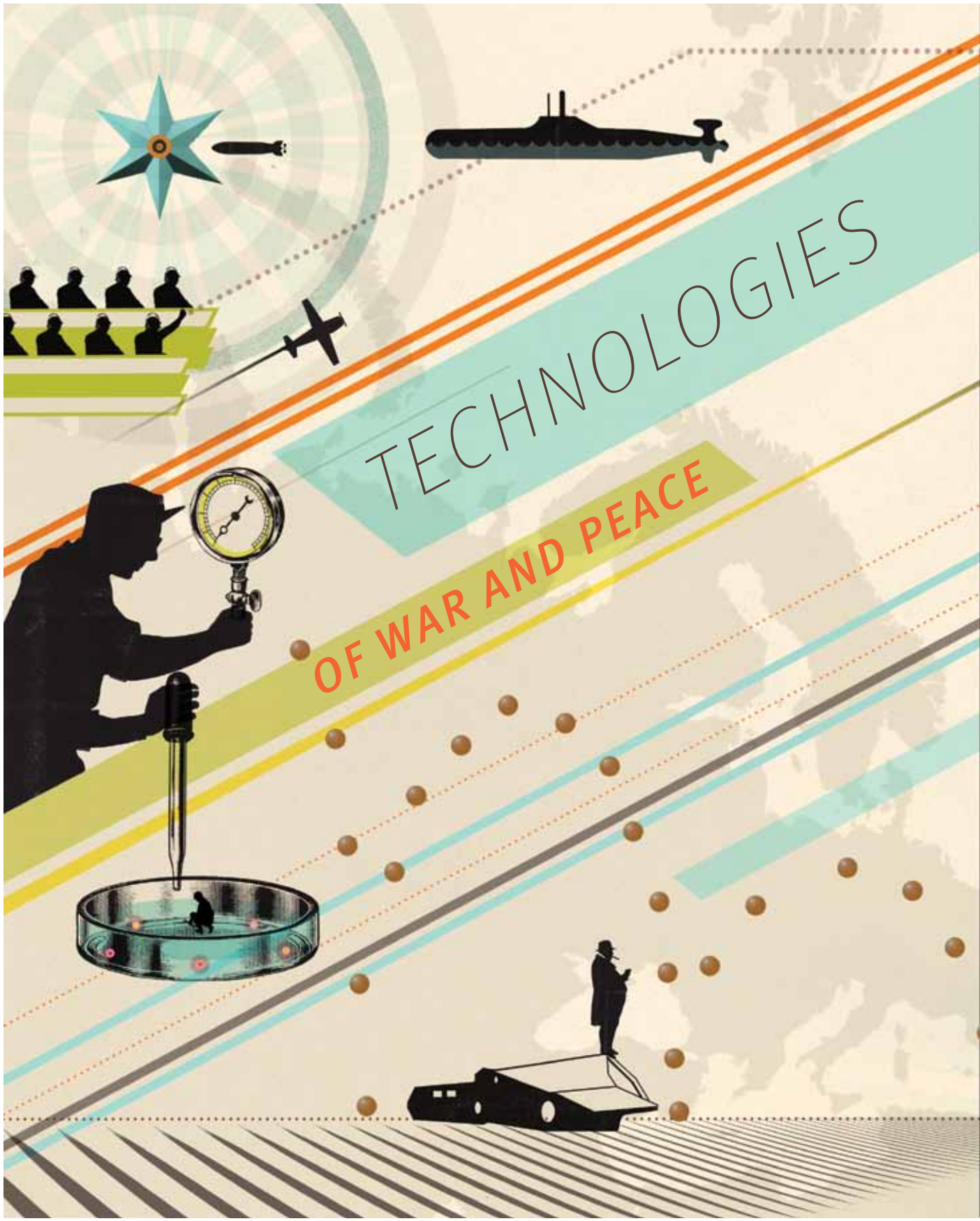
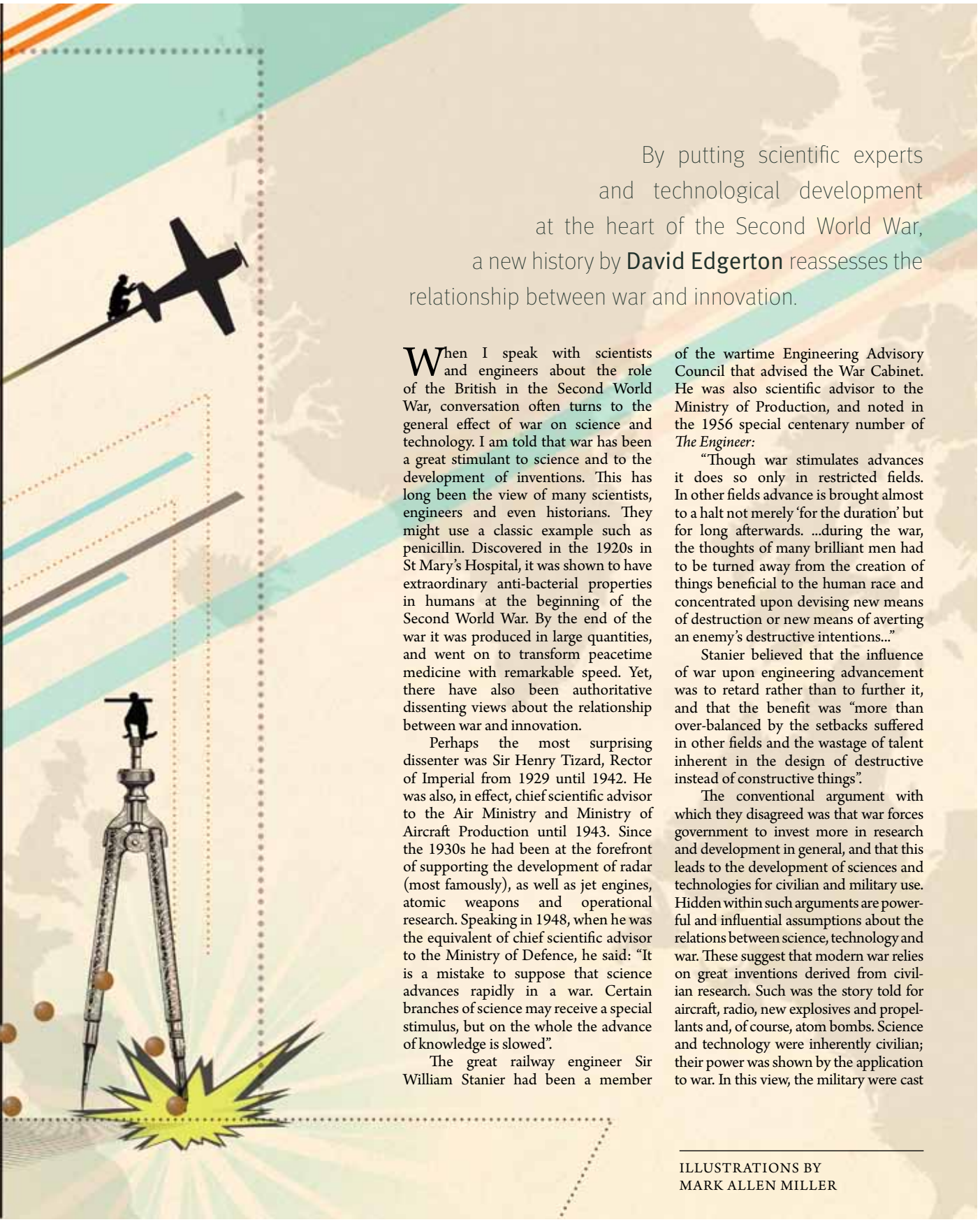

TECHNOLOGIES
OF WAR AND PEACE



By putting scientific experts and technological development at the heart of the Second World War, a new history by **David Edgerton** reassesses the relationship between war and innovation.

When I speak with scientists and engineers about the role of the British in the Second World War, conversation often turns to the general effect of war on science and technology. I am told that war has been a great stimulant to science and to the development of inventions. This has long been the view of many scientists, engineers and even historians. They might use a classic example such as penicillin. Discovered in the 1920s in St Mary's Hospital, it was shown to have extraordinary anti-bacterial properties in humans at the beginning of the Second World War. By the end of the war it was produced in large quantities, and went on to transform peacetime medicine with remarkable speed. Yet, there have also been authoritative dissenting views about the relationship between war and innovation.

Perhaps the most surprising dissenter was Sir Henry Tizard, Rector of Imperial from 1929 until 1942. He was also, in effect, chief scientific advisor to the Air Ministry and Ministry of Aircraft Production until 1943. Since the 1930s he had been at the forefront of supporting the development of radar (most famously), as well as jet engines, atomic weapons and operational research. Speaking in 1948, when he was the equivalent of chief scientific advisor to the Ministry of Defence, he said: "It is a mistake to suppose that science advances rapidly in a war. Certain branches of science may receive a special stimulus, but on the whole the advance of knowledge is slowed".

The great railway engineer Sir William Stanier had been a member of the wartime Engineering Advisory Council that advised the War Cabinet. He was also scientific advisor to the Ministry of Production, and noted in the 1956 special centenary number of *The Engineer:*

"Though war stimulates advances it does so only in restricted fields. In other fields advance is brought almost to a halt not merely 'for the duration' but for long afterwards. ...during the war, the thoughts of many brilliant men had to be turned away from the creation of things beneficial to the human race and concentrated upon devising new means of destruction or new means of averting an enemy's destructive intentions..."

Stanier believed that the influence of war upon engineering advancement was to retard rather than to further it, and that the benefit was "more than over-balanced by the setbacks suffered in other fields and the wastage of talent inherent in the design of destructive instead of constructive things".

The conventional argument with which they disagreed was that war forces government to invest more in research and development in general, and that this leads to the development of sciences and technologies for civilian and military use. Hidden within such arguments are powerful and influential assumptions about the relations between science, technology and war. These suggest that modern war relies on great inventions derived from civilian research. Such was the story told for aircraft, radio, new explosives and propellants and, of course, atom bombs. Science and technology were inherently civilian; their power was shown by the application to war. In this view, the military were cast

ILLUSTRATIONS BY MARK ALLEN MILLER

as technologically conservative, resistant to the new machines offered by civilian ingenuity. Those who held this view, often also believed that these technologies would bring about a world of perpetual peace, if only human organisation were modernised, in the form of a world state.

Such assumptions may help explain a curious implicit distinction made between different kinds of machines used by armed forces. Compare, for example, London's Science Museum with its Imperial War Museum, both of which are full of machines. In the Science Museum we find military aero-engines, military aircraft, early rockets (including V2s, illustrated below), radar and the story of atomic bombs, but none of the tanks, guns, or bombs that reside in the Imperial War Museum.

The distinction here is that, while aeroplanes, aero-engines, electronics and atomic physics are essentially civilian and have proved their worth by their centrality to war, 'pure weapons' lie outside the realm of science and technology. But does this distinction make sense? Would it not be better to think of separate but overlapping realms of military and civil machines, both subject to research and rapid advance? This is, in effect, what Tizard and Stanier thought, and I believe that the answer is an obvious 'yes'. Less obvious, perhaps, is that machines and techniques, such as aviation, radio and radar, routinely labelled as civilian innovations that have transformed war, should be seen as primarily military.

Aviation and aero-engines were overwhelmingly a military concern, even in peacetime before and after the Second World War (some 75 per cent by value was military). The connections between radio and the military had been intimate from the earliest days, when the Navy was the major customer for radio. Radio remained closely allied to the state through the inter-war years. Radar was the product of military research establishments. The atomic bomb was more clearly distant from the military, but soon became an essentially military project.

Perhaps the Science Museum should consider removing its primarily military technologies, like aeroplanes, aero-engines, early radio, many early computers, and most of the nuclear field, and donate them to the Imperial War Museum? Or better, maybe it should display a wider range of weapons that were as much the product of science and technology, as the civilian technologies it focuses on. For the military used science and technology, not only to develop the aeroplane, radio or atom bomb, but also guns, explosives and poison gas. We might also consider why the V2 rocket is prominently displayed in both the Science and War Museums pointing upwards, rather than downwards in the direction in which most Londoners would have experienced it, as a former curator once memorably pointed out to me.

In assessing the role of war in driving the progress of science and technology, we also need to recognise the significance of the military and military institutions for science and technology. It is greater than we might imagine.

Take, for example, the history of Imperial College London. More than half of its 15 Rectors have had significant and long-standing connections to the military. Sir Alfred Keogh, the first long-serving rector (1910–22), was a medical man, and creator and great organiser of the Royal Army Medical Corps. Successive Rectors from 1929 to 1954 – Sir Henry Tizard, Sir Richard Southwell and Air Chief Marshall Sir Roderic Hill – came from the military aeronautical world. From the late 1960s through to the 1980s, two nuclear knights, both later nuclear peers, presided: William Penney (Mathematics and Mechanics 1929, PhD 1930), Rector from 1967–73, led the team that built the first British atomic bombs; Brian Flowers, Rector from 1973–85, played a leading role in developing atomic energy in postwar Britain. More recently, three Rectors have worked as chief scientific advisor to the Ministry of Defence: Lord Oxburgh, Sir Roy Anderson (Botany and Plant Technology 1968, PhD 1971) and Sir Keith O'Nions. Together with Cambridge, Imperial also provided the core of scientific civil servants who rose to senior positions – men like A.P. Rowe (Physics 1920, DIC 1924), who headed the main radar laboratory during the war, and Harold Roxbee-Cox (Aeronautics 1923, DIC 1926), who supervised the jet engine programme.

The world of weapons development stretched beyond government laboratories and programmes. It involved not just academic research scientists, but also industrial researchers, inventors, military officers and, indeed, politicians. The idea that the British political and military elite have been technologically conservative is wrong. For example, in the Second World War, Britain saw an extraordinary cult of invention, and its high priest was Winston Churchill. The myths that have accumulated around Barnes Wallis (inventor of the bouncing bomb and a Civil Engineering researcher in 1937–38) and, to some extent, Frank Whittle (co-inventor of the turbojet engine) are just that. The reality was very different.

Winston Churchill not only personally supported all sorts of inventions, and kept unorthodox inventive organisations going, but invented an extraordinary machine himself. In November 1939, he came up with an idea, a sketch, for a gigantic earth-moving mole that would cut huge trenches. His idea was that 200–300 of these 100-ton monsters would be used along a front of 20–25 miles, moving through the night from one front line to the other. Churchill wanted a means of "breaking a dead-

lock on the French front without repetition of the slaughter of the previous war". They were to be powered by a Rolls-Royce Merlin aero-engine, precious things in early 1940, which even Churchill could not prise out of the hands of the Air Ministry, despite his furious efforts. With the fall of France, the machine was essentially redundant, and Churchill, now in Downing Street, reduced the order to 33 machines, and then to four, which did get built.

It is tempting to look at Churchill's mole and to assume, since no-one else made one and none was needed, that the whole effort was thoroughly misplaced. Yet, in a different scenario, the mole could have become a famous and decisive weapon, one which might have led, say, to an Anglo-French march on Berlin in 1941.

There were other inventors in Parliament. William Helmore, MP for Watford, invented a giant air-launched and radio-guided torpedo powered by aero-engine, which was developed at the end of the war. A former MP, Sir Dennistoun Burney, worked on a gliding torpedo, the Toraplane. He also invented a recoilless gun (he had invented the mine-sweeping paravane in the Great War, and was later to pioneer the freezer-trawler).

Military inventors included Major General Sir (as he became) Millis Jefferis, who ran an outfit called 'Winston Churchill's Toyshop', which was responsible for all sorts of gadgets, and Lieutenant Colonel Stewart Blacker, inventor of the Blacker Bombard and the Petard, and important contributor to the Hedgehog anti-submarine device and the PIAT anti-tank gun. Or take the reclusive genius Geoffrey Pyke, inventor of the iceberg aircraft carrier, or the lawyer Edward Terrell (son of Terrell of *Terrell on Patents),* inventor of plastic armour.

So much invention was going on that, for some senior scientists, it was causing problems. A particularly vocal opponent of over-invention, and indeed of Churchill, was the only scientific Nobel laureate ever to sit in Parliament. In 1940, A.V. Hill was elected by the graduates of the University of Cambridge to one of their two parliamentary seats as an independent conservative. He complained to parliament in February 1942: "There have been far too many ill-considered inventions, devices, and ideas put across, by persons with influence in high places, against the best technical advice… They have cost the country vast sums of money and a corresponding effort in development and production, to the detriment of profitable expenditure of labour and materials elsewhere." We know from Hill's papers that he thought the greatest waste of money was the anti-aircraft rocket programme, strongly backed by Churchill, which he described as a "most infernal waste of time, effort, manpower and material".

Another example is physicist Patrick Blackett, then at Manchester but later to become a key figure at Imperial. Blackett engaged in a general critique of the pursuit of novelty, criticising the call for 'new weapons for old' as a form of "escapism". Too little effort was going into "the proper use of what we have got", he wrote. Changing tactics could be more effective than changing weapons. He wanted to redeploy scientists from research and development to "improve the operational efficiency of equipment and methods now in use".

These were also very much the views of Sir Henry Tizard, another key figure in promoting operational research. With Blackett, he opposed the British atom bomb programme on the grounds that it was likely to take longer and cost more than promised. They were proved correct, with no bomb being made until the US one in 1945. Far from being cheaper than conventional explosive, it was the most expensive explosive device ever made: the US bomb took at least two years longer, and cost 50 times more, than the British bomb was meant to. Here, it is scientists who seem to be the technological conservatives.

The war inevitably also saw wasted invention. Yet the extent to which some of these wasteful inventions became known as important contributors to victory is surprising. The atomic bomb is the most famous new device of the war, but its contribution to fighting the war was negative. It marked, rather than brought about, the end of conflict. British jet engines made no impact. Although the two artificial Mulberry harbours towed to the Normandy beaches were much celebrated, they contributed less than propaganda implies, then and since. The PLUTO (Pipe Line Under the Ocean) was designed to take petrol across the English Channel. Built at great expense, it turned out to be quite unnecessary and worked very badly. The impact of the bouncing bomb was exaggerated: it led to severe losses, ensuring that Bomber Command never used it again. Of the famous developments only radar and penicillin made definite positive contributions, to which can be added the more recently known code-breaking methods and machines.

> "It is a mistake to suppose that science advances rapidly in a war."
>
> *Sir Henry Tizard, Rector, 1929–42*

What then is the verdict? Does war accelerate or decelerate the progress of science and technology in general? My view is that, on balance, Tizard and Stanier were right: the development of key civil technologies has probably been retarded by war. On the other hand, we should not neglect the significance of the military and military-related institutions that have been remarkably productive of military technologies (contrary to cliché), some of which are mistakenly characterised as civilian technologies applied to war.

The proper answer is that we cannot really be certain. As with so many debates about science and technology, this one must proceed by assertion and anecdote rather than carefully analysed evidence. It does so, not at random, but within a framework of assumptions that we would do well to be aware of, and against a backing track of quiet dissenting voices, not least from Imperial, which provide a little grist to the mill of critical analysis. ▣

DAVID EDGERTON *(PhD Social and Economic Studies 1984) is the Hans Rausing Professor at Imperial's Centre for the History of Science, Technology and Medicine. His latest book,* Britain's War Machine: Weapons, Resources and Experts in the Second World War, *is published by Allen Lane.*