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BRITISH TANK PRODUCTION, 1934-1945

Benjamin Coombs

Submitted for the degree of PhD

University of Kent

2011

Abstract

This thesis examines the governmental, industrial and strategic factors that influenced British tank production from 1934 until 1945 against the wider context of the British war economy and the tank programmes of Canada and the United States. The changing organisational structure of controlling the British tank programme has been reviewed alongside the mutual considerations of war planning for the armed forces generally. A central theme of this research has been to provide a history of war production by highlighting the specific demands placed upon individual firms against the different pressures of war, such as the threat and effects of bombing and shortages of skilled labour and components. This study has shown that the priority for aircraft production, together with the immediate requirement to provide large numbers of tanks to the army during the first half of the war, meant that the initial problems associated with British tank design were unavoidable. The transformation from quantity to quality tank output during the second half of the war was achieved by the introduction of new tank designs, improvements in assembly efficiency, and by accepting greater numbers of Lend-Lease tanks to supplement General Staff requirements. This reliance upon American armour originated from the first orders during 1940 until the end of the war, although British over dependency was demonstrated when both nations contracted their respective tank programmes prematurely during 1944. The Canadian tank programme greatly assisted British efforts to supply the Russian authorities with the preferred Valentine tank, which was necessary to achieve their operational doctrine of standardised equipment. Finally, the post-war British tank programme mirrored the pre-war arrangement of Vickers-Armstrongs and the new state controlled Royal Tank Arsenal, whilst the civilian tank firms transferred to their core industries to supply the re-emerging peacetime markets.

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Abbreviations

ACIGS	Assistant Chief of the Imperial General Staff
AFV	Armoured Fighting Vehicles
APCBC	Armour-Piercing Capped Ballistic Capped
APDS	Armour-Piercing Discarding Sabot
ARP	Air Raid Precautions
ASE	Allied Supplies Executive
BAH	Birmingham Archives and Heritage
BAS	British Army Staff
BCVM	British Commercial Vehicle Museum
BLO	Bodleian Library, Oxford
BPC	British Purchasing Commission
BSM	British Supply Mission
CAFV	Chairman, Armoured Fighting Vehicles
CCA	Churchill College Archives
CDL	Canal Defence Light
CGMP	Controller-General of Munitions Production
CGRD	Controller-General of Research and Development
CIGS	Chief of the Imperial General Staff
CMH	Canadian Military Headquarters
CUL	Cambridge University Library
DAFV	Director of Armoured Fighting Vehicles
DCIGS	Deputy Chief of the Imperial General Staff
DD	Duplex-Drive
DDGAE	Deputy Director-General of Army Equipment
DDGOF	Deputy Director-General of Ordnance Factories
DDGTT	Deputy Director of Tanks and Transport
DDRAC	Deputy Director, Royal Armoured Corps
DGAE	Director-General of Army Equipment
DGAR	Director-General of Army Requirements
DGAFFV	Director-General of Armoured Fighting Vehicles
DGFVP	Director-General of Fighting Vehicles Production
DGMP	Director-General of Munitions Production
DGP	Director-General of Programmes
DGTS	Director-General of Tank Supply
DGTT	Director-General of Tanks and Transport
DME	Director of Mechanical Engineering
DMS	Department of Munitions and Supply
DND	Department of National Defence
DRAC	Director, Royal Armoured Corps
DTD	Department of Tank Design
FPS	Feet Per Second
FVPE	Fighting Vehicle Proving Establishment
GAG	Gloucestershire Archives, Gloucester
GMC	General Motors Corporation
HMC	Heritage Motor Centre
LAC	Library and Archives Canada
LHCMA	Liddell Hart Centre for Military Archives

MEE	Mechanization Experimental Establishment
MGAFV	Major-General, Armoured Fighting Vehicles
MGO	Master-General of the Ordnance
MRC	Modern Records Centre
NAA	National Archives of Australia
NCL	Nuffield College Library
ODNB	Oxford Dictionary of National Biography
RAOC	Royal Army Ordnance Corps
REME	Royal Electrical and Mechanical Engineers
RLG	Russian Liaison Group
ROF	Royal Ordnance Factory
SMM	Soviet Military Mission
SRO	Staffordshire Records Office
STD	Soviet Trade Delegation
SVDC	Special Vehicle Development Committee
TLO	Technical Liaison Officer
TNA	The National Archives
TOG	The Old Gang
VCIGS	Vice-Chief of the Imperial General Staff

Selection of tank specifications relevant to this study¹

Tank	Crew	Battle Weight	Main Gun	Max Armour	Engine	Max Speed	Max Range	Track Width
Number and Name		tons		mm	bhp	mph	miles	inches
<i>Britain</i>								
Light Mark VI B	3	5.50	0.50 mg	14	Meadows 88	35	130	9.50
A.17 Tetrarch	3	7.50	2-pdr	14	Meadows 165	40	140	9.50
A.25 Harry Hopkins	3	8.50	2-pdr	38	Meadows 148	30	125	10.50
A.11 Infantry	2	11.00	0.303 mg	60	Ford 70	8	80	11.50
A.12 Matilda	4	26.50	2-pdr	78	2 x AEC 87	15	160	14.00
Valentine III	4	17.50	2-pdr	65	AEC 131	15	90	14.00
Valentine X	3	18.50	6-pdr	65	GMC 165	15	90	14.00
Valentine XI	3	18.50	75 mm	65	GMC 165	15	90	14.00
A.22 Churchill II	5	39.00	2-pdr	102	Bedford 350	8	90	14.00
A.22 Churchill III	5	39.00	6-pdr	102	Bedford 350	8	90	14.00
A.22 Churchill VII	5	40.00	75 mm	152	Bedford 350	8	90	14.00
A.22 Churchill VIII	5	40.00	95 mm	152	Bedford 350	8	90	14.00
A.9 Cruiser	6	13.00	2-pdr	14	AEC 150	25	150	14.00
A.10 Cruiser	5	14.00	2-pdr	30	AEC 150	16	100	14.00
A.13 Covenanter	4	18.00	2-pdr	40	Meadows 280	31	100	10.75
A.15 Crusader	5	19.00	2-pdr	40	Liberty 340	27	100	10.75
A.15 Crusader III	3	19.75	6-pdr	66	Liberty 340	27	100	10.75
A.24 Cavalier	5	26.50	6-pdr	76	Liberty 358	24	165	14.00
A.27L Centaur	5	28.00	6-pdr	76	Liberty 395	27	165	14.00
A.27L Centaur IV	5	28.00	95 mm	76	Liberty 395	27	165	14.00
A.27M Cromwell III	5	28.00	6-pdr	76	Meteor 600	32	173	14.00
A.27M Cromwell VI	5	28.00	95 mm	76	Meteor 600	32	173	14.00
A.27M Cromwell VII	5	28.00	75 mm	101	Meteor 600	32	173	15.50
A.30 Challenger	5	32.50	17-pdr	101	Meteor 600	32	120	15.50
A.34 Comet	5	35.00	77 mm	101	Meteor 600	29	123	15.50
A.41 Centurion	4	48.00	17-pdr	152	Meteor 600	22	60	24.00
A.39 Tortoise	7	78.00	32-pdr	229	Meteor 600	12	50	33.00
<i>United States</i>								
M3 Stuart	4	12.75	37 mm	51	Continental	36	70	11.65
M3 Grant II	6	29.00	75 mm	75	GMC 375	26	160	16.50
M4A4 Sherman	5	31.50	75 mm	75	Chrysler 425	24	150	16.50
M4A3 Sherman	5	32.50	76 mm	62	Ford 500	24	100	16.50

Key: AEC Associated Equipment Company GMC General Motors Corporation

NB: Specifications for Russian and German tanks are compared during the relevant sections of this thesis.

¹ The National Archives, Kew, CAB 102/851, 'Brief Particulars of British, American, Russian and German Tanks', October 1944; P. Chamberlain and C. Ellis, *British and American Tanks of World War Two: The complete illustrated history of British, American and Commonwealth tanks, 1939-1945* (Leicestershire, Silverdale Books, 2004).

Introduction

A scholarly examination of British tank production relating to the Second World War has not been established within the historiography despite a continuing interest in the subject matter. The two-part analysis by David Fletcher displays a good chronological analysis and appears to be based on the original findings from the Tank Museum in Bovington, however the methodology is let down by this limited research and presenting unreferenced evidence.¹ Peter Beale's later account is highly critical and as a war veteran displays a great deal of genuine anger and negativity towards the government and military authorities. Despite using some original material, this work has too many faults including insufficient research and unreferenced evidence, but more importantly provides contradictory arguments and lacks objectivity to add anything new to the historiography.² In contrast, David Edgerton offers a more positive history of British tank production as part of his recent study that challenges the poor perception of Britain's war production generally.³

The variety of tank related histories written for the popular market are generally illustrative in nature and lack referencing, as demonstrated by the specific tank histories from the Tank Museum and the New Vanguard Osprey series. Whilst the latter provides detailed cross-sections to identify the positioning of tank components, these works offer a limited understanding and will therefore be omitted from this study.⁴ On the other hand, the comprehensive review of Allied armour by Peter Chamberlain and Chris Ellis will be consulted to clarify tank specifications and particular nuances between the various models.⁵ Therefore in the absence of an academic study this thesis will use material held within the various archives that historians have either under researched or completely overlooked. As a result, this thesis will provide new arguments and greater analysis of British tank production

¹ D. Fletcher, *The Great Tank Scandal: British Armour in the Second World War, Part 1* (London, H.M.S.O., 1989); D. Fletcher, *The Universal Tank: British Armour in the Second World War, Part 2* (London, H.M.S.O., 1993).

² P. Beale, *Death by Design: British Tank Development in the Second World War* (Stroud, Sutton Publishing, 1998), pp. vii, 45-46, 67, 144, 165 & 196.

³ D. Edgerton, *Britain's War Machine: Weapons, Resources and Experts in the Second World War* (London, Allen Lane, 2011), pp. 65, 155-156 & 220-226.

⁴ The Tank Museum, *Churchill Tank: Vehicle History and Specification* (London, H.M.S.O., 1983); The Tank Museum, *Cromwell Tank: Vehicle History and Specification* (London, H.M.S.O., 1983); D. Fletcher, *Crusader and Covenant Cruiser Tanks, 1939-1945* (Oxford, Osprey Publishing, 1995); S. Dunstan, *Centurion Universal Tank, 1943-2003* (Oxford, Osprey Publishing, 2003); D. Fletcher and R. C. Harley, *Cromwell Cruiser Tank, 1942-50* (Oxford, Osprey Publishing, 2006); B. Perrett, *Churchill Infantry Tank, 1941-51* (Oxford, Osprey Publishing, 2007).

⁵ P. Chamberlain and C. Ellis, *British and American Tanks of World War Two: The complete illustrated history of British, American and Commonwealth tanks, 1939-1945* (Leicestershire, Silverdale Books, 2004).

efforts within the overall context of war planning and the war economy, alongside the greater global perspective of Canadian, American and Russian wartime history.

The term 'tank production' can relate to any part of the process from the original desire for a particular tank, through the design, development and testing stages, and then on to full production and eventual shipment for use by front line units. Therefore this study will examine the governmental, strategic and industrial influences upon the British tank programme within the period of 1934 to 1945. From the political perspective, this study will highlight the role of government in controlling the tank programme, against the various strategic and industrial pressures in meeting the changing requirements of the General Staff. The strategic factors relate to providing tanks to British theatres of war overseas, whilst simultaneously adjusting the tank programme to meet the expected number of tanks from the United States and supplying tanks to Russia alongside Canadian industry. The industrial considerations include the experience of the tank firms involved in completing the tank contracts and the different effects that the war had upon the workers within the factories.

With regard to particular sources, the documents relating to government departments have been found at the British National Archives at Kew, together with the personal papers held at King's College London, and Cambridge and Oxford Universities. Similarly, the official papers from the Canadian Library and Archives in Ottawa have been reviewed for information relating to the Canadian war effort, and for reports sent by Britain to Canada which had not been located from within British sources. Additional international context has been provided by the National Archives of Australia for information regarding how the supply of tanks from Britain and the United States affected the Australian requirement to raise armoured units. Given the limitations on time and space, the extent to which this study can consider the United States tank programme has been limited to the material found within the British, Canadian and Australian sources. However these sources have provided: trans-Atlantic correspondence between key officials; reports on visits to American tank factories to highlight differences in productive practices; and opinion from British front line workshops in respect of the benefits and problems of American industry.

The most significant area of research relates to the archives of British industry, which include the papers of motor manufacturers, railway locomotive and carriage constructors, heavy engineering and other industrial firms. These have been studied at Cambridge, Oxford,

Reading and Warwick Universities, the Heritage Motor Centre Motor Museum in Gaydon, the British Commercial Vehicle Museum in Leyland, and the public archives in Birmingham, Gloucester and Stafford. From a methodological standpoint, as these papers relate to individual commercial entities the standard and amount of information recorded will vary from one firm to the other, making direct comparisons difficult on occasion. However as this thesis will demonstrate, the information contained within these archives provides specific insights into the experience of industry across the period under review, and a level of context hitherto not considered within the existing historiography.

These archival sources will be used in conjunction with works of scholarship and academic journals to provide general information and to contextualise the specific themes identified in this thesis. Memoirs and biographies will be used to incorporate the wartime experience of tank crews, the General Staff, senior government officials and leading industrialists. Newspapers and the official histories from Britain, Canada, the United States, and Australia will be considered for information to support the findings of this study or to identify areas of dispute. To identify the new arguments presented by this thesis and the particular outcomes of each chapter, the general themes within the historiography will be discussed.

The official histories relating to British tank production during the Second World War provide a good narrative by using government papers before their general release to the public, but the analysis is limited by being divided amongst the different accounts.⁶ The source material is generally unidentified and the analysis may support certain agendas and emphasis and thus exclude other areas of importance.⁷ Furthermore, Professor Postan was prevented from publishing his detailed findings of tank production from the factory floor for reasons of security due to the onset of the Korean War.⁸ Given the similarities in source material, methodology and interpretation, the official histories will be referred to as one source in this thesis, unless there is an obvious dispute that requires highlighting.

⁶ W. M. Hancock and M. M. Gowing, *British War Economy* (London, H.M.S.O., 1949); M. M. Postan, *British War Production* (London, H.M.S.O. and Longmans, Green, 1952); W. Ashworth, *Contracts and Finance* (London, H.M.S.O., and Longmans, Green, 1953); J. D. Scott and R. Hughes, *The Administration of War Production* (London, H.M.S.O., 1955); P. Inman, *Labour in the Munitions Industries* (London, H.M.S.O., 1957); W. Hornby, *Factories and Plant: A History of the Second World War* (London, H.M.S.O., 1958); M. M. Postan, D. Hay and J. D. Scott, *Design and Development of Weapons: Studies in Government and Industrial Organisation* (London, H.M.S.O., 1964).

⁷ D. Edgerton, *Warfare State: Britain, 1920-1970* (Cambridge, Cambridge University Press, 2006), pp. 63-64.

⁸ R. C. D. Allen, 'History of the Second War. "British War Production" by M. M. Postan', *The Economic History Review, New Series*, Vol. 6, No. 1 (1953), p. 89.

Manufacturing histories from Vickers-Armstrongs, Vauxhall Motors, the Nuffield Organisation and Harland & Wolff will provide some unique insights not found in the other histories, however they are deliberately written to promote the firm and therefore lack objectivity. Memoirs published after the war have the inherent problems of being written with hindsight and the desire to present either the events or themselves in the best possible light, which is particularly relevant to German officers and officials attempting to separate themselves from the Nazi regime.

The historiography relating to British tank production efforts together with analysis relating to the overall war economy, industrial strengths and weaknesses, and the changing situation on the various battlefronts, can be divided into three distinct sections. To begin with, economic history highlights the overall ability of Britain to commence and maintain war production against the internal pressures of government priorities, industrial capacity, raw materials and finance, and against the external pressures of enemy attack and blockade. Whilst the analysis is not tank specific, it establishes important factors that were influential to tank production. The second section of the historiography relates to the diverse nature of tank manufacturing which provides some detail on the design, development, testing and production stages of the British tank programme. The final section of the historiography relates to how British tanks performed within armoured units in relation to firepower, reliability and armour protection. To put these sections into perspective, the commentary relating to Britain has been compared to the similar analysis by historians regarding the wartime experiences of the United States, Germany and Russia. The tank production efforts of France, Japan and Italy have not been examined during this thesis because of the limited contribution of each nation, although there has been some recent scholarly analysis of the Italian war effort.⁹

The first section of this historiographical review will consider the economic situation to provide a broader understanding of tank production for the different nations at war. On a general basis, John Sweet argues extensively that armoured policy depended upon: national policy to decide on radical mechanisation or conservative motorisation; the doctrine to

⁹ V. Zamagni, 'Italy: how to lose the war and win the peace', in M. Harrison (ed.), *The Economics of World War II: Six great powers in international comparison* (Cambridge, Cambridge University Press, 2000); J. Gooch, *Mussolini and his Generals: The Armed Forces and Fascist Foreign Policy, 1922-1940* (Cambridge, Cambridge University Press, 2007); J. J. T. Sweet, *Iron Arm: The Mechanization of Mussolini's Army, 1930-1940* (Mechanicsburg, Stackpole Books, 2007).

determine the theoretical use of tanks; and the type and use of such equipment.¹⁰ The unique nature of tank development in mechanical and electrical engineering has been accurately described by the official history to be a 'highly-specialised industrial art without parallel in peace-time industry'.¹¹ As this study will highlight, the new firms introduced to the tank programme could not rely upon any pre-war experience but instead increased their productivity by overcoming the problems in tank manufacturing on an on-going basis.

When considering tank production generally, John Sweet correctly identifies that it is necessary to examine the economic, political and social issues as these influenced the development of mechanisation in each country.¹² The effect of economic considerations upon the war have been emphasised by Mark Harrison who argues that whilst these factors were less important for Germany during the early military successes, they later determined the outcome of the war through stalemate and attrition.¹³ Allan Millet highlights that the production priorities for the army, navy and air force followed the different 'strategic realities' of each nation.¹⁴ As a result Raymond Goldsmith describes how Britain and the United States prioritised aircraft production, whilst Germany and Russia emphasised a greater proportion of ground equipment.¹⁵ Goldsmith and Alan Milward argue that the advantages of qualitative production of German weapons was not enough to overcome the ability of the Allies to mass produce and ship armaments to all theatres of war in vast quantities.¹⁶ Furthermore as Richard DiNardo and Austin Bay have shown, the quality of German fighting efficiency was affected by the un-mechanized nature of German society that was reflected in the pre-dominantly horse-drawn army throughout the war.¹⁷

Historians argue that rather than the British Treasury hindering rearmament, investment was purposefully directed towards the air force and navy at the expense of the army to meet the

¹⁰ Sweet, *Iron Arm*, pp. 2, 4 & 9-14.

¹¹ Postan, *British War Production*, 426

¹² Sweet, *Iron Arm*, pp. ix & 3.

¹³ M. Harrison, 'The economics of World War II: an overview', in Harrison, *Economics of World War II*, pp. 1-2; M. Harrison, 'Resource Mobilization for World War II: The U.S.A., U.K., U.S.S.R., and Germany, 1938-1945', *The Economic History Review*, New Series, Vol. 41, No. 2 (May, 1988), p. 177.

¹⁴ A. R. Millett, 'Patterns of military innovation in the interwar period', in W. Murray and A. R. Millett (eds.), *Military Innovation in the Interwar Period* (Cambridge, Cambridge University Press, 1996), pp. 339-342.

¹⁵ R. W. Goldsmith, 'The Power of Victory: Munitions Output in World War II', *Military Affairs*, Vol. 10, No. 1 (Spring, 1946), p. 72.

¹⁶ *Ibid.*, p. 80; A. S. Milward, *War, Economy and Society: 1939-1945* (Berkeley and Los Angeles, University of California Press, 1979), pp. 58 & 75.

¹⁷ R. L. DiNardo and A. Bay, 'Horse-Drawn Transport in the German Army', *Journal of Contemporary History*, Vol. 23, No. 1 (Jan., 1988), pp. 129-142; G. Phillips, 'Scapegoat Arm: Twentieth-Century Cavalry in Anglophone Historiography', *The Journal of Military History*, Vol. 71, No. 1 (Jan., 2007), p. 66.

strategic demands of protecting British cities and home and overseas ports.¹⁸ The planning for war production was carried out by specialist ministries instead of being instigated by central planners.¹⁹ With regard to tank production, this study will examine the creation and changing role of the various Tank Boards that brought the Ministry of Supply and the General Staff together to control the tank programme on a joint basis. With the demand for increased output during 1940, a new system to prioritise the distribution of raw materials, capacity and labour was introduced which the official history describes as ‘clumsy and dangerous’ on any long term basis.²⁰ For the short term, this study will show how the greater priority for aircraft production dominated this system at the expense of tank production until November 1941.

In comparison to the United States, the official history draws the important distinction that American industry went straight into producing ‘offensive’ weapons, whereas Britain had to direct her initial production efforts to weapons for the ‘defensive’.²¹ In relation to Germany, Albert Speer argues that until he received control over the tank and navy programmes, German war production was constantly hampered by the intervention of Hitler and the Nazi leadership resulting in contradictory priorities.²² Finally from the Russian perspective, following the mistakes and paralysing effects of the outbreak of war, Harrison argues that a high degree of economic mobilization was quickly achieved, with a fully centralized and coordinated war economy operating after 18 months.²³ Upon comparing the different nations, Adam Tooze highlights that unlike Britain and Germany, the United States and Russia concentrated the war effort amongst a group of ‘truly enormous production facilities’ as a result of being outside the range of enemy bombers.²⁴

With regard to maintaining and increasing production levels, historians have emphasised that in the absence of a domestic supply, both Britain and Germany depended upon imported raw

¹⁸ Hancock and Gowing, *British War Economy*, pp. 65-66; G. C. Peden, *British Rearmament and the Treasury: 1932-1939* (Edinburgh, Scottish Academic Press, 1979), pp. 174-176; Edgerton, *Warfare State*, p. 18; D. French, *Raising Churchill's Army: The British Army and the War against Germany 1919-1945* (Oxford, Oxford University Press, 2001), pp. 107-108.

¹⁹ Edgerton, *Warfare State*, p. 71.

²⁰ Hancock and Gowing, *British War Economy*, pp. 283 & 301.

²¹ *Ibid.*, p. 368.

²² A. Speer, *Inside the Third Reich, Memoirs by*, first published 1969, trans. R. and C. Winston (London, Book Club Associates, 1971), pp. 183 & 272-273; Milward, *War, Economy and Society*, pp. 56-57.

²³ M. Harrison, ‘The Soviet Union: the defeated victor’, in Harrison, *Economics of World War II*, pp. 273-274; Harrison, ‘Resource Mobilization’, pp. 178 & 180.

²⁴ A. Tooze, *The Wages of Destruction: The Making and Breaking of the Nazi Economy* (London, Allen Lane, 2006), p. 578.

materials.²⁵ In relation to the demand upon steel supplies in Britain, Peter Howlett highlights that the distribution was carried out by the Raw Materials Department of the Ministry of Supply after the 'independent' Materials Committee had decided upon the appropriate allocation amongst the different service departments.²⁶ To illustrate the demand upon raw materials, this study will highlight the effects that shortages in finished tank components had upon tank output. As for Russia, despite being almost self-sufficient in food, fuel and mineral ores for industry, Harrison argues that the low state of development as measured by GDP per head meant that this capital-poor economy struggled with the high costs of machinery.²⁷ When compared to the economic ability of Britain, this study will examine the costs of expanding industrial capacity to meet the requirements under the tank programme.

In relation to British manpower, the official histories identify that mechanised warfare brought a greater need for skilled workers to produce and continuously maintain the machines of war.²⁸ Furthermore, until the difficulties regarding the movement of labour to meet the different demands of industry and the armed forces had been overcome, Britain was not fully mobilised until mid-1943.²⁹ In addition to the shortages of skilled labour and strike action upon tank output, this study will provide case examples of how particular factories adjusted to the introduction of women into the workforce. By 1944, Gowing argues that the increased mobilisation and role of the United States allowed Britain to maintain the armed forces at an 'extraordinary high level' for the final assault on German occupied Europe.³⁰

In comparison to the United States, Sweet argues that the mechanised nature of pre-war American society provided the necessary skilled manpower and essential facilities to produce a highly mechanised army.³¹ Unique amongst the Allies, Mark Harrison points out that the United States avoided the 'direction of industrial labour or a universally compulsory service

²⁵ Hancock and Gowing, *British War Economy*, p. 112; Hornby, *Factories and Plant*, pp. 32 & 189; Harrison, 'Economics of World War II', pp. 21-22; Edgerton, *Warfare State*, pp. 56-57; Milward, *War, Economy and Society*, p. 29; R. Overy, 'Mobilization for Total War in Germany 1939-1941', *The English Historical Review*, Vol. 103, No. 408 (Jul., 1988), pp. 615-616.

²⁶ Howlett, P., 'Resource Allocation in Wartime Britain: The Case of Steel, 1939-45', *Journal of Contemporary History*, Vol. 29, No. 3 (Jul., 1994), pp. 523-544.

²⁷ Harrison, 'Soviet Union', p. 269.

²⁸ Hancock and Gowing, *British War Economy*, p. 290; Hornby, *Factories and Plant*, p. 338; Postan, *British War Production*, p. 184.

²⁹ Hancock and Gowing, *British War Economy*, p. 289; M. Gowing, 'The Organisation of Manpower in Britain during the Second World War', *Journal of Contemporary History*, Vol. 7, No. 1/2 (Jan. - Apr., 1972), pp. 147, 149, & 151-156; Hornby, *Factories and Plant*, pp. 286-287.

³⁰ Hancock and Gowing, *British War Economy*, pp. 449-450; Gowing, 'Organisation of Manpower', pp. 155 & 166.

³¹ Sweet, *Iron Arm*, 14

law', which Hugh Rockoff attributes to an extensive 'across-the-board effort' to successfully mobilise resources.³² To demonstrate, this study will show how British cash orders supported the expansion of industrial capacity for the American tank programme, and how Britain competed with the U.S. War Department for the same tanks under production.

When considering the Lend-Lease Act, far from being an 'unsordid act', historians point out that the purpose was primarily concerned with promoting the defence of the United States by keeping the war away from American shores.³³ Despite the benefits of receiving raw materials, equipment and munitions, Stephen Broadberry and Peter Howlett argue that Lend-Lease gave the United States an advantage and controlling interest over Britain's war production efforts.³⁴ In support of this argument, this study will demonstrate how Britain became too dependent upon Lend-Lease tanks by 1944 and how front line strength was threatened when this supply was suddenly cut-off later in the year. However, the large numbers of Sherman tanks delivered during 1943 permitted British industry to concentrate on improving the Cromwell tank, whilst some firms were transferred to meet the demand for tank adaptations and essential non-tank work such as locomotive production. Wartime Minister Herbert Morrison identified that the sudden removal of Lend-Lease at the end of the war added to Britain's 'severe economic and financial problems' in supplying the post-war home and exports markets.³⁵

In relation to Germany, Werner Abelshauser points out that full employment had been achieved in 1936 and the British official history argues that provided Germany was sufficiently ruthless to meet manpower requirements, the war effort would not fail for lack of labour.³⁶ Burton Klein and Abelshauser state that the 'Blitzkrieg' strategy was designed not to involve a large use of resources and simultaneously permitted minimal war preparations and a prosperous civilian economy.³⁷ However Tobias Jersak supports the opinion that prior

³² Harrison, 'Resource Mobilization', p. 181; H. Rockoff, 'The United States: from ploughshares to swords', in Harrison, *Economics of World War II*, pp. 105 & 117.

³³ Hancock and Gowing, *British War Economy*, p. 246; W. S. Churchill, *The Second World War, Volume II: Their Finest Hour* (London, Cassell, 1949), p. 503.

³⁴ S. Broadberry and P. Howlett, 'The United Kingdom: "Victory at all costs"', in Harrison, *Economics of World War II*, p. 53.

³⁵ H. Morrison, *Government and Parliament: A Survey from the Inside* (London, Oxford University Press, 1956), pp. 288-289.

³⁶ W. Abelshauser, 'Germany: guns, butter, and economic miracles', in Harrison, *Economics of World War II*, pp. 130 & 149; Hancock and Gowing, *British War Economy*, pp. 101-102 & 281.

³⁷ B. Klein, 'Germany's Preparation for War: A Re-examination', *The American Economic Review*, Vol. 38, No. 1 (Mar., 1948), pp. 76-77; Abelshauser, 'Germany', p. 148.

to the relatively sudden collapse of France, the German munitions programme was actually preparing for a long war based upon the static defences of the Great War.³⁸ Richard Overy states that by the end of 1941 most of the labour and industrial capacity had been transferred to the war economy, with mass production beginning in 1942 before slowing down during 1944 due to the effects of Allied bombing.³⁹

The second section of the historiography relates to British manufacturing histories. To begin with, whilst pre-rearmament tank design and development was limited to Vickers-Armstrongs and the Royal Ordnance Factory at Woolwich, David Edgerton highlights that the War Office had created ten research and development establishments or departments in 1932.⁴⁰ In respect of Vickers, this study will show how the firm invested in the period since the Great Depression to provide a series of standardised components and tank models for the domestic and export markets. Poor financial investment prevented a greater involvement by industry in tank development, although Edgerton stresses that this was because expenditure had increased faster in other countries rather than spending cuts in Britain.⁴¹ Contrary to the interwar arguments of J. F. C. Fuller and Basil Liddell Hart, historians have argued that the British army was not resistant to incorporating the tank, but instead failed to organise the armoured divisions so that the different arms worked together effectively.⁴²

The historiography identifies that British armoured doctrine during rearmament divided tank production into different classes, namely: the 'Light' tank for cavalry reconnaissance and scouting; the 'Cruiser' and 'Medium' for use in the Tank Brigades; and the 'Infantry' and 'Assault' tank which had the greatest armour for close support. The emphasis was on the tank fulfilling a particular rather than a general role as demonstrated by the German, American and Russian tank programmes that concentrated upon the Medium tank.⁴³ The official history states that this division was caused by Britain having to prioritise the need for Light and Cruiser tanks in case of war with Italy in the Middle East, and Infantry tanks as

³⁸ T. Jersak, 'Blitzkrieg Revisited: A New Look at Nazi War and Extermination Planning', *The Historical Journal*, Vol. 43, No. 2 (Jun., 2000), pp. 566-571.

³⁹ Overy, 'Mobilization for Total War', pp. 627 & 638.

⁴⁰ Hornby, *Factories and Plant*, pp. 183-184; Scott and Hughes, *Administration of War Production*, p. 281; J. P. Harris, *Men, ideas and tanks: British military thought and armoured forces, 1903-1939* (Manchester, Manchester University Press, 1995), p. 274; Edgerton, *Warfare State*, pp. 80 & 120.

⁴¹ Postan, et al., *Design and Development of Weapons*, pp. 304-306; Edgerton, *Warfare State*, pp. 23-25.

⁴² J. P. Harris, 'British Armour 1918-1940: Doctrine and Development', in J. P. Harris and F. H. Toase (eds.), *Armoured Warfare* (London, B. T. Batsford, 1990), pp. 49-50; Edgerton, *Warfare State*, pp. 45 & 193.

⁴³ Postan, et al., *Design and Development of Weapons*, pp. 309-311; Harris, *Men, ideas and tanks*, p. 305; Harris, 'British Armour', pp. 41-42.

part of an expeditionary force to France in the event of war with Germany.⁴⁴ As a result, the constantly changing nature of Infantry and Cruiser tank priorities meant that neither programme was completed by the outbreak of war.⁴⁵ However, this study will illustrate how many new firms were introduced to tank production from 1937 for the Infantry and Cruiser programmes, whilst instigating a policy of quantity production of the latest Light tank.

David French argues that the rigid tactical distinction between Infantry and Cruiser tanks unintentionally impeded British armoured doctrine for most of the war by not having a more balanced formation of infantry and tank units for greater combined-arms co-operation.⁴⁶ From the tactical perspective, Timothy Harrison Place points out that tank crews were limited by the differences in armament relating to whether the main gun fired an armour-piercing or high-explosive shell, together with the presence of a hull mounted machine-gun.⁴⁷ By comparison with German armoured doctrine, the pre-war writings of Heinz Guderian stipulated that tanks had to work in close co-operation with other arms, including airpower and armoured and motorised reconnaissance, artillery, anti-tank and infantry units.⁴⁸ Historians have emphasised that Guderian should not be overestimated or exaggerated, and that interwar Generals Ludwig Beck and Werner von Fritsch should be recognised for providing earlier support and resources towards the first Panzer divisions.⁴⁹

From a manufacturing perspective, the official history describes how the pre-war and early war tank design was constrained by tank width for railway transportation; tank weight for bridge crossing ability; and tank height to produce a low silhouette.⁵⁰ David French points out that German tank designers increased armour protection and firepower due to the wider gauge of Continental railways, and by not having to ship these heavy tanks overseas in large quantities.⁵¹ The historiography highlights that because Vickers was the only commercial firm with any tank experience and capacity, the process of involving new tank firms was

⁴⁴ Postan, *British War Production*, p. 190.

⁴⁵ *Ibid.*, pp. 190-193.

⁴⁶ French, *Raising Churchill's Army*, pp. 34 & 191-192.

⁴⁷ T. Harrison Place, *Military Training in the British Army, 1940-1944: From Dunkirk to D-Day* (London, Frank Cass, 2000), pp. 80-82.

⁴⁸ H. Guderian, *Achtung-Panzer!: The Development of Tank Warfare*, first published 1937, trans. C. Duffy (London, Cassell, 2002), pp. 160-172, 178-184 & 188-198.

⁴⁹ W. Heinemann, 'The Development of German Armoured Forces 1918-40', in Harris and Toase, *Armoured Warfare*, pp. 56-58; W. Murray, 'Armored warfare: The British, French, and German experiences', in Murray and Millett, *Military Innovation*, pp. 41-42.

⁵⁰ Postan, *British War Production*, p. 189.

⁵¹ French, *Raising Churchill's Army*, pp. 104-105.

divided into the production of specialised items, partial assembly and the complete manufacture.⁵² The expectation was that motor firms would bring their experience in mass production, combustion engines, gear-boxes and transmissions, whilst locomotive firms would have the equipment and experience in handling, fitting and assembling large and heavy vehicles.⁵³ Similarly with regard to pre-1941 Russian tank production, Barbara Katz and Chris Bellamy state that agricultural vehicle firms were introduced to tank production at the expense of civilian production.⁵⁴ For a greater examination of British wartime planning, this study will identify the different tank orders with the 27 civilian firms until June 1943 and place the factory locations within the general manufacturing context of the United Kingdom.

J. P. Harris states that when the Cabinet and the Treasury approved an increased tank programme in March 1939, industrial capacity could not expand rapidly enough to meet the new demand and that the Royal Ordnance Factories were now fully engaged on other work.⁵⁵ Harland & Wolff was contracted to design the prototype A.20 Infantry tank because they were the only firm that had the required amount of unused capacity, therefore this work was essential for the firm to remain active.⁵⁶ The pressure of rearmament meant that the government ordered new tanks straight off the 'drawing-board' without the necessary and elaborate trials. Given the numerous 'teething-troubles' that followed the official history correctly argues that this policy saved time, gave the army some tanks for training and the tank firms experience in the methods of production.⁵⁷ However, this study will identify that the A.12 Matilda tank was not ordered off the 'drawing board' with the pilot models completing successful trials before production commenced.

During the important period from the outbreak of war until the Battle of France the history of Vickers contends that it was only after several months of war that Britain came to grips with

⁵² Postan, et al., *Design and Development of Weapons*, pp. 312 & 318; Hornby, *Factories and Plant*, pp. 87, 184 & 188; J. D. Scott, *Vickers: A Story* (London, Weidenfeld and Nicolson, 1963), p. 284.

⁵³ Hornby, *Factories and Plant*, pp. 184-186; Postan, *British War Production*, p. 426; R. Jackson, *The Nuffield Story* (London, Muller, 1964), p. 187.

⁵⁴ B. G. Katz, 'Purges and Production: Soviet Economic Growth, 1928-1940', *The Journal of Economic History*, Vol. 35, No. 3 (Sep., 1975), p. 568; C. Bellamy, *Absolute War, Soviet Russia in the Second World War: a modern history* (London, Pan Books, 2007), p. 35.

⁵⁵ Harris, *Men, ideas and tanks*, p. 302.

⁵⁶ Postan, et al., *Design and Development of Weapons*, p. 319; M. Moss and J. R. Hume, *Shipbuilders to the world: 125 years of Harland and Wolff, Belfast, 1861-1986* (Belfast, Blackstaff Press, 1986), pp. 319, 323, 330-331, 352-353.

⁵⁷ Postan, et al., *Design and Development of Weapons*, pp. 310-311, 319-321, 334, 354 & 357.

the formidable difficulties of tank production.⁵⁸ Brian Bond highlights that whilst the British Expeditionary Force in 1939 could be deemed to be “motorized” by no longer being dependent upon horse transport, the army was not “fully mechanized” and had to requisition civilian transport upon mobilization.⁵⁹ The official histories identify that from an organisational perspective, matters deteriorated when the responsibility for tank design and production had separated.⁶⁰ Even allowing for these shortcomings, William Philpott and Martin Alexander argue convincingly that a ‘stronger and more mechanised BEF’ would not have prevented the defeat of France.⁶¹

Historians agree that following the defeat of France the tank programme emphasised quantity instead of quality output to replace the equipment lost on the continent and to gain time to test the new designs before introducing them to the production lines.⁶² As a result the number of tank firms was increased under the ‘Parent’ system, which organised production by the parent firm controlling the ordering and supply of components to the dependent firms.⁶³ Angus Calder highlights that the initial system to calculate the profit on the early contracts was based upon the ‘cost plus’ a fixed percentage or fixed amount, although the former was more lucrative and thus open to abuse.⁶⁴ In respect of the tank contracts later in the war, this study will demonstrate that the rate of profit was negotiated with the Ministry of Supply on an annual basis for the actual work carried out for that particular year.

The administration of war production history contends that the frequent modifications to the Crusader, Churchill and Cromwell tanks made it obvious that something was wrong.⁶⁵ Lieutenant-General Weeks highlights a likely common example that whilst the War Office no longer wanted the Crusader tank, the Ministry of Supply was unable to cease production for reasons of maintaining capacity.⁶⁶ George Peden argues that whilst some of the criticisms by Correlli Barnett regarding the quality of British tanks are justified, the controversial author

⁵⁸ Scott, *Vickers: A Story*, p. 284.

⁵⁹ B. Bond, *British Military Policy between the Two World Wars* (Oxford, Clarendon Press, 1980), p. 329.

⁶⁰ Postan, et al., *Design and Development of Weapons*, p. 308; Scott and Hughes, *Administration of War Production*, p. 282.

⁶¹ W. Philpott and M. S. Alexander, ‘The French and the British Field Force: Moral Support or Material Contribution?’, *The Journal of Military History*, Vol. 71, No. 3 (Jul., 2007), p. 771.

⁶² French, *Raising Churchill’s Army*, p. 107; Postan, *British War Production*, pp. 190-193; Lieut.-General Sir R. Weeks, *Organisation and Equipment for War* (Cambridge, Cambridge University Press, 1950), p. 49.

⁶³ Postan, *British War Production*, pp. 419-420; L. C. Darbyshire, *The Story of Vauxhall, 1857-1946* (Luton, Vauxhall Motors, 1946), p. 46.

⁶⁴ A. Calder, *The People’s War: Britain 1939-45* (London, Panther Books, 1971), pp. 294-295.

⁶⁵ Scott and Hughes, *Administration of War Production*, p. 283.

⁶⁶ Weeks, *Organisation and Equipment for War*, p. 8.

underestimated the design and development problems that the new tank firms had to overcome.⁶⁷ Through a series of case examples against the background of a planned war economy, this study will illustrate these problems in greater detail such as: the delays in factory expansion; the shortages in the supply of labour and tank components; the effects of enemy bombing; and the overriding priority for quantity instead of quality production.

Later in the war, the official history of war production praises the manufacturers of the Churchill, Cromwell and Comet tanks for successfully overcoming the teething troubles to produce very effective vehicles.⁶⁸ Peden argues that this 'suggests movement along a learning curve' for the manufacturers involved in the design.⁶⁹ To demonstrate, this study will examine how the tank programme transferred to quality production on a sustainable basis by: the reduction in tank assembly man-hours; the increase in experience by the concentration of effort amongst fewer tank firms; and the use of specialist jigs and equipment. The official history provides additional praise for the government for the decision to place the design and manufacture of the Centurion tank with the Royal Ordnance Factories.⁷⁰ As this study will highlight, the emphasis upon the state retaining some control over the tank programme continued with the creation of a Royal Tank Arsenal to meet the demand during peace-time.

The final section of the historiography relates to commentary that is generally restricted to comparisons with foreign tanks by highlighting the areas of armament, mechanical reliability and armour protection once the tanks were manufactured and given to the users. A number of historians argue that Britain was under-equipped at the outbreak of war.⁷¹ To qualify this, David French argues that the regular cavalry's poor mechanised performance during the first half of the war was because suitable vehicles for tactical training only became available at a

⁶⁷ G. C. Peden, *Arms, Economics and British Strategy: From Dreadnoughts to Hydrogen Bombs* (Cambridge, Cambridge University Press, 2007), p. 187; C. Barnett, *The Audit of War: The Illusion and Reality of Britain as a Great Nation* (London, Macmillan, 1986).

⁶⁸ Postan, *British War Production*, p. 426.

⁶⁹ Peden, *Arms, Economics and British Strategy*, pp. 187-188.

⁷⁰ Postan, et al., *Design and Development of Weapons*, pp. 349 & 352.

⁷¹ Montgomery of Alamein, *The Memoirs of Field-Marshal the Viscount Montgomery of Alamein* (London, Collins, 1958), p. 50; Baron H. L. Ismay, *The Memoirs of General the Lord Ismay* (London, Heinemann, 1960), p. 152; Lieutenant-General Sir B. Horrocks, *A Full Life* (London, Collins, 1960), pp. 132-133; Weeks, *Organisation and Equipment for War*, p. 99; Field Marshal Lord Carver, *The Apostles of Mobility: The Theory and Practice of Armoured Warfare* (London, Weidenfeld and Nicolson, 1979), p. 53; S. Bidwell and D. Graham, *Firepower: British Army Weapons and Theories of War, 1904-1945* (Barnsley, Pen & Sword, 2004), pp. 191-192.

later stage in rearmament.⁷² Philip Warner describes how these Light tanks were inadequate against anti-tank defences and other historians highlight that obsolete Light tanks were still present in many divisions until well into 1941.⁷³

In respect of British firepower, two-pounder armed tanks are credited with knocking-out Axis tanks until 1941 when the armour protection of the Panzer III and IV increased.⁷⁴ The lack of a heavier gun in British tanks meant that tank units adopted tactical dispersion instead of concentration due to the ability of German tanks to fire at much longer ranges with impunity.⁷⁵ Historians describe how British tank armament remained inadequate as the British six-pounder gun could not fire a high-explosive shell of sufficient impact against soft targets, thereby negating any superiority in tank quantity or mobility.⁷⁶ The 75 mm dual-purpose gun gave greater high-explosive firepower, but historians have been keen to emphasise that this and the later American 76 mm was still inadequate in the armour-piercing role.⁷⁷ The 77 mm gun on the Comet tank was capable of combating German heavy tanks, although this tank has received scant and even misplaced commentary within the historiography.⁷⁸ Whilst tank veteran Bill Close identifies that the Comet was an excellent tank with a better gun than on the Sherman, he understandably would have preferred the well established and more powerful 17-pounder gun instead.⁷⁹ In respect of tank armament on the Eastern Front, Adam Tooze points out that the production of the German Tiger and Panther

⁷² D. French, 'The Mechanization of the British Cavalry between the World Wars', *War in History*, July 2003, Vol. 10 Issue 3, pp. 299-300 & 320-321.

⁷³ P. Warner, *The Battle of France, 1940: 10 May – 22 June* (London, Cassell, 2002), pp. 209-210; French, *Raising Churchill's Army*, p. 107; Harris, 'British Armour', p. 46.

⁷⁴ Brigadier O. E. Chapman, 'The influence of the late war on tank design', *RUSI Journal*, vol. 96, 581, 1951, p. 50; Major-General F. W. von Mellenthin, *Panzer Battles: A Study of Employment of Armour in the Second World War*, first published 1956, trans. H. Betzler (London, Futura, 1979), pp. 5 & 16; B. H. Liddell Hart (ed.), *The Rommel Papers*, first published 1953, trans. P. Findlay (London, Hamlyn, 1984), p. 147; General H. Guderian, *Panzer Leader*, first published 1952, trans. C. Fitzgibbon (London, Futura Publications, 1977), pp. 277-279; N. Barr, *Pendulum of War: The Three Battles of El Alamein* (London, Pimlico, 2005), p. 62.

⁷⁵ J. Fennell, *Combat and Morale in the North African Campaign: The Eighth Army and the Path to El Alamein* (Cambridge, Cambridge University Press, 2011), pp. 64-65.

⁷⁶ French, *Raising Churchill's Army*, pp. 99, 101-105 & 278; Harrison Place, *Military Training*, pp. 114 & 141-142; Sir B. Horrocks, with E. Belfield & Major-General H. Essame, *Corps Commander* (London, Sidgwick and Jackson, 1977), p. 43.

⁷⁷ P. Delaforce, *Churchill's Desert Rats: From Normandy to Berlin with the 7th Armoured Division* (Stroud, Sutton, 2003), p. 4; Major General J. F. C. Fuller, *The Second World War 1939-1945: A Strategic and Tactical History* (London, Eyre and Spottiswoode, 1962), p. 297; M. Hastings, *Overlord: D-Day and the Battle of Normandy 1944* (London, Pan Books, 1999), pp. 225-228; C. d'Este, *Decision in Normandy: The Unwritten Story of Montgomery and the Allied Campaign* (London, Collins, 1983), pp. 71-72; S. D. Badsey, 'The American Experience of Armour 1919-53', in Harris and Toase, *Armoured Warfare*, p. 139.

⁷⁸ R. Humble, *Tanks* (London, Weidenfeld & Nicolson, 1977), pp. 108-109; C. F. Foss and P. McKenzie, *The Vickers Tanks: From Landships to Challenger* (Wellingborough, Patrick Stephens, 1988), p. 126.

⁷⁹ Major B. Close, *A View from the Turret: A History of the 3rd Royal Tank Regiment in the Second World War* (Tewkesbury, Dell & Bredon, 1998), p. 152.

tanks were accelerated 'to counter the remarkable' Russian T-34 and KV-1 tanks.⁸⁰ In response, historians have highlighted that Russian designers were similarly forced to make modifications to their tank armament resulting in the T-34/85 and Joseph Stalin tanks that were equal, and in some areas superior, to the heavy German tanks.⁸¹

With regard to poor tank reliability, the official history points out that with the emphasis on quantity over quality production most components performed differently when in the vehicle and under battle conditions than when compared to their record on the factory bench.⁸² The Valentine tank is the exception and receives credit from historians for being a reliable and adaptable vehicle despite quickly becoming obsolete, whilst the Matilda was mechanically unreliable with a short operational range.⁸³ Historians contend that Vauxhall was never allowed to hold up production of the Churchill tank because of the overriding military necessity for quantity production, although the vehicle became tactically very useful.⁸⁴ With regard to these Infantry tanks, this study will highlight how the Matilda tank was supplied to the Eastern Front towards the defence of Moscow in 1941 and to Australia from 1942 onwards. The Churchill programme was extended by a series of continuation orders to prevent an unacceptable break in production and misdirection of labour resources. Despite being obsolete, the Valentine tank remained in production in Britain and Canada to meet the continued requests by the Russian authorities for this particular vehicle late into the war.

The problems associated with many of the Cruiser tanks are attributed to the Liberty engine which was unable to provide the power necessary for increases in mobility and armour protection.⁸⁵ By comparison, whilst the German Panther and Tiger tanks had superior armour

⁸⁰ Tooze, *Wages of Destruction*, p. 441.

⁸¹ Harrison, 'Economics of World War II', p. 26; B. H. Liddell Hart, *History of the Second World War* (London, Pan Books, 1973), p. 695; C. J. Dick, 'The Operational Employment of Soviet Armour in the Great Patriotic War', in Harris and Toase, *Armoured Warfare*, p. 101; Bellamy, *Absolute War*, p. 603.

⁸² Postan, et al., *Design and Development of Weapons*, pp. 328 & 363.

⁸³ French, *Raising Churchill's Army*, p. 98; Liddell Hart, *History of the Second World War*, p. 350n; Brigadier C. N. Barclay, *Against Great Odds: The Story of the first offensive in Libya in 1940-41 – the first British victory in the Second World War* (London, Sifton Praed, 1955), p. 12; V. Schofield, *Wavell: Soldier & Statesman* (London, John Murray, 2006), p. 156.

⁸⁴ Darbyshire, *Story of Vauxhall*, pp. 46-47; French, *Raising Churchill's Army*, p. 102; Harrison Place, *Military Training*, p. 162; P. G. Griffith, 'British Armoured Warfare in the Western Desert 1940-43', in Harris and Toase, *Armoured Warfare*, p. 74.

⁸⁵ Jackson, *Nuffield Story*, p. 187; Chapman, 'Influence of the late war on tank design', p. 58; M. Craster, 'Cunningham, Ritchie and Leese', in J. Keegan (ed.), *Churchill's Generals* (New York, Grove Weidenfeld, 1991), pp. 211-212; D. Fraser, *And We Shall Shock Them: The British Army in the Second World War* (London, Cassell, 2002), p. 159; W. A. Robotham, *Silver Ghosts & Silver Dawn* (London, Constable, 1970), pp. 130 & 154; Postan, et al., *Design and Development of Weapons*, pp. 343-344.

protection and firepower, the limitations in operational range and mechanical reliability meant that these vehicles could not improve Germany's deteriorating strategic situation.⁸⁶ The British situation improved with the Meteor engine although historians have identified that engine output could not meet demand until 1944, resulting in what Peden describes as the 'opportunity cost' of continuing with the Liberty engine until the Meteor became available.⁸⁷ To demonstrate this within the overall context of centralised war planning, this study will review the orders for Meteor engines by the Ministry of Supply that were necessary to transfer the manufacturing responsibility away from the Ministry of Aircraft Production. Furthermore, the increased reliability of British tanks later in the war will also be attributed to the improved servicing techniques that required less maintenance and repair.

In terms of armour protection, the historiography points out that the early Cruiser tanks were capable of withstanding Italian anti-tank fire, but otherwise failed to provide protection against German guns of 50 mm calibre or heavier.⁸⁸ The Matilda tank stands out in the historiography for its ability to withstand anti-tank artillery with the exception of the German 88 mm gun.⁸⁹ A welded tank hull provided increased armour protection, faster production, a watertight hull and less weight when compared to riveted construction.⁹⁰ To illustrate this further, this study will examine the expansion of welding in British tank assembly and how the poor system of ventilation in the factories affected the health of the workers. By comparison, the reasons why American industry was able to successfully incorporate the mass production of welded assemblies early into their tank programme will be established. Cast armour was an alternative to welding, but the official history states that this was limited by the problems of insufficient casting capacity and skilled-labour in Britain.⁹¹ In relation to British tank production, this study will identify specific occasions when the introduction of cast turrets and tank hulls was prevented by this shortfall in capacity.

⁸⁶ Tooze, *Wages of Destruction*, p. 612; French, *Raising Churchill's Army*, pp. 104-105; Robotham, *Silver Ghosts & Silver Dawn*, p. 136; Milward, *War, Economy and Society*, pp. 181-182.

⁸⁷ Postan, *British War Production*, p. 188; Weeks, *Organisation and Equipment for War*, p. 53; Robotham, *Silver Ghosts & Silver Dawn*, pp. 147-156; Peden, *Arms, Economics and British Strategy*, p. 188.

⁸⁸ Harris, *Men, ideas and tanks*, p. 240; French, *Raising Churchill's Army*, p. 98; Liddell Hart, *History of the Second World War*, p. 184; Harrison Place, *Military Training*, p. 114.

⁸⁹ Liddell Hart, *Rommel Papers*, pp. 185-186; R. Woollcombe, *The Campaigns of Wavell, 1939-1943* (London, Cassell, 1959), p. 33; Mellenthin, *Panzer Battles*, pp. 22 & 64; B. Pitt, 'O'Connor', in Keegan, *Churchill's Generals*, p. 190; H. von Luck, *Panzer Commander: The Memoirs of Colonel Hans von Luck* (London, Cassell, 2002), p. 41; Schofield, *Wavell: Soldier & Statesman*, p. 156; French, *Raising Churchill's Army*, p. 97; Liddell Hart, *History of the Second World War*, pp. 184 & 186.

⁹⁰ Tank Museum, *Churchill*, p. xi; Postan, et al., *Design and Development of Weapons*, p. 345; Robotham, *Silver Ghosts & Silver Dawn*, p. 157.

⁹¹ Hornby, *Factories and Plant*, pp. 282-283.

Having discussed the historiography in detail it is now possible to draw some conclusions and general schools of thought. It is important to recognise the unique nature of the tank when compared to the other mass produced weapons of war, especially when considering the issue of reliability. The economic factors to produce quantity instead of quality equipment were crucial to the outcome of the war by the combined Allied ability to ultimately convert their civilian industries to the requirements of war in large quantities. Tank production efforts by the combatants under review were affected by finance, raw materials, manpower and industrial capacity. The two continental powers gave greater priority to the supply of ground forces, whilst Britain and the United States devoted more resources to their aircraft or naval programmes in accordance with their unique strategic requirements. Whilst Lend-Lease was primarily designed to defend and support the United States, it did provide immediate benefits to Britain in terms of important raw materials and equipment. Pre-war and early war British tank design and development suffered from being under-financed, having a confused and changing doctrine and lacked central direction for too long. The new tank manufacturers introduced from rearmament had an understandably difficult start, but eventually managed to meet the demands of mass production. Whilst the continued practice of concentrating on quantity instead of quality tank production is questioned, there is some recognition that it did provide the army with at least some armour for training and fighting when battle commenced. British tanks were generally considered to be a combination of being unreliable, under-gunned and apart from the Infantry tanks considered under-armoured for most of the war. The tank situation improved in late 1943 with the decision to centrally design and produce the Centurion with the reintroduction of government factories. With the particular areas that this study will cover now highlighted against the historiography, the structure of this thesis can be established. This will identify the main themes of each chapter relevant to British tank production as part of an overall case study of British war planning within the war economy.

To commence this study chapter 1 will review the growth of the British tank programme during the period of rearmament from 1934 to 1938. This will highlight that the War Office expanded their commitments to provide tanks to the army, against the limitations of finance, industrial capacity and that Britain's strategic reality meant that air defence was given the correct priority. Tank development was intrinsically linked to not just the experimentation at Vickers-Armstrongs, but also to technical advances in motor vehicle components and metallurgy within civilian industry, and the availability of skilled labour generally. The decision to mass produce the latest Light tank provided the army with workable vehicles by

1939, whilst orders were placed for the emerging Cruiser and Infantry types resulting in the comparatively successful Matilda tank. The new firms introduced to the tank programme benefitted from increased sales and employment, but also with the recognition after March 1938 to initiate individual programmes of air raid precautions.

The centralised control of the British tank programme from 1939 until the end of the war will be examined in chapter 2, by highlighting how changes in priority and direction were brought about by the introduction of each new Minister of Supply. This was illustrated when the experimental TOG tanks continued until April 1943 instead of terminating in late 1941, and more significantly by the introduction of five separate Tank Boards from June 1940 until September 1942. This chapter will review the origins, membership and terms of reference of each Tank Board to emphasise that the tank programme was not properly directed until the fifth board was granted the all-inclusive executive authority which remained until 1945. The attempt to permit an open discussion on tank policy between government officials and armoured commanders will be considered with the short lived Tank Parliament. Finally, the control of the Canadian tank programme will be identified in preparation for later chapters to highlight the important contribution that this production had towards the British war effort.

Chapter 3 will review the British tank programme from 1939 until 1942 by establishing the five stages of the tank production life span. Firstly, in accordance with General Staff requirements for quantity production, continuation orders introduced additional firms to the tank programme by industrial expansion, that reflected the preference for Cruiser instead of Infantry types. The second stage identifies the difficulties in commencing production, with the third stage highlighting how shortages in labour and tank components prevented firms from maintaining the prescribed rate of output. The fourth stage considers the number of tanks deemed unfit for action due to poor workmanship and inspection, and the measures taken to rectify the situation. The final stage considers how continuation orders of unwanted tanks were necessary to avoid a loss of output and retain labour resources.

The transformation of the British tank programme from quantity to quality output will be examined during chapter 4 for the period of 1943 until the end of the war. This change in production emphasis was the result of the problems discussed in chapter 3, and with the expectation of receiving tanks from the United States examined later in chapter 5. In addition to quality production, the programme achieved a sustainably high rate of output by using

fewer tank firms with greater experience, the use of specialist jigs, and that the latest tank designs required fewer man-hours to assemble. The Meteor tank engine introduced new firms outside of the Ministry of Aircraft Production and meant that new tank designs could include more armour protection. Industry was able to assemble welded tanks on a mass produced basis against the interruptions of worker holidays and strikes. Finally, the end of the war will be considered with the plans to transfer industry to peacetime production and with the creation of a Royal Tank Arsenal for part of the post-war tank programme.

The benefits for Britain of receiving large numbers of tanks from the United States will be discussed in chapter 5, together with the problems of becoming too reliant upon this supply. The initial requirements to make purchases in cash were not only limited by British financial reserves, but also because Britain had to compete with the U.S. War Department for the same munitions and industrial capacity. The introduction of Lend-Lease strengthened the level of co-operation between Britain, Canada and the United States on tank and industry related matters. Whilst the mass production of tanks by American industry highlighted advances in production techniques, many of the vehicles received by British units into 1943 displayed manufacturing faults that required workshop attention. The number of Lend-Lease tanks increased during 1943 and 1944 so that Britain could transfer some industrial capacity to locomotive production. The numerous reductions in the British and American tank programmes meant that both nations were caught unawares when the campaigns in north-west Europe reduced tank reserves to dangerously low levels.

Whilst Britain received tanks from the United States, chapter 6 will review the simultaneous supply of tanks and other equipment to the Russian war effort, including details of tank production in Canada. The importance of the British tank industry will be highlighted by an examination of the reported success and reality of 'Tanks for Russia' week. Before Allied tanks could be shipped to Russia they had to be 'Arcticised' in order to cope with the extreme winter conditions. The co-operation between the Western Allies described in chapter 5 was not repeated by the Russian government, despite signing a reciprocal agreement with Britain to facilitate such an exchange of information and equipment. Whilst Britain was committed to supply tanks to Russia, the particular models under consideration conflicted with Britain's other strategic obligations to supply the same tanks. As for the Russians, they preferred the Valentine tank in accordance with the doctrine of standardised equipment for the Red Army. Overall, this study will show how Britain developed a tank programme that achieved a

'synthesis of the tactical and production plans', that the wartime Minister of Production Oliver Lyttelton stated was so essential for successful production in war.⁹²

⁹² O. Lyttelton, Viscount Chandos, *The Memoirs of Lord Chandos* (London, Bodley Head, 1962), p. 285.

Chapter 1

Rearmament 1934 to 1938

Before embarking upon a study of British tank production during the Second World War, it is necessary to consider the 1930s, as this period is intrinsically linked to the events approaching and following the outbreak of war. As highlighted in the introductory chapter, there is a great deal of commentary within the historiography regarding the inter-war period, with the emphasis on the time of rearmament. For the purposes of this study, the period of rearmament will relate to the five years from 1934 to the end of 1938. Whilst there are valid arguments to consider rearmament from 1932 with the abandonment of the 'Ten-Year Rule',¹ during February 1934 the Cabinet received a five-year programme of increased defence expenditure from the Defence Requirements Sub-Committee.²

Furthermore, the Mechanization Board was formed during 1934, the impact of which will be discussed in greater detail below. The events of 1939 will be given the appropriate attention in the following chapters because whilst Britain was still at peace for much of the year, the nation had moved towards a very strong position of total war. This was demonstrated by a combination of: the rising tensions on the Continent; the creation of the Ministry of Supply; the much greater transformation of industry to armaments work; the attempts to secure supply from North America by establishing a Purchasing Commission; and the large expansion of the Services. Whilst this chapter will consider the period before 1934 or extend into 1939, it would be used to contextualise the five year period under review.

A brief comparative overview of tank output by Britain, France and Germany from 1936 until the end of 1939 can reveal the relative size and strength of these tank programmes. The figures for 1934 and 1935 are not considered because, as discussed later in the chapter, Britain only entered into a period of 'serious rearmament' from 1936, thereby excluding the production of the Mark IV and V Light tanks. Britain produced a total of 1,462 tanks over the four years from 1936, although the vast majority were the Light Mark VI whilst only 280 were of the early Cruiser and Infantry type. By comparison, French industry delivered 2,411

¹ J. P. D. Dunbabin, 'British Rearmament in the 1930s: A Chronology and Review', *The Historical Journal*, Vol. 18, No. 3 (Sep., 1975), pp. 588-589; M. Thomas, 'Rearmament and Economic Recovery in the Late 1930s', *The Economic History Review*, New Series, Vol. 36, No. 4 (Nov., 1983), p. 553.

² G. C. Peden, *British Rearmament and the Treasury: 1932-1939* (Edinburgh, Scottish Academic Press, 1979), pp. 8 & 56; Dunbabin, 'British Rearmament in the 1930s', p. 590.

tanks including many of the highly regarded Char B1 and Somua S35, whilst German output totalled 3,670 tanks although at least 70 per cent of these were the insufficiently armed and armoured Panzer Mark I and IIs.³ To account for the shortfall in output and fighting effectiveness of British tank production during the rearmament period, this chapter will examine the factors that affected tank development by considering the wider governmental, industrial and financial contexts.

The first section of this chapter will consider the role of the various boards and individual departments, through which the government directed an expanding tank programme against the limitations of Britain's strategic reality. The second section will discuss the relationship between tank development and the motor industry for mechanized components, the advances in metallurgy, and how industry and the unions responded to shortages in skilled labour. By reviewing the minutes of company board meetings during 1938, the third section examines the growing recognition by industry to instigate air raid precautions in light of the events in Europe, including the particular costs involved to undertake the various measures. The fourth section considers the expansion of industrial capacity with new plant and equipment towards meeting the demand for rearmament orders, including the costs involved and government policy towards reimbursing the firms concerned.

The fifth section highlights tank development and production from Vickers-Armstrongs before and after to 1934, by considering the programme of new tank designs in response to the limited demand from the War Office and the export market. The sixth section examines the growth of War Office orders for Light, Infantry and Cruiser tanks from 1934 until 1938, by identifying when the ten firms involved were contracted. The seventh and final section of this chapter will put these tank orders into context by reviewing the different effects upon industry including: a comparison of tank production against the other manufacturing activity at Vickers; the development and comparative cost of the Matilda tank at Vulcan Foundry; how the levels of employment at Vickers and Vulcan Foundry compared against the overall rate of unemployment between 1935 and 1939; and how some firms were deliberately excluded from rearmament work due to concerns about the internal economy and exports.

³ For Britain: The National Archives, Kew, AVIA 46/188, 'Deliveries to 30.6.40', draft official history narrative by D. Hay, after 1950, p. 65; For France: J. Jackson, *The Fall of France: The Nazi Invasion of 1940* (Oxford, Oxford University Press, 2003), pp. 13-14; For Germany: AVIA 46/188, "Estimate of German Tank Production", p. 298.

Before considering the different boards and departments used to control and expand tank production within the context of rearmament, it is necessary to identify the separate responsibilities within government. The official history identifies that the task of supplying the British Army at the beginning of rearmament, was the joint responsibility of the Master-General of the Ordnance (MGO) and the Chief of the Imperial General Staff (CIGS), fulfilling the role of 'supplier' and 'user' respectively.⁴ Whilst the department titles or individuals responsible changed during peace and wartime, this clear distinction in function remained throughout and as such this thesis will be similarly consistent. The effectiveness of each CIGS influenced the progress of the army's attempt to mechanize in the years approaching and during rearmament. J. P. Harris provides compelling evidence to demonstrate how Field Marshal Sir George Milne attempted to advance the mechanization of the army between 1926 and 1933, but was limited by financial stringency.⁵ Harris similarly rejects the view of Basil Liddell Hart that Field Marshal Sir Archibald Montgomery-Massingberd from 1933 to 1936 was a 'blinkered reactionary'. Instead, Montgomery-Massingberd was 'fairly progressive' with proposals to make the British Army the most highly mechanized in the world, incorporating the highest proportion of armour.⁶ For 1936 to 1937, Harris argues that it was 'commendable' that Field Marshal Sir Cyril Deverell attempted to appoint the Inspector of Cavalry, Major-General Blakiston-Houston, as commander of the Mobile Division, but was prevented by the influence and interference of Liddell Hart.⁷ Finally during 1938, George Peden identifies that Lord Gort raised the concern that if the 'Air Defence of Great Britain' received complete priority through the production of fighter aircraft and anti-aircraft measures, Britain would be unable to send a Field Force to the Continent.⁸

The formation of the Mechanization Board in 1934, representing the beginning of this study, reflected an expansion of War Office policy towards the continued mechanization of the Army. This programme was seriously advanced in 1927 with the creation of the Director of Mechanization and then with the establishment of the Mechanical Warfare Board, announced during the Army Estimates in 1928. The President of this new board was the MGO, Lieutenant-General Sir Webb Gillman, with Colonel Sydney Peck as the Director of

⁴ J. D. Scott and R. Hughes, *The Administration of War Production* (London, H.M.S.O., 1955), p. 19.

⁵ J. P. Harris, *Men, ideas, and tanks: British military thought and armoured forces, 1903-1939* (Manchester, Manchester University Press, 1995), pp. 241-242.

⁶ *Ibid.*, pp. 242-244, 258 & 261.

⁷ *Ibid.*, pp. 284-286 & 292.

⁸ Peden, *British Rearmament*, p. 145.

Mechanization and Vice-President. Membership consisted of Army officers from the Mechanization Directorate, the Royal Tank Corps, the Ordnance Committee and the Design Department at Woolwich, with further representation from leading civil and mechanical engineering institutions. The purpose of the Mechanical Warfare Board, which also directed the Mechanical Warfare Experimental Establishment to instigate vehicle trials at Farnborough, was to advise the MGO who now had centralised control over the research, design, supply, inspection and repair of all types of vehicle for the army.⁹

The Army Estimates of 1934 brought about two important changes in perception and organisation regarding tank research and development. Firstly, the term 'Warfare' was removed from both the Mechanical Warfare Board and the Mechanical Warfare Experimental Establishment, to become the Mechanization Board and Mechanization Experimental Establishment (MEE) respectively. As highlighted above, during February 1934 the Cabinet received recommendations to instigate a five-year programme of increased defence expenditure. Therefore it would not follow that the removal of the term 'Warfare' meant a position of *disarmament*, but instead appeared to be a surreptitious attempt to seem less threatening or aggressive, whilst simultaneously initiating a policy of *rearmament*. Under the new MGO and former Tank Corps commander during the Great War, Lieutenant-General Sir Hugh Elles, all design authorities were centralised with the Mechanization Board, under the control and technical direction of the Director of Mechanization.¹⁰ The board was constituted with a President, Vice-President, four military members and one civilian engineer member and divided into two main Committees for Armoured Fighting Vehicles and Mechanical Transport Vehicles respectively. The terms of reference were:

- 1) To act in an advisory capacity on technical problems in connection with mechanization of all types of vehicles for Army requirements.
- 2) To carry out investigation, research and experiment and to put forward recommendations as to the development in design of mechanized vehicles of all types for Army requirements.
- 3) To secure liaison with the Mechanical Engineering Industry so that the Army may be in close touch with engineering progress and commercial production.

⁹ *The Times*, 2 March 1928; 17 March 1928; 20 March 1928.

¹⁰ *The Times*, 9 April 1934; 25 April 1934.

- 4) To direct the technical work of the Mechanization Experimental Establishment.¹¹

There is a difference of opinion within the official histories regarding the creation of the Mechanization Board. From an administrative standpoint, one positive change was to give the associate members, notably the civilian scientists and engineers, an executive function within their field, which had been denied to them under the previous Mechanical Warfare Board.¹² Whereas, the transfer of tank experts from the Superintendent of Design to the Mechanization Board was deemed to be less successful, as the staff merely vetted the designs submitted by manufacturers and suggested modifications, instead of originating any designs themselves.¹³ As shown in the following chapters, this lack of official instigation of tank design continued until November 1943 with the A.41 Centurion, although the Mechanization Board did provide direct support to new tank manufacturers to assist in the design stages. The Mechanization Board was replaced at the end of July 1940 by the Directorate of Tank Design to coincide with the recent introduction of the new Tank Board in June.¹⁴

During July 1936 a further organisational change was announced with regard to overall production of munitions. The Secretary of State for War, Duff Cooper, appointed Engineer-Vice-Admiral Sir Harold Brown to the Army Council, as the new Director-General of Munitions Production (DGMP) to 'coordinate and to expedite the production of munitions' towards the programme of rearmament.¹⁵ Whilst the DGMP would in reality meet the demands of the War Office, the appointment of a naval officer instead of an army officer as expected, was because Vice-Admiral Brown had the necessary experience in working with the engineering industry.¹⁶ This new position on the Army Council was designed to assist and complement the functions of MGO Elles, who still had the responsibility of deciding on the specific requirement, research, design and inspection of munitions before being supplied to service units. DGMP Brown was responsible for all functions connected to production and the expansion of manufacturing including the requirements for gauges, machine tools and jigs. Brown had four directorates under his authority, namely the: Director of Army Contracts; Director of Ordnance Factories; Director of Industrial Planning; and Director of

¹¹ TNA, WO 194/57, First Report of the Mechanization Board, 1934, 'Preface'.

¹² Scott and Hughes, *Administration of War Production*, p. 30.

¹³ M. M. Postan, D. Hay & J. D. Scott, *Design and Development of Weapons: Studies in Government and Industrial Organisation* (London, H.M.S.O., 1964), pp. 238n, 305-306 & 319-320.

¹⁴ TNA, WO 194/57, Sixth and Final Report of the Mechanization Board, 1939 to 1940, 'Preface'.

¹⁵ *The Times*, 15 July 1936.

¹⁶ TNA, CAB 24/263, 'War Office Production', 19 June 1936; obituary: *The Times*, 27 February 1968.

Progress. Collectively these directorates placed orders for building supplies, prepared plans for peacetime production of munitions, and monitored the progress of production contracts.¹⁷

Within this new organisation there still existed an administrative problem which had consequences on production, with the DGMP being wholly dependent upon the speed in which the demands for armaments came from the General Staff.¹⁸ Peden argues convincingly that the War Office was disadvantaged by having ordinary cost accountants, whereas both the Admiralty and Air Ministry used technical cost accounting. This meant that the War Office had very little understanding of the production processes and could only estimate the likely cost at the outset, whereas the other two services understood manufacturing and could better control the costs involved. This weak War Office position was also affected by having to use inexperienced firms when compared to the Admiralty and Air Ministry, which employed manufacturers that had civilian markets for similar products before rearmament.¹⁹ Therefore one important reason for the introduction of the DGMP was to reduce the industrial disparity between the services, although this was further exacerbated by government policy towards the priorities of rearmament.

The historiography has paid particular attention to the issue of the Continental Field Force receiving insufficient priority and funding when compared to the Royal Navy, the Royal Air Force, and in respect of air defence capability from within the Army. J. L. Hughes states how Chamberlain advocated a dramatic increase in offensive air power at the expense of other defence programmes in order to deter Germany.²⁰ As established in the introductory chapter, the Royal Navy was less affected by this decision at the outbreak of war as the Admiralty programme provided superiority in large naval vessels when compared to other nations. J. P. D. Dunbabin highlights that rather than deterring Adolf Hitler, British rearmament actually brought forward the decision to attack.²¹ As the rearmament programme continued into 1938, Harris highlights that the Cabinet wanted the War Office to concentrate upon anti-aircraft defence, thereby further limiting what was available to equip the Field Force,

¹⁷ TNA, WO 32/4585, Office Memo No. 1822, 2. Department of the Director-General of Munitions Production, 10 November 1936.

¹⁸ TNA, WO 24/263, 'War Office Production', 25 June 1936.

¹⁹ Peden, *British Rearmament*, pp. 48-50.

²⁰ J. L. Hughes, 'The Origins of World War II in Europe: British Deterrence Failure and German Expansionism', *Journal of Interdisciplinary History*, Vol. 18, No. 4 (Spring, 1988), pp. 856-857 & 889.

²¹ Dunbabin, 'British Rearmament in the 1930s', p. 609.

especially in tanks.²² Whilst this strategy of deterrence arguably left Britain more vulnerable when it failed, the justification at the time was nonetheless realistic by stating that any Field Force sent aboard would be miniscule by Continental standards.²³

In respect of funding the rearmament, Peden and Harris establish that the actual control of financial expenditure rested with the Treasury Inter-Service Committee, whereas the various defence committees could only approve rearmament measures in principle.²⁴ Harris argues that when the Cabinet halved the allocation of funds to the Army in 1934, this delayed the War Office programme by about two years.²⁵ The official history points out that when funding for the tank programme grew from £12 million to £36 million from 1936 to 1939 respectively, this was due to the increase in new divisions which out-paced the development of new tank designs.²⁶

When put in context, the decision intentionally to make the Army a ‘Cinderella service’ by prioritising air power, air defence and control of the seas was correct, as it responded to Britain’s strategic reality. Geoffrey Till describes Britain’s ‘unfavourable strategic circumstances’ as being a European power that was vulnerable to adversaries developing on the continent, whilst also holding the position as an imperial power with overseas possessions that needed protection. As a result, Britain ‘simply did not have the resources to cope with this multiplicity of risk’.²⁷ In response to this situation, in 1937 the Chamberlain government chose to prioritise Fighter Command and the system of air defence measures based around radar, which as Williamson Murray contends, was ultimately the right decision to make.²⁸

To sum up, Britain responded to this strategic reality by adopting a policy that prepared for each threat in the order that the island nation would be attacked on a serious basis. This meant that first priority was given to meet the danger from the air; if overcome then the naval programme would aim to prevent the seaborne invasion across the channel; if that failed, then the army equipment would be needed to counter the various landings on British soil from the

²² Harris, *Men, ideas and tanks*, p. 274.

²³ Peden, *British Rearmament*, p. 137.

²⁴ *Ibid.*, pp. 37-38 & 47-48; Harris, *Men, ideas and tanks*, p. 282.

²⁵ *Ibid.*, pp. 252-253.

²⁶ Postan, et al., *Design and Development of Weapons*, pp. 308-309.

²⁷ G. Till, ‘Adopting the aircraft carrier: The British, American, and Japanese case studies’, in W. Murray and A. R. Millett (eds.), *Military Innovation in the Interwar Period* (Cambridge, Cambridge University Press, 1996), p. 201.

²⁸ W. Murray, ‘Strategic Bombing: The British, American, and German experiences’, in *ibid.*, pp. 119-120.

sea and air. The essence of this policy was to prevent the second and third threat by increasing the strength and capability of successfully defending against the first.

Towards the end of 1937 the Secretary of State for War, Leslie Hore-Belisha, reorganized the existing design and production arrangement to coincide with the retirement of Lieutenant-General Elles as MGO, by amalgamating this department with the duties of the DGMP. It was emphasised that the office of DGMP was created to meet the emergency brought on by rearmament and that the present restructuring did not preclude the role of MGO being 'resuscitated' at some point in the future.²⁹ The purpose of this reorganisation was to bring the research, design, experimentation, production and inspection under one authority and if events dictated, presumably with the imminence or outbreak of war, production would receive priority over the other considerations. Greater demarcation was established under the Director of Mechanization with the formation of two Deputy Directors, one for engineering and signals and one for vehicles with Brigadier Giffard Le Q. Martel.³⁰ Having considered the changes within the government to commence rearmament, the second section of this chapter will review the industrial advances and limitations to make this programme a reality.

The official history rightly contends that despite initial appearances to the contrary, the British motor industry during rearmament was unsuitable for both tank development and production.³¹ That being said, the quality of mechanized components for use within the British tank programme before and during rearmament was dependent upon the advances of design and development from within the motor industry. To begin with, the effect of government policy to tax vehicles based upon their unladen weight, meant that manufacturers were forced to design commercial vehicles within this limitation and thus have smaller engines.³² Whilst this certainly hampered commercial vehicle design, Appendix 2 demonstrates that the size of engines for the tanks under development did increase during rearmament to meet the growing demand for larger and heavier designs.

²⁹ TNA, WO 32/4196, 'Re-organisation of the Master-General of the Ordnance's Department', 22 November 1937.

³⁰ TNA, WO 32/4196, DGMP to Hore-Belisha, 11 November 1937; *London Gazette*, 21 January 1938; *The Times*, 4 March 1938; Scott and Hughes, *Administration of War Production*, p. 28.

³¹ Postan, et al., *Design and Development of Weapons*, p. 239.

³² TNA, WO 194/57, First Report, para. 1; Second Report of the Mechanization Board, 1935, para. 1; Third Report of the Mechanization Board, 1936, para. 1.

A demonstration of design progress or stagnation by motor manufacturers was displayed during the annual motor exhibitions. During 1934 the Mechanization Board reported that there had been no significant developments in the design of commercial vehicles. Part of the reason for this inactivity was attributed to the absence of the Commercial Motor Transport Exhibition in London, and when the Scottish Motor Exhibition in Glasgow was attended, it displayed 'no great advance in vehicle design'.³³ Another reason for the decline in new designs was the lack of economic activity up to 1935, whereby the revival of trade was complemented by an increase in motor industry work.³⁴ For 1936 and 1937, the board suggested that the absence of any new developments was because motor manufacturers were 'satisfied with their designs and have called a halt in the march of innovation'. This analysis was incomplete as the Board later highlighted that the cessation in new design work was due to the 'exceptional activity' in relation to armaments production throughout industry.³⁵

The impact of rearmament upon the motor industry was also reflected in the poor level of global trade and recession during 1938 and thus a continued lack of developments in motor vehicle design and research. The Mechanization Board was uncertain whether the downturn in motor vehicle sales could be entirely attributed to the threat of war, or whether it was also due to a 'normal industrial cycle'.³⁶ In any event, Associated Equipment Company (AEC) noted that the general reduction in work resulted in 200 workers being discharged by May 1938, with the prospect of a further 500 workers by August 'unless more immediate work could be obtained from outside sources'.³⁷ What remains clear is that the poor economic situation was similar to that experienced up to 1934 when rearmament commenced, with the resultant curtailment of new designs and research within the motor industry.

During 1934 Professor F. W. Harbord reported to the Mechanization Board that the industrial processes of working with metals or metallurgy, had displayed improvements and experimentation of general practice but without any great metallurgical advances. Having said this, these activities were nonetheless very important for industry in the fields of welding and casting and to understand the different properties of various alloys. The technique of

³³ TNA, WO 194/57, First Report, para. 1.

³⁴ TNA, WO 194/57, Second Report, para. 1.

³⁵ TNA, WO 194/57, Third Report, para. 1; Fourth Report of the Mechanization Board, 1937, para. 1.

³⁶ TNA, WO 194/57, Fifth Report of the Mechanization Board, 1938, para. 3.

³⁷ Modern Records Centre, Warwick, Associated Equipment Company, MSS.226/AE/1/1/12, Minutes of Board and General Meetings, 1935-1960, '5284. Reduction in volume of output and number of employees', 3 May 1938.

electric welding had become more common and skilled with parts of high pressure boilers transferring from riveted to welded construction, and welded railway track could now withstand the changes of expansion and contraction in temperate climates.³⁸

The use of alloy cast iron, instead of ordinary cast iron, expanded during this period by incorporating nickel, chromium and molybdenum to double the life-span of the engine cylinder liners.³⁹ The official history states how experimentation with these three elements continued during the 1930s to produce better quality armoured plate when combined with steel.⁴⁰ During 1936 the English Steel Corporation incorporated a much higher percentage of chromium-molybdenum to produce 'Hykro' steel tank armour, that was less prone to flake and produced a wider range of tensile strength than with other alloy combinations.⁴¹ This type of armour on British tanks was appreciated by Russian tank crews in 1941 during the defence of Moscow discussed in chapter 6, when the British turret did not shatter upon being hit resulting in greater crew survivability, unlike with the turret on the T-34 tank.

The Ford Motor Company successfully experimented with a mixture of cast iron and steel alloyed with copper, chromium and silicon to form cast crankshafts instead of those by steel forgings. Legitimate concern was raised with the use of castings with each component being an independent unit, whereby defects would be hard to detect during mass production. Alloy cast irons also lacked the flexibility of steel castings. Whilst these fears were justified, they could be overcome once the manufacturing processes had been standardised into routine foundry practice. Moreover, the benefits of casting in case of war were appreciated with an anticipated higher and cheaper rate of output when compared to forgings, with the result of releasing alloy steels to fulfil other requirements.⁴²

The deficiencies and transformation of the labour force is another way to illustrate the changes brought about by the rearmament programme within industry. The impact of armament contracts upon motor manufacturing was an acute shortage of skilled designers and workers, with new research being prevented and progress with existing products limited to

³⁸ TNA, WO 194/57, First Report, para. 7.

³⁹ Ibid.

⁴⁰ Postan, et al., *Design and Development of Weapons*, p. 307.

⁴¹ Cambridge University Library, Manuscripts Department, Vickers-Armstrongs, VICKERS 755, 'Armour Development', 9 January 1948.

⁴² TNA, WO 194/57, Second Report, para. 7; Fifth Report, para. 11.

tried and tested components.⁴³ Peden identifies that it was ironic that Britain's 'army of unemployed' could not be incorporated into rearmament work due to the reduction of apprenticeships during the Depression, and that some skills had been superseded by industrial advances. Peden describes the lack of skilled labour as 'the worst bottleneck in industry' and that the 'dilution' of labour could not be used due to the problems encountered with the Trade Unions during the Great War.⁴⁴ Dilution was the practice of dividing skilled work into tasks which could be completed by semi-skilled men, or by 'up-grading' workers to a task that was 'higher than the union reckoned their qualification entitled them to undertake'.⁴⁵

At the beginning of 1938, the chairman of Vickers-Armstrongs Sir Charles Craven wrote to the Minister for Coordination of Defence Sir Thomas Inskip, expressing concern that the lack of skilled labour had resulted in a 'tremendous amount' of "deskilling" work. Deskilling was an extension to 'dilution' that involved semi-skilled men to operate *machinery* on work that would otherwise have needed a skilled engineer or craftsman. Craven emphasised that whilst the Trade Unions were 'definitely opposed to any form of real dilution', they had not raised any serious obstacles at this time.⁴⁶ In common with other firms engaged on rearmament orders, R. A. C. Parker points out that Vickers sub-contracted part of their work to other firms that had skilled and semi-skilled men available, thereby reducing the overall requirement for more workers at Vickers.⁴⁷ The process of sub-contracting was generally accepted by those unions opposed to dilution as it avoided the disruption caused by transferring labour from one firm to another, and maintained the employment of skilled workers at the contracted firms.⁴⁸

As the main rearmament priority was aircraft production, Sebastian Ritchie argues that during 1938 'serious deficiencies' in skilled labour were avoided by sub-contracting and by the internal transfer of workers within Shadow firms from car factories affected by the recession onto aircraft work.⁴⁹ In response to the German annexation of Austria in March 1938 or *Anschluss*, the Air Ministry and War Office wanted an increase in the supply and volume of munitions output. As a result of this pressure, the Chamberlain government reversed their

⁴³ TNA, WO 194/57, Third Report, para. 1.

⁴⁴ Peden, *British Rearmament*, pp. 81-82.

⁴⁵ R. A. C. Parker, 'British Rearmament 1936-9: Treasury, Trade Unions and Skilled Labour', *The English Historical Review*, Vol. 96, No. 379 (Apr., 1981), p. 328.

⁴⁶ CUL, VICKERS 722, Craven to Inskip, 19 January 1938.

⁴⁷ Parker, 'British Rearmament 1936-9', p. 332.

⁴⁸ P. Inman, *Labour in the Munitions Industries* (London, H.M.S.O., 1957), pp. 23-25.

⁴⁹ S. Ritchie, *Industry and Air Power: The Expansion of British Aircraft Production, 1935-1941* (London and New York, Routledge, 2007), pp. 156-157.

existing policy of avoiding direct contact with the unions to prevent demands for better pay and conditions, and instead sought closer co-operation with the unions rather than reducing civilian production.⁵⁰

Following the warning by Stanley Baldwin during 1932 that the ‘bomber will always get through’,⁵¹ and with the higher priority given to the air force and air defence during rearmament, the third section of this chapter will identify how industry responded to the air threat as the situation on the continent deteriorated. This review is particularly relevant since the crippling of industry would be a key war aim for any belligerent and that these factories would be priority targets. One of the earliest indications of industry reacting to the potential dangers of bombing occurred following the *Anschluss*, when in April 1938 the Gloucester Railway Carriage & Wagon Company initiated an investigation into the issue of taking precautions against air attack.⁵²

The possible consequences of European leaders failing to reach agreement at the Munich conference during September 1938 was clearly understood by manufacturers, together with continued uncertainty regarding the prospect of war until the outbreak a year later. At the time of the ‘Munich Crisis’ for Gloucester Railway, the firm was satisfied that the existing measures could be swiftly enacted in the event of a national emergency.⁵³ During October 1938, AEC reported that an ‘Air Raids Precautions Scheme’ had been established involving expenditure estimated at £6,000.⁵⁴ Similarly during October, the Managing Director of Metropolitan-Cammell announced to the Board that the current state of precautions at all the works required a further £2,000 ‘to bring the arrangements into such a condition that they would be of use if the occasion arises’.⁵⁵ Likewise, the English Electric Company recognised the necessity of protecting important company records, with precautions to ‘provide duplicate sets of Drawings, Accounts and Records, as a safety measure in the event of Air Raids’.⁵⁶ By February 1939, Gloucester Railway revised their earlier position and decided to spend £2,000

⁵⁰ G. C. Peden, *Arms, Economics and British Strategy: From Dreadnoughts to Hydrogen Bombs* (Cambridge, Cambridge University Press, 2007), p. 142; Parker, ‘British Rearmament 1936-9’, pp. 334-336.

⁵¹ *The Times*, 11 November 1932.

⁵² Gloucestershire Archives, Gloucester, Gloucester Railway Carriage & Wagon Company, D4791/6/18, Directors’ Minute Book, ‘50/38. Air Raid Precautions’, 7 April 1938.

⁵³ GAG, D4791/6/18, ‘132/38. Air Raid Precautions’, 29 September 1938.

⁵⁴ MRC, MSS.226/AE/1/1/12, ‘5323. Air Raids Precautions Scheme’, 3 October 1938.

⁵⁵ Birmingham Archives and Heritage, Birmingham Central Library, Metropolitan-Cammell, MS 99/2006/024, ‘409. Air Raid Precautions’, 19 October 1938.

⁵⁶ Bodleian Library, Department of Special Collections and Western Manuscripts, Oxford, English Electric, MS. Marconi 2392, Minutes of Board Meeting, Minute Book No. 7, ‘3. Air Raid Precautions’, 6 October 1938.

'for the protection of the Company's workmen', with 'Shelters and Equipment' becoming available by the following April.⁵⁷ By the end of August 1939 and in response to the 'International Situation', the Board of Gloucester Railway authorised the Managing Director to take whatever precautionary measures were deemed necessary.⁵⁸

Table 1.1 Vickers ARP expenditure for all factories and against total sales, 1938-39

Factory Location	Expenditure to 19.10.38 ⁵⁹	Expenditure to 31.12.39 ⁶⁰	Comparative Increase
	£	£	%
Head Office	-	4,797	
Barrow	25,000	88,532	254.1
Naval Yard	5,000	15,672	213.4
Crayford	25,835	41,713	61.5
Dartford	14,480	37,514	159.1
Manchester	-	2,698	
Elswick	23,920	69,862	192.1
Spotswood	-	42,651	
Chertsey	440	721	63.9
Weybridge	-	74,726	
St Albans	250	-	
Supermarine	-	20,966	
Total ARP expenditure	£ 94,925	£ 399,852	321.2%
Vickers total sales⁶¹	£ 17,683,823	£ 26,406,147	49.3%
Percentage of ARP of total sales	0.54%	1.51%	179.6%

The factories of Vickers, being the only firm dedicated to armaments production were an obvious and well established target in respect of air attack. The level of seriousness displayed by Vickers towards taking ARP was reflected by the level of expenditure during 1938 and 1939 totalling a considerable £495,000, as demonstrated in Table 1.1 for the different locations and as a percentage of total sales. In the absence of a monthly or quarterly breakdown of these costs, the majority of the 1939 expenditure might have related to the last three months of the year when war was declared. However, the Board agreed at the beginning of 1939 that each factory should proceed with individual ARP schemes, whereby final preparations could be completed within 48-hours of an emergency arising.⁶² Therefore the majority of these precautions and costs involved would have taken place in the eight

⁵⁷ GAG, D4791/6/19, Directors' Minute Book, '23. Air Raid Precautions', 9 February 1939; '58. Capital Expenditure', 20 April 1939.

⁵⁸ GAG, D4791/6/19, '137. Air Raid Precautions', 28 August 1939

⁵⁹ CUL, VICKERS 1225, '2064. Air Raid Precautions', 19 October 1938.

⁶⁰ CUL, VICKERS 1226, '2648. Air Raid Precautions', 14 May 1941.

⁶¹ CUL, VICKERS 722, 'Summary of Sales from 1931 to 1939', 24 December 1940

⁶² CUL, VICKERS 1226, '2146. Air Raid Precautions', 18 January 1939.

months prior to the outbreak of war. In addition to the precautions to existing premises, Vickers went one stage further by purchasing neighbouring premises to meet the concerns of air attack. During April 1939 the firm purchased property from the London, Midland and Scottish Railway Company for the sum of £5,500, to act as a site where employees at the Barrow works could be evacuated during an air raid.⁶³ A similar purchase was made again just after the outbreak of war, when the firm purchased premises near the Weybridge works for the sum of £2,750.⁶⁴

Rover Company reveals some elements of government policy towards air raid precautions for industry and highlights the understandable fears that these firms had regarding the extent of centralised control in the case of war. During November 1938, Rover received a letter from the Air Ministry suggesting various precautionary measures which the Board sanctioned for £2,000. The point of concern was whether this expenditure would actually benefit the Shareholders, as it was believed that in the event of war the government would take control of the factories, and the Shareholders' interests would thus be eliminated.⁶⁵ Despite these legitimate concerns, by the end of 1940 Rover had spent over £50,000 on ARP since 1938, and as discussed in the chapter 3, the government now provided industry with a grant towards part of the amounts incurred.⁶⁶ The fourth section of this chapter continues with the review of industry during the rearmament period, by identifying the type and cost of plant and machine tool expansion that was necessary for increased munitions production.

The increase in industrial capacity over this period has been described by the official history as the creation of 'war potential' by transforming 'industry to a point at which it could be relied upon to turn out great quantities of weapons at the very outbreak of war'.⁶⁷ The general expansion of the steel industry occurred during 1935 by incorporating modern by-product facilities, rebuilding blast furnaces and the installing of new plant for the cost of £20 million.⁶⁸ Peden highlights that the higher priority given to the Air Ministry established a 'shadow industry' during peacetime for the production of aircraft, whereas the lower War

⁶³ CUL, VICKERS 1226, '2207. Expenditure', 19 April 1939.

⁶⁴ CUL, VICKERS 1226, '2293. Air Raid Precautions', 8 September 1939.

⁶⁵ MRC, Rover Company, MSS.226/RO/1/1/6, '(14) 6559. Capital Expenditure', 22 November 1938.

⁶⁶ MRC, MSS.226/RO/1/1/6, '(10) 6899: A.R.P.', 12 December 1940.

⁶⁷ M. M. Postan, *British War Production* (London, H.M.S.O., 1952), p. 35.

⁶⁸ S. H. Friedelbaum, 'The British Iron and Steel Industry: 1929-49', *The Journal of Business of the University of Chicago*, Vol. 23, No. 2 (Apr., 1950), p. 120.

Office priority meant that expansion plans were delayed until wartime.⁶⁹ As will be established in chapter 3, the intense construction of new factories relevant to the War Office and in particular to tank production occurred after the outbreak of war. However as displayed in Table 1.2, there were important exceptions in relation to Vickers and English Steel, with the expansion of plant and machine tool capacity during 1936 to meet the growing demands of the War Office and Admiralty.

Table 1.2 Vickers capital expenditure programme from June 1936⁷⁰

Company and Factory Location	Costs at 2 June 1936 £	Capital Expenditure	Manufacturing Purpose
A) Vickers-Armstrongs			
Barrow	240,000	Additional machine tools	Gun mountings and field equipment
	240,500	Gun mountings	Heavy naval guns
Elswick	47,000	New tank shop	Assembly of tanks
	129,000	Additional machine tools	Guns Breech mechanisms Cartridge cases Tanks and Track vehicles
	50,500	Gun mountings	Heavy naval guns
Crayford	20,000	Additional machine tools	Increase machine guns output
	70,000	Additional machines	Admiralty requirements
Dartford	10,000	Additional machine tools	Increased capacity for Fuses
	£ 807,000		
B) English Steel			
	1,000,000	Additional plant	Naval armour plate
	145,000	Additional plant	Bullet proof plate
	33,000	Gun forging plant	Guns
	£ 1,178,000		

This record provides a useful statement of the production diversity of Vickers and the level of expandable capacity that was already available had an increased demand for munitions been received earlier. By November 1937 the cost of the 'New Tank Shop' at Elswick had increased to £51,838, although this was not due to an increase in tank orders, but rather that the existing space was required to assemble the 'Heavy Naval Guns' before converting to

⁶⁹ Peden, *British Rearmament*, p. 171.

⁷⁰ CUL, VICKERS 722, 'Programme of Capital Expenditure', 16 May 1936; CUL, VICKERS 722, 'Capital Expenditure, Government Defence Programme', 2 June 1936.

tank production.⁷¹ The increase in the demand for machine tools and equipment to supply the rearmament programme affected the similar requirements for machinery from those firms still involved in manufacturing civilian products. For example, during May 1939 Rover was compelled to sanction new machinery for their Tyseley car plant four months ahead of schedule due to the expected delays in delivery.⁷²

The amount reimbursed by the Treasury in relation to industrial expansion reflected government policy towards industry in respect of the financial impact and preventing undue enhancement. The recommendations of the Robinson Committee during 1936 stated that the government should pay the entire cost of new factories, thereby ensuring that the war potential remained under direct state ownership.⁷³ In respect of English Steel and the additional plant for naval armour plate above, the Admiralty agreed to reimburse the whole expenditure eventually adjusted to £1,056,000.⁷⁴ It was understood that at the end of the 'abnormal period of production' the government would maintain the additional plant and reinstate the original facilities displaced by the expansion.⁷⁵ In respect of the additional machine tools relating to Barrow, Elswick and Crayford, the government agreed to reimburse 60 per cent of the cost back to Vickers.⁷⁶ The reason for not amounting to a full repayment was because Vickers obtained complete ownership of the new facilities for the cost of 40 per cent of the value.⁷⁷ This policy of providing reimbursement to industry but also ensuring that the firm did not unduly benefit from the larger plant facilities and brand new machine tools, continued throughout war as examined in greater detail during chapter 3.

As highlighted in the introductory chapter, tank design and production prior to rearmament was carried out by Vickers, with a minor contribution from the state owned Royal Ordnance Factory at Woolwich (ROF). Many of these tanks continued to be developed and used by service units through the rearmament period, although they played no role once war was

⁷¹ CUL, VICKERS 1225, '1720. Government Defence Programme', 14 April 1937; '1851. Government Defence Programme', 17 November 1937.

⁷² MRC, MSS.226/RO/1/1/6, '(8) 6632. Future Development Expenditure', 25 May 1939.

⁷³ Peden, *British Rearmament*, pp. 46-47.

⁷⁴ CUL, VICKERS 1225, '1675. Government Defence Programme, (b) English Steel Corporation Limited Armour Plant Extensions', 17 February 1937.

⁷⁵ CUL, VICKERS 1225, '1578. English Steel Corporation Limited, Armour Plant', 16 September 1936.

⁷⁶ CUL, VICKERS 1225, '1805. Government Defence Programme', 16 September 1937.

⁷⁷ D. Edgerton, 'Public ownership and the British arms industry 1920-50', in R. Millward and J. Singleton (eds.), *The political economy of nationalisation in Britain 1920-1950* (Cambridge, Cambridge University Press, 1995), p. 178.

declared or when fighting commenced in France or the Western Desert during 1940.⁷⁸ The fifth section of this chapter will therefore examine how Vickers maintained tank design and development against the background of infrequent War Office demand, the Depression, and the export market.

The commercial monopoly that Vickers had during rearmament on tank design and development can be largely attributed to government financial policy. The amounts centrally allocated for tank experimentation between 1927 and 1936 varied between £22,500 and £93,750 per annum, which Harris rightly argues was barely enough to keep Vickers and the ROF active on tank development, let alone introduce any new firms.⁷⁹ Whilst the ability of Vickers to supply armoured fighting vehicles was heavily dependent upon the prospect of regular demand through this inconsistent financial commitment from the government, the firm did adapt to deteriorating circumstances.

At the beginning of January 1932 and after years of successive cuts in the Army Estimates, tank designer John Carden proposed to cut the expenditure relating to new models for a period of two years, thereby saving an estimated £13,000 per year. Carden justified these recommendations by emphasising that the developmental work of the previous four years had produced a series of standardised tank models and components, which could be successfully marketed around the world.⁸⁰ In relation to Carden's memo, it was recommended to Vickers' Director and former MGO, General Sir Noel Birch, that the expenditure of new design work should instead be limited at the beginning of the year.⁸¹ Vickers had therefore front-loaded their experimental work before and even during the Great Depression, with a programme to provide standardised tank models and components for generic sale. The particular benefit to Vickers by concentrating upon standardised production was that the overall quality of the components would improve.⁸² When compared against financial stringency and negligible demand, it is commendable that Vickers maintained any form of new tank development at all.

Despite these positive indications on tank design, the problem was a shortfall in demand to provide the necessary manufacturing experience. During 1933, the MGO, Lieutenant-

⁷⁸ For Medium Marks I, II and III see Harris, *Men, ideas and tanks*, pp. 238 & 278; for Medium A.7 see *ibid.*, p. 239.

⁷⁹ Postan, et al., *Design and Development of Weapons*, p. 304; Harris, *Men, ideas and tanks*, p. 274

⁸⁰ CUL, VICKERS 744, Memo by John Carden, 8 January 1932.

⁸¹ CUL, VICKERS 744, Wonfor to Birch, 14 January 1932.

⁸² CUL, VICKERS 744, 'Tank Policy', 21 September 1932.

General Sir Ronald Charles, confirmed that requirements for tanks were limited to 18 Light tanks at £1,500 each, despite Vickers having sufficient capacity to manufacture more.⁸³ During 1934, the War Office indicated the desire to increase deliveries of the Vickers 3-man Light Mark V tank, but not at the expense of enhanced labour costs.⁸⁴ Therefore whilst there were early intentions to expand the tank programme, the restriction on finance meant that this was limited to an existing instead of a new order.

Until an increase in new orders and finance was received, Vickers maintained their supply of tanks to foreign markets to utilise their existing designs and available capacity. From 1934 until the end of 1936 Vickers supplied a variety of tanks and tractors to Belgium, Holland, Switzerland, Poland, Lithuania, Latvia, Finland, India and China.⁸⁵ Vickers was not given *carte blanche* authority to supply any of their tanks for export as available vehicles needed to be approved by the War Office beforehand. In one example, the Vickers Command Tank, which had been on the 'free list' since April 1936, was placed back onto the War Office 'secret list' during March 1938. The reason was an apparent similarity with the Light Tank Mark VI B, which was under production for the British Army. Given the context of the time, the War Office was naturally keen not to reveal current tank attributes to foreign powers. Vickers was able to persuade the War Office that the only similarities related to the positioning of the engine, transmission and cooling system and four months later the CIGS, Lord Gort, approved the release of the Command Tank from the 'secret list'.⁸⁶

The slow introduction of new firms to the production of tanks can be partly attributed to the absence of long-term requirements from the government. DGMP Brown informed the Secretary of State for War that new General Staff orders had to be substantial enough or be coupled with 'continuation orders', for firms to accept the commercial risks and expense.⁸⁷ Furthermore, Peden highlights how it was necessary to provide firms with sufficiently large orders to create the level of industrial capacity required.⁸⁸ This was an issue of administrative understanding by simultaneously educating industrialists to understand military requirements

⁸³ CUL, VICKERS 744, Birch to Yapp, 12 April 1933.

⁸⁴ CUL, VICKERS 744, '3-Man Tanks', 30 January 1934.

⁸⁵ CUL, VICKERS 722, 'Notes from Quarterly Reports, Military Armaments, 1934-39', by J. D. Scott, post-war undated; VICKERS 744, 'Armoured Fighting Vehicles 1937 to 1959', 7 September 1959.

⁸⁶ CUL, VICKERS 744, Birch to Brown, 2 March 1938; 'Command Tank', 15 July 1938.

⁸⁷ Postan, *British War Production*, p. 43.

⁸⁸ Peden, *British Rearmament*, pp. 173 & 177.

and the War Office to understand large-scale industrial processes.⁸⁹ The sixth section of this chapter will continue to review the relationship between the War Office and industry, by identifying the different tank orders placed with each of the ten firms from 1934 until 1938.

The numbers of tanks used by the army in 1936, whether as a result of the legacy of pre-reamament production or via new orders, was 375 tanks divided into 209 Light and 166 Medium. A total of 304 or 81 per cent were considered obsolete being all but two Mediums and 140 Light tanks. Therefore, to put tank production up to 1936 in context, only 69 Light Marks V and VI were of any use to the Army and these were still deficient in armament.⁹⁰ Having considered the organisational changes at the War Office; the competition between the services; the level of finance available; and the limitations of skilled labour and industrial capacity, the number of tank orders between 1934 and 1936 was understandably limited, in both the models under consideration and for the introduction of new manufacturers. This is demonstrated in greater detail by Figures 1.1 and 1.2 below. Where there are discrepancies in the plotting of the two graphs it is because the order was placed on the same day for the same type of tank split equally between two different manufacturers. Hence, Figure 1.1 shows the combined order for that type of tank, whereas Figure 1.2 show individual orders for each manufacturer and may therefore display an overlap.

As displayed in the graphs, Vickers continued to be the sole commercial organisation capable of receiving new tank orders from the War Office during 1934 and 1935. The official history establishes that this was an advantage for the new Mechanization Board as it could refrain from interfering with Vickers in respect of production, as the vehicles were designed by this firm and that any problems would be dealt with internally.⁹¹ Despite the death of Sir John Carden during 1935, the War Office could expect a reasonable rate of delivery from Vickers given their experience, the ready facilities and commercial drive.

⁸⁹ Scott and Hughes, *Administration of War Production*, p. 22.

⁹⁰ Postan, *British War Production*, p. 7.

⁹¹ Postan, et al., *Design and Development of Weapons*, p. 318.

Figure 1.1 Tank orders by type, 1934 to 1936⁹²

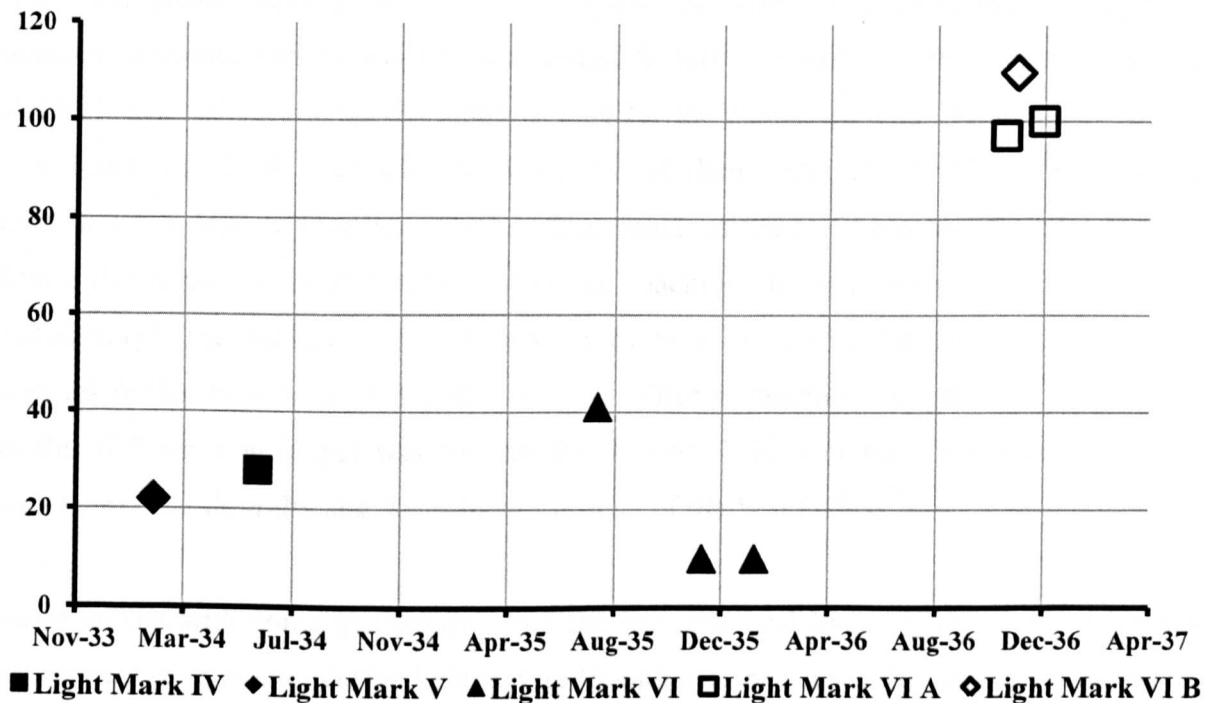
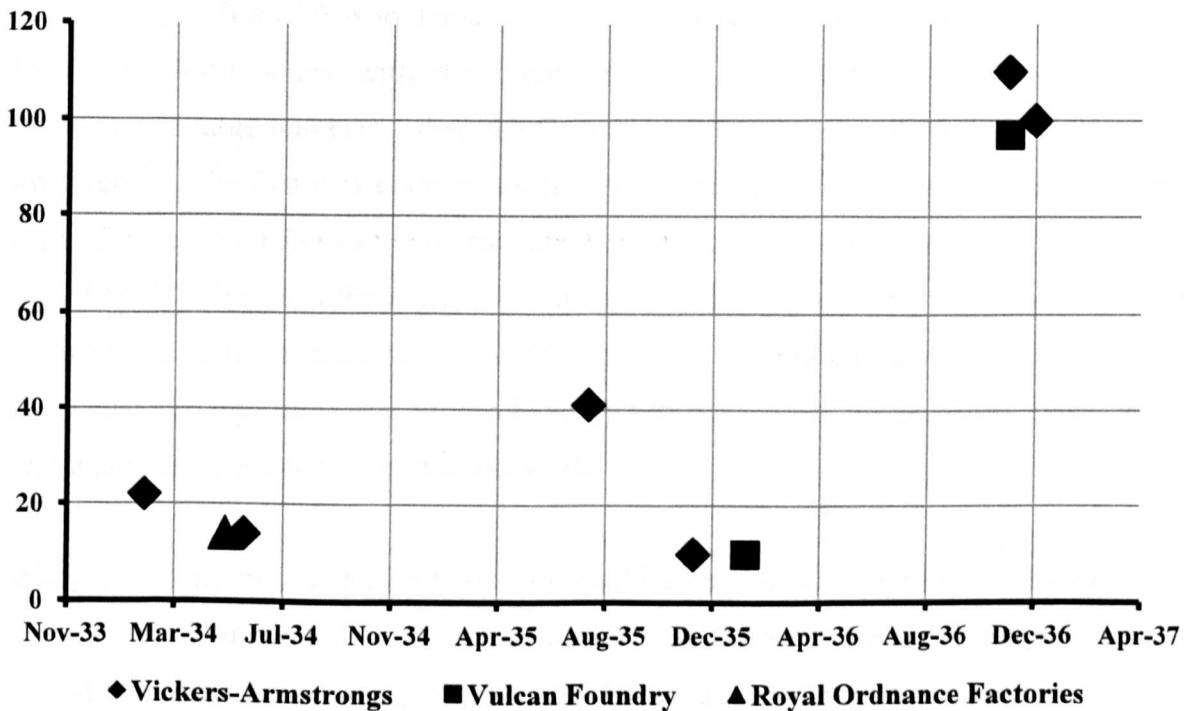


Figure 1.2 Tank orders by manufacturer, 1934 to 1936



⁹² TNA, WO 194/57, First Report, para. 18; Third Report, para. 22; CUL, VICKERS 722, 'Notes', 1934-1939; BLO, Vulcan Foundry, MS. Marconi 2739, Board minutes, 1934-40, 24 January and 25 November 1936.

This expectation can be illustrated by the order of 28 Light Mark IV tanks during June 1934, which was shared equally between Vickers and the ROF. The difference in productive capability between Vickers and the state owned factory was striking with Vickers delivering all 14 of their vehicles to service units in time for the annual training during 1935. On the other hand, the ROF eventually delivered 12 of their order during May 1936 and the remaining two later in October, which was as much as ten to fifteen months after Vickers. Whilst the performance and reliability of the machines from either source were deemed 'satisfactory', the difference in delivery times was not indicative towards giving state factories further tank production orders as War Office requirements expanded.⁹³ The reason for this difference in output was because the Woolwich Factory had to give priority to the work from the Admiralty and Air Ministry instead of the War Office.⁹⁴

Harris argues with some justification that the late approval by the Cabinet for a 'serious rearmament programme' during February 1936, and that the role of the British Army was not defined until February 1939, meant that there was insufficient time for tank development and production up to the outbreak of war.⁹⁵ That being said, the growth of War Office tank orders at the end of 1936 demonstrated a marked improvement when compared to the combined orders from 1934 to January 1936. The later orders also display the reality of British tank development with the Light Mark VI being the only tank available for manufacture in large numbers, when the Cabinet embarked on the 1936 policy of 'serious' rearmament.⁹⁶ The first new commercial firm to be introduced to tank production shown in Figure 1.2 was the locomotive manufacturer, Vulcan Foundry, with two contracts for 10 and 97 Light Mark VI tanks at the beginning and end of 1936 respectively. The increased orders reflects both a 'serious' attempt by the War Office to expand the number of tanks for the army, whilst also indicating that Vulcan Foundry had now gained the necessary experience to accept a greater proportion of armaments work.

The largest expansion of orders in terms of both different designs and different manufacturers was experienced during 1937 and 1938 as depicted by Figures 1.3 and 1.4 below. To begin with and whilst being accurately described by Harris as reconnaissance machines that were obsolete by the outbreak of war, the Light Mark VI B was still the only tank with a proven

⁹³ TNA, WO 194/57, Second Report, para. 17; Third Report, para. 19.

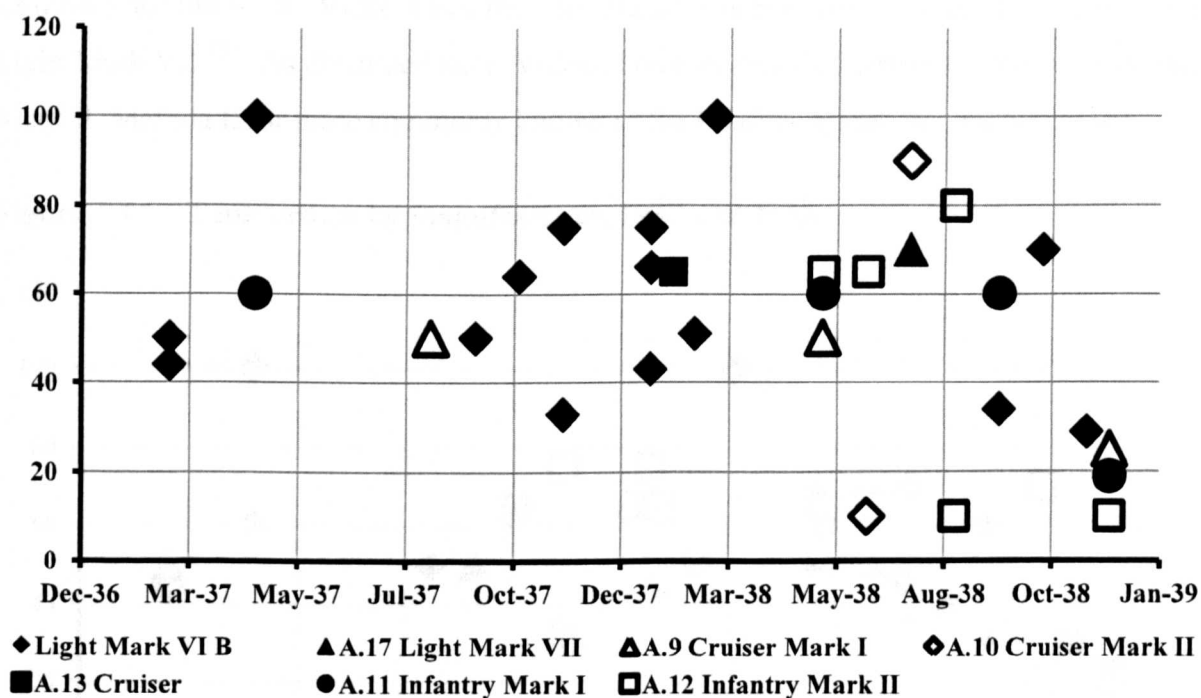
⁹⁴ Harris, *Men, ideas and tanks*, p. 301.

⁹⁵ *Ibid.*, p. 273.

⁹⁶ *Ibid.*, p. 275.

production record.⁹⁷ As a result the government decided upon quantity production for this Light tank in order to equip the army with 1,182 vehicles by the end of 1939 as highlighted at the start of this chapter, whilst simultaneously introducing the new Infantry and Cruiser tanks towards later requirements. As identified in the next chapter and examined in greater detail in chapter 3, this emphasis to provide the army with quantity output at the expense of quality was similarly repeated and extended as a result of the Battle of France in 1940.

Figure 1.3 Tank orders by type, 1937 and 1938⁹⁸



The policy of quantity production for 1937 and 1938 was demonstrated by the introduction of three new tank manufacturers for the Light Mark VI B, with the North British Locomotive Company and agricultural vehicle engineers, Ruston & Hornsby and John Fowler & Co. Vickers and Vulcan Foundry also received additional orders during 1937 and 1938 for this Light tank, in addition to receiving orders for the new Infantry and Cruiser tanks. Harris argues that these two new classes of tank resulted from the failure to produce a suitable all-purpose Medium tank before rearmament, and the desire for tanks to provide close support to unmechanized infantry and for mobile operations respectively. Therefore in general terms, Infantry tanks were formed into an 'Army Tank Brigade' and Cruiser tanks became part of an armoured division. Despite fulfilling two separate roles, MGO Elles and Assistant Director

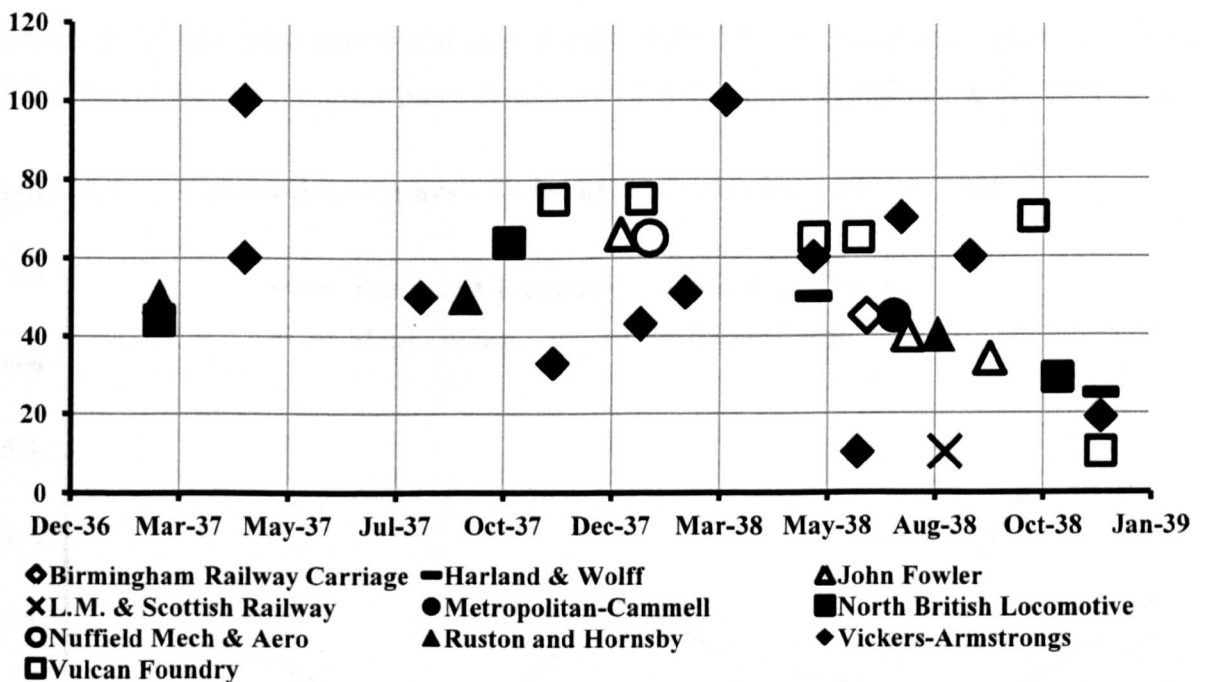
⁹⁷ Harris, *Men, ideas and tanks*, p. 263.

⁹⁸ TNA, WO 194/57, Fourth Report, para. 28; Fifth Report, para. 33.

of Mechanization Martel agreed that these two complementary but otherwise very different designs of tank were both necessary.⁹⁹

To meet these new requirements, Vickers introduced three new tank designs for production during 1937 and 1938 with the A.9 Cruiser Mark I, and A.10 Mark II, and with the A.11 Infantry Mark I, Matilda I. In respect of the Cruiser tanks, Vickers were joined by shipbuilders Harland & Wolff for the A.9, and by railway carriage constructors Birmingham Railway Carriage & Wagon Company and Metropolitan-Cammell Carriage & Wagon Company for the A.10. Vickers was the only manufacturer of the A.11 and for the new A.17 Light Mark VII.¹⁰⁰ As discussed later, Vulcan Foundry received orders for the A.12 Infantry Mark II, Matilda II, or more commonly known as the Matilda, which this study will use.

Figure 1.4 Tank orders by manufacturer, 1937 and 1938



The order of 65 A.13 Cruiser tanks in January 1938 followed the desire by Martel to introduce the same levels of mobility into British tank design with the Christie type suspension, which the Russian BT tank had demonstrated during September 1936. This work was given to Nuffield Mechanization & Aero due to the lack of capacity at any existing

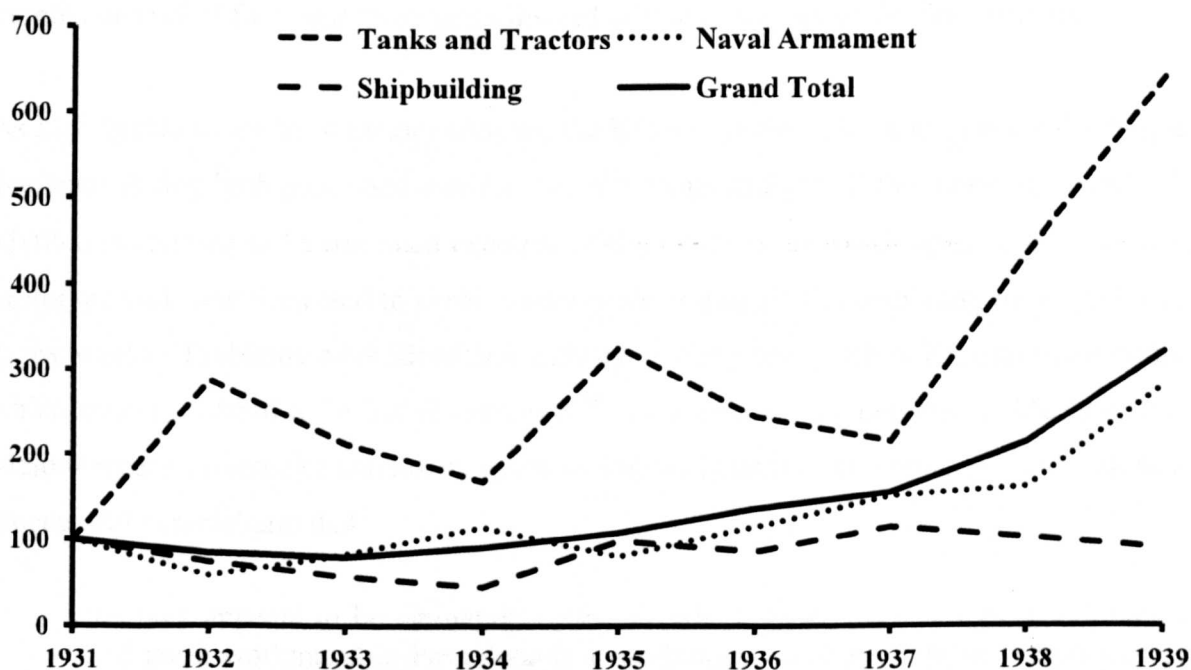
⁹⁹ Harris, *Men, ideas and tanks*, pp. 278-279 & 282.

¹⁰⁰ For A.9 and A.10 see Harris, *Men, ideas and tanks*, pp. 240, 275-276, 298, 302-303 & 305 and Postan, et al., *Design and Development of Weapons*, pp. 312-313; for A.11 see Harris, *Men, ideas and tanks*, pp. 241, 299 & 303.

armaments firm.¹⁰¹ Despite the Russian Christie type tanks displaying impressive manoeuvrability, the Mechanization Board reported during 1937 that the vehicles were only reliable for short periods.¹⁰² Harris points out that this problem plagued British Christie based tanks during the rearmament period and throughout most of the Second World War.¹⁰³

The seventh and final section of this chapter will contextualise these tank orders by reviewing the different effects upon industry. To begin with, the intense activity by Vickers in the production of Light, Cruiser and Infantry tanks mentioned above needs to be compared against the firm's other activities over the same period as shown in Figure 1.5 by annual sales. The graph deliberately omits aircraft sales because these only commenced in 1937 and the amounts for the three years were: 1937: £29,026; 1938: £3,908,831; and 1939: £8,314,350, resulting in the comparative indexation becoming distorted beyond all recognition. The graph shows that 'Tanks and Tractors' experienced the greatest increase in sales over the nine year period and in particular from 1937 as shown by Figure 1.4 above, whilst 'Naval Armament' grew more slowly and 'Shipbuilding' ended below the 1931 level.

Figure 1.5 Vickers-Armstrongs – Index of total sales from 1931 to 1939¹⁰⁴



¹⁰¹ TNA, WO 194/57, Third Report, para. 15; Fourth Report, paras. 18 & 19; Fifth Report, paras. 15 & 16; also see Harris, *Men, ideas and tanks*, pp. 277-278, 298-299 & 302.

¹⁰² TNA, WO 194/57, Fourth Report, 'Armoured Fighting Vehicles'.

¹⁰³ Harris, *Men, ideas and tanks*, pp. 298-299.

¹⁰⁴ CUL, VICKERS 722, 'Summary of Sales from 1931 to 1939', 24 December 1940.

Given the shortages of time, money and skilled resources, the development of the Matilda tank should be considered a resounding success. When compared to other vehicles of the time, Harris pays tribute to the 'greater tactical responsiveness and flexibility' of the tank resulting from a four-man crew and fitted radio.¹⁰⁵ The official history suggests that Matilda tank development took four years from the General Staff specification in 1934 to being approved for production in 1938, and five years before the first delivery in September 1939. This history does qualify these assertions by stating that the figures are 'rough and ready and should not be pressed too far'.¹⁰⁶ Despite this caveat, the suggestions are misleading as the 1934 specification related to the general requirement for an Infantry tank, which became the A.11 Infantry Mark I above, rather than directly relating to the later Matilda. Instead, Vulcan Foundry received instructions for the construction of two pilots in November 1936 with only two draughtsmen under employment by May 1937, although the Mechanization Board did provide assistance. Even though the official history negatively records that the total number of draughtsmen had 'only' quadrupled to eight by November 1937, the first prototype was delivered to the MEE during April 1938.¹⁰⁷ Sizeable production orders were received the following month and again in June 1938 with the first two tanks being delivered during September 1939. Therefore the time between the specification and a production order was 18 months instead of four, and three years instead of five in respect of the first delivery.

As highlighted in the introductory chapter, the historiography is keen to criticise the frequent decisions during both peace and wartime to order tanks straight off the 'drawing board'. The Matilda is claimed to be one such example of this practice, although upon closer review the prototype tank was subjected to performance trials during 1938, completing over 1,000 miles in six weeks. Problems were identified with the cooling and gearbox but otherwise nothing which was considered to be insurmountable.¹⁰⁸ Furthermore, the Director of Mechanization, Major-General Alexander Davidson, wrote to Vulcan Foundry expressing that the tank was a 'successful vehicle' and that:

the tank appears to be eminently sound, to which good detail design, good material and good workmanship have largely contributed. In short, I do not remember any pilot model of tank coming through its early tests with so little trouble and so little

¹⁰⁵ Harris, *Men, ideas and tanks*, p. 301.

¹⁰⁶ Postan, et al., *Design and Development of Weapons*, pp. 355 & 357-358.

¹⁰⁷ TNA, WO 194/57, Fourth Report, para. 22; Postan, et al., *Design and Development of Weapons*, p. 319.

¹⁰⁸ TNA, WO 194/57, Fifth Report, para. 22.

apparent need for alteration. This is all the more creditable to you in that the design incorporates as many new features and differs as much from any previous model.¹⁰⁹

This can only be described as a highly impressive introduction to tank design and development for Vulcan Foundry. The increased level of interest by the military authorities in the Matilda was seen by the involvement of three more manufacturers during August 1938. Two of these firms, John Fowler & Co and Ruston & Hornsby, were already involved with the production of Light tanks. Even with this prior experience and given that the actions of Ruston & Hornsby were likely repeated by other firms, the introduction of a new tank model required additional jigs and machine tools before production could commence.¹¹⁰ The third firm introduced to the Matilda, London, Midland and Scottish Railway, were new to tank manufacturing which was likely reflected in their much smaller order for just ten vehicles.

In addition to the growing pressure to increase tank output generally, the level of confidence that the military authorities had with Vulcan Foundry was displayed by the two large production orders indicated above, for 130 tanks divided equally between May and June 1938.¹¹¹ Both of these orders were valued of £1,170,000 each, with corresponding increases in the company's order book.¹¹² To put these orders into context with the other production activity at Vulcan Foundry during 1938, the value of locomotive work on the books remained static at an average of £692,000. By comparison, government orders during 1938 increased by 282 per cent from £821,953 in January to £3,143,321 in December, and as an average across the year represented 77 per cent of the total value of work on the order book.¹¹³

By using the order figures from Vulcan Foundry, the unit cost price of these 130 tanks was £18,000, which is identical to that quoted in the official history. These figures from 1964 therefore form the basis of Table 1.3 below for a cost comparison across the tank programme for the period up to 1938. The threefold increase from the A.11 at £6,000 and Matilda at £18,000 can reflect both the greater complexity of the second over the first as highlighted by Davidson above, and the likely increase in costs by involving a new tank manufacturer with Vulcan Foundry, as opposed to a well experienced firm like Vickers. Due to the absence of a

¹⁰⁹ BLO, MS. Marconi 2739, 'Tank A.12. Expressing Satisfaction', 18 May 1938.

¹¹⁰ Museum of English Rural Life, Reading, Ruston & Hornsby, TR 4RAN/MP1/48, 'Type A12, Ruston & Hornsby, Tank components for government orders', 8 October and 24 December 1938.

¹¹¹ BLO, MS. Marconi 2739, 18 May and 14 June 1938.

¹¹² BLO, MS. Marconi 2739, 23 April, 18 May and 14 June 1938.

¹¹³ BLO, MS. Marconi 2739, January to December 1938 inclusive.

complete breakdown of costs associated with individual tank orders, it is not possible to establish fully the cost efficiency of production between Vickers and Vulcan Foundry.

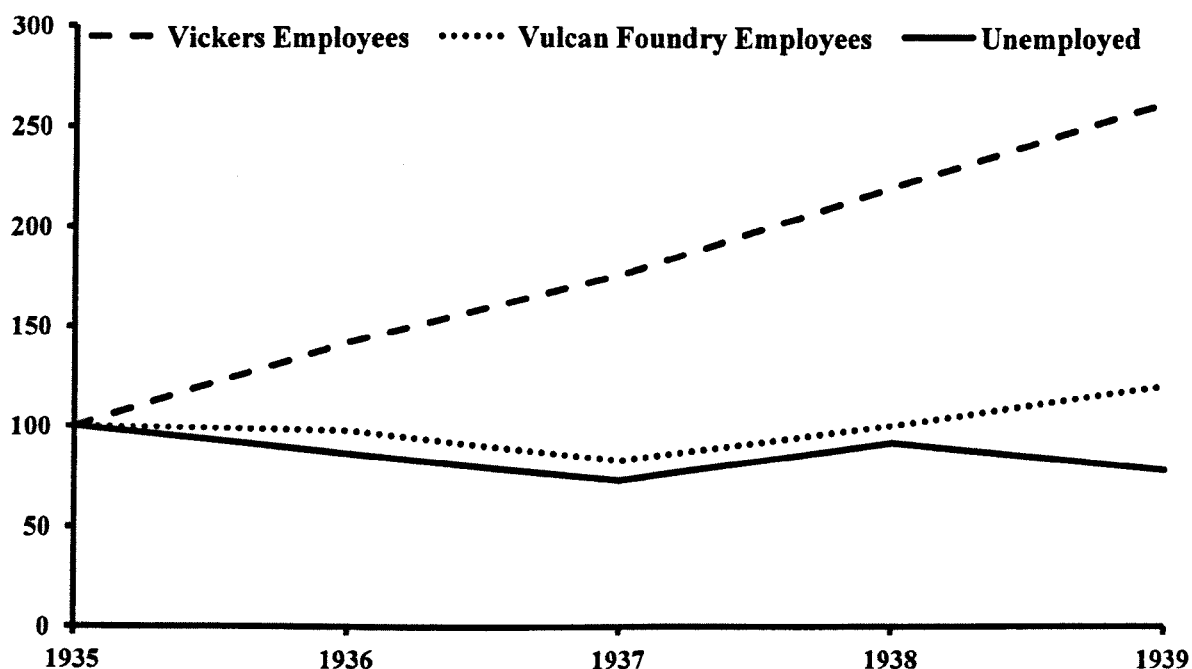
Table 1.3 Basic cost price of British tanks at first year of order, 1936 to 1938¹¹⁴

Year of Order	Tank Type and Mark	Basic Cost Price
1936	Light	£3,250
1938	Light	£4,000
1937	A.11 Infantry Mark I	£6,000
1938	A.12 Infantry Mark II, Matilda	£18,000
1937	A.9 Cruiser Mark I	£12,710
1938	A.10 Cruiser Mark II	£12,950
1938	A.13 Cruiser Mark III	£12,000

It is still possible to draw some conclusions regarding the capacity of firms to deal with these orders, by comparing the employment situation between these two firms, against the levels of employment across the country as a whole. Figure 1.6 below clearly shows that the employment of workers at Vickers grew at a sustained rate throughout the period under review against an overall declining rate of unemployment. As for Vulcan Foundry, whilst the orders for Light tanks were received during 1936 and work continued on the two prototype Matilda tanks during 1937, the number of employees fell during a time when the rate of unemployment also declined. Conversely, when the unemployment rate increased during the 1938 recession, the level of employment at Vulcan Foundry also increased, indicating that the firm had transformed to meet the demands of the large tank orders placed during that year.

¹¹⁴ For Light: Peden, *British Rearmament*, p. 199n, 186; For Infantry and Cruiser: Postan, et al., *Design and Development of Weapons*, p. 360.

Figure 1.6 Index of total persons employed at Vickers-Armstrongs and Vulcan Foundry compared against the index of unemployment, 1935 to 1939¹¹⁵



In addition to those firms that have been identified for tank production or other armaments work, there were still large firms who had not received any war production orders as late as two years into 'serious' rearmament. This delay was as much to do with the industrial limitations highlighted above, as it was government reluctance from 1936 to expand the demands of rearmament to new firms by a policy of 'business as usual'. This stipulated that service departments were not encouraged to let their demands displace normal commercial production.¹¹⁶ Peden highlights how this policy hindered rearmament efforts in respect of gun production, as non-interference with normal trade meant that the DGMP was not able to place all the orders that had been authorised.¹¹⁷ The official history highlights that by March 1938, the Secretary of State for Air, Viscount Swinton, considered that the demands of rearmament meant that this situation could no longer continue and asked the government to allow some priority over ordinary civilian business.¹¹⁸ Peden establishes that defence contracts had already received some degree of priority over exports, but problems existed in encouraging firms to transfer their skilled labour to armament work.¹¹⁹

¹¹⁵ Vickers: CUL, VICKERS 722, 24 December 1940; Vulcan-Foundry: BLO, MS. Marconi 2739, Board Minutes, 1934-40; Unemployment: Peden, *British Rearmament*, p. 208.

¹¹⁶ Harris, *Men, ideas and tanks*, p. 293.

¹¹⁷ Peden, *British Rearmament*, p. 171.

¹¹⁸ Postan, *British War Production*, p. 12.

¹¹⁹ Peden, *British Rearmament*, p. 93.

This late transfer to rearmament work was experienced by the English Electric Company who had not become involved in government contracts for war production to any considerable extent until 1938. When the company attempted to secure armament contracts during April 1938, they were informed that government policy had prevented their involvement to date as they were fully occupied with supplying overseas and domestic markets.¹²⁰ Upon pursuing the matter further into July, English Electric considered manufacturing 75 aircraft frames, but only under the condition that it did not interfere with their normal business, and that a reasonable guarantee could be given that further contracts would follow.¹²¹ It was therefore English Electric who had approached the government to become involved in rearmament work, whilst at the same time being suitably diligent not to allow munitions work to affect their normal business. This attitude was reflected in the sales book for October 1938. Within six months of the initial rearmament enquiry and not including aircraft work already received, the firm had orders totalling £5,300,000 of ordinary business for the year to date compared to other defence orders at £390,000, thus representing 6.9 per cent of the combined total.¹²² This was a measured and steady introduction by English Electric into rearmament work which did not displace the existing capacity or skilled labour needed for supplying the civilian markets. It also suggests how many other firms could have become involved in armaments production much earlier had the government not deliberately excluded them.

In conclusion, the attempt by the government to expand the existing tank programme, as part of a policy of rearmament for all three services, had to overcome a series of political, industrial and financial limitations. This chapter has shown that these efforts were not without achievements, such as: technical advances in industry; positive organisational changes within the War Office to better understand the requirements; and examples of remarkable success in tank design and development against many obstacles.

This is not to ignore or diminish the various difficulties whether on general terms or in direct relation to tank production efforts. The legacy of the Depression upon the labour market meant an insufficient supply of skilled labour to match the demands of the services, despite high levels of unemployment. Various types of dilution were necessary to transfer skilled work to semi-skilled employees, whilst avoiding antagonising the Trade Unions as

¹²⁰ BLO, MS. Marconi 2392, '4. Chairman's Report - Munition Work', 7 April 1938; '2. (a) Munition Work', 5 May 1938.

¹²¹ BLO, MS. Marconi 2392, '3. (a) Munition Work', 5 July 1938; '3. (d) Munition Work', 28 July 1938.

¹²² BLO, MS. Marconi 2392, '7. Monthly Report - Sales Report', 6 October 1938.

experienced during the Great War. The method of sub-contracting part of the work helped firms to overcome labour shortages, and also gained union support as sub-contractors were able to retain their labour. The example of English Electric highlights that some firms were deliberately excluded from munitions work until very late into the period, as the government did not want to affect domestic consumption and the export market.

Obstacles to the army and the Continental Field Force were that the Admiralty, the Royal Air Force and anti-aircraft requirements from within the army received a higher political priority and level of funding. This was the correct policy to take as it mirrored the strategic reality that Britain faced. Whilst the motor industry did not transfer directly to tank production at this time, the design and research activities of these firms, or lack thereof, were inherently linked to the rate of progress in respect of engines and transmissions in tank development. Despite government policy to levy taxation based upon the unladen weight of the vehicle, tank engine sizes did increase during rearmament as the necessity for a greater power-to-weight ratio was recognised. Specific obstacles to the tank programme were that new designs had to be generated and tested, industrial capacity needed to be created, and the War Office then had to provide a definite requirement. Despite these difficulties and resultant delays, there were still examples of significant achievements during the rearmament period towards improving the pre-war tank programme.

With regards to organisational achievements, whoever held the position of Chief of the Imperial General Staff typically supported the mechanization of the army and recognised the need for equipping the Continental Field Force with tanks. The creation of the Director of Mechanization in 1927 and the Mechanical Warfare Board in 1928, brought greater emphasis upon mechanization under the centralised control of the Master-General of the Ordnance. The concept of bringing together key representatives from the army and the experience from mechanical engineering continued with the Mechanization Board in 1934 and later with the first Tank Board from June 1940 as demonstrated in the next chapter.

The chief responsibility of the Director-General of Munitions Production was to coordinate and accelerate the various production efforts for the army by rectifying the limited technical understanding within the War Office when compared to the Admiralty and Air Ministry. Furthermore, due to the complete absence of civilian markets similar to shipbuilding and aviation, the War Office could not rely upon industry with the exception of Vickers, to have

had experience in tank production prior to rearmament. The dissolution of the MGO resulted in the DGMP obtaining complete authority over the tank programme upon receipt of a General Staff requirement, with the ability to increase production in the event of war.

In respect of the achievements within industry, there were useful advances in metallurgy with electric welding that could withstand high pressures and modest fluctuations in temperature. Experiments with different elements to produce alloy castings brought the benefits of added strength and mass production, which could be successfully applied to the assembly of tanks and in particular to armoured plate. The problems during this period were not a lack of technical understanding, but instead a shortage in skilled operatives and industrial capacity.

The extent of the programme for factory expansion for Vickers and English Steel from 1936 displays the amount of potential capacity already available, once the government embarked upon a policy of 'serious' rearmament. Whilst the government did not expect the firms to incur the costs of these new factories by providing subsidies, it created the centralised control over the pace of expansion and purpose of these facilities with state ownership. The high demand for machine tools for munitions work affected those industries still producing civilian products. The example of Vickers demonstrated that firms could own the new plant and equipment by paying a proportion of the cost. Overall, government policy towards expanding industrial capacity was aimed at meeting the increasing demands of rearmament, whilst preventing the firms from unduly benefitting from these enhancements.

The response of the firms towards the threat of air attack reflected the rise in tensions on the Continent with various precautionary measures carried out. These efforts ranged from the construction of shelters, the duplication of important documents and in the case of Vickers, to purchasing adjacent premises. The question that Rover had in respect of centralised control in the case of war reveals another concern regarding the future of commercial industry, beyond the loss of workers and physical damage caused by bombing.

Pre and early rearmament tank design and production were the commercial purview of Vickers, with some limited involvement by the Royal Ordnance Factory at Woolwich, with many vehicles fulfilling an important experimental and training function. The difference in productive efficiency between Vickers and the ROF was the result of the state factory having to give priority to Admiralty and Air Ministry work. The order for Light tanks in 1934 was

the last time that a state owned factory was involved in tank assembly until ten years later with the A.41 Centurion.

Despite the restrictions on funding and infrequent demand for new tanks during the early 1930s, Vickers had invested in standardised designs for both vehicles and components. Until the War Office provided sizeable orders, Vickers continued to supply the export market albeit with the occasional interruption in respect of the tank being allocated to the 'secret' list. The increase in orders with new firms and for new tank designs during 1937 and 1938 demonstrated that a serious tank programme had now been passed to industry. Many of the tank orders given to new firms were limited in size as the existing capacity could not support anything greater, and that the firm needed to gain production experience before receiving larger contracts. The emphasis upon the Light Mark VI B was because this could be mass produced to provide the army with tanks, whilst the programme began to introduce the new Infantry and Cruiser types. This policy of quantity production expanded during the crisis of mid-1940 as shown during chapter 3.

The successful development of the Matilda tank by Vulcan Foundry was demonstrated by the ability to provide a pilot tank that was ready for production in 18 months, and deliver the first production tank three years after the initial instruction. In a situation that was likely repeated amongst other munitions firms, the tank orders at Vulcan Foundry provided a much needed increase in sales following a period of stagnation in the core business. The time lag between the production order and first delivery can be partly explained by the gradual increase in employment at Vulcan Foundry during 1938 after a period of decline, whereas the level of employment at Vickers grew with the continued expansion of tank sales since 1931.

Overall, the British tank programme grew during the rearmament period against the strategic reality that rightfully gave priority to the air defence of Great Britain. The nature and pace of tank production was fundamentally linked to the technical advances within civilian industry. The relationship between industry and the War Office improved once the DGMP became singularly responsible for transforming General Staff requirements into production tanks. The number of tank firms expanded to achieve the necessary quantity production of the latest Light tank for the army in the short term, whilst introducing the new Cruiser and Infantry designs with notable success being achieved at Vulcan Foundry with the Matilda.

Chapter 2

Government control of Tank Production, 1939 to 1945

With British tank policy and production during the period of rearmament established in the previous chapter, it is necessary to continue this review to understand how the government responded to control the challenges brought on by the immediacy of war until the end of hostilities. The history of day-to-day government intentions and decision making during the war is significant enough for an entire study to be devoted to the subject in addition to the official histories identified throughout this thesis. Instead this chapter will establish the necessary background and overall direction of the British government in expanding and maintaining the tank programme during the war, in preparation for the examination of the specific details during each of the following chapters.

Before discussing the central organisation of the British tank programme during the war, the overall control of industry and the particular responsibility of the Ministry of Supply should be established. Peter Howlett highlights that the ‘extent of state influence on the economy during the war cannot be underestimated’, with controls over the supply of labour and scarce resources, new taxes, restrictions on capital and the curtailment of exports. Whilst business generally ‘supported the temporary centralisation of economic power in the hands of the state’, there were concerns that this might become permanent or extend to greater nationalisation of private companies.¹

The creation of the Ministry of Supply in 1939 was a demonstration of state influence, which J. P. Harris describes as a ‘milestone on the road from a free-market civil economy to a system of State control in which defence had absolute priority’.² Kevin Jefferies highlights that once shipbuilding had remained with the Admiralty and with the creation of the Ministry of Aircraft Production in May 1940, the Ministry of Supply became responsible for just meeting the needs of the army.³ In respect of the tank programme, during June 1939 Vice-Admiral Sir Harold Brown, as the Director-General of Munitions Production (DGMP)

¹ P. Howlett, “‘The Thin End of the Wedge?’: nationalisation and industrial structure during the Second World War”, in R. Millward and J. Singleton (eds.), *The political economy of nationalisation in Britain 1920-1950* (Cambridge, Cambridge University Press, 1995), pp. 237 & 248.

² J. P. Harris, ‘The War Office and Rearmament, 1935-1939’ (PhD thesis, King’s College London, 1983), pp. 224-225.

³ K. Jefferies, *The Churchill coalition and wartime politics, 1940-1945* (Manchester and New York, Manchester University Press, 1991), p. 64.

discussed in the previous chapter, transferred from the War Office to the emerging Ministry of Supply.⁴ Given the sudden increase in overall requirements following the outbreak of war, the responsibility for tank production was given to the President of the Federation of British Industries, Peter Bennett, as the new Director-General of Tanks and Transport (DGTT).⁵

This chapter will continue to identify the different War Office and Ministry of Supply officials responsible for the centralised control of the tank programme during the war, and examine the changes within the context of wartime developments, industrial considerations and other war production. This will begin with a review of the decision by the Ministry of Supply to form the Special Vehicle Development Committee at the outbreak of war to design and construct experimental tanks. With the previous chapter examining the different orders for Light, Cruiser and Infantry tanks, the vehicles built by this new committee were designed to fulfil the unique heavy assault role based upon the experience of the Great War. Whilst none of these vehicles went beyond the pilot stage, the Ministry of Supply and War Office were aware of the actions of the committee, and that the Ministry authorised the continued development of these tanks until April 1943, when this work should have ended in late 1941.

A transformation of government intentions to control the tank programme occurred prior to the German offensive in May 1940, with plans to set up a Tank Board for joint discussions between with War Office, Ministry of Supply and leading industrialists. When the first Tank Board met following the evacuations from Dunkirk, it provided recommendations on the current and future direction of the tank programme. The early decision to introduce experts from industry into the Ministry of Supply was done to incorporate their knowledge and experience of production techniques, and ultimately replaced the military personnel in these roles of authority. The transfer from the military to civilian direction of the tank programme was essential to meet the demands for mass production under wartime conditions.

In the course of this chapter five separate Tank Boards will be identified each with a different chairman, variations in membership, and different terms of reference that changed whether the board was meeting the requirements of the War Office or the Ministry of Supply. The catalyst for these changes was the introduction of each new Minister of Supply and whilst

⁴ *The Times*, 26 June 1939.

⁵ J. D. Scott and R. Hughes, *The Administration of War Production* (London, H.M.S.O., and Longmans, Green, 1955), pp. 218; House of Commons, *Parliamentary Debates*, 'Ministry of Supply', vol. 351 col. 1088, 21 September 1939.

they were disruptive, by September 1942 the fifth and final Tank Board had a stronger organisational structure with increased executive responsibility over the tank programme.

In addition to the various Tank Boards, this analysis will identify the purpose, possible benefits and problems of the short-lived 'Tank Parliament', which was meant to incorporate the opinions of armoured commanders to the discussions on current and future tank policy. Furthermore, the functions of the Armoured Fighting Vehicle Liaison Committee will be highlighted to show how this dealt with the minor issues of tank production, so that the fifth Tank Board could concentrate upon making the major decisions on the tank programme.

In addition to the examination of British boards and committees, this chapter will also discuss the key committees instigated by the Canadian government to manage their own tank programme and to discuss the trials of Canadian vehicles at British testing facilities. This review is necessary for comparative purposes and because Canadian production contributed towards the British war effort, as examined in greater detail during the following chapters.

The first section of this chapter will demonstrate that contrary to the claims by Brigadier George Macleod Ross, the pilot tanks developed by the Special Vehicle Development Committee (SVDC) were not ignored by the 'Officialdom'. Furthermore, neither was the original design 'a figment' of the committee's imagination, nor 'so hush-hush that no one ever saw it'.⁶ The origins of the SVDC began on 28 June 1939 when the new Minister of Supply, Leslie Burgin, approached Sir Albert Stern for his views on mechanical warfare based upon his Great War experience on tank procurement and supply.⁷ During July, Stern met with DGMP Brown to discuss the matter of tanks because whilst Brown had the experience in respect of industrial matters discussed in the previous chapter, he considered the issue of tank strategy and the type of tank required to be outside of his 'province'.⁸ By late August, Stern met with the Director of Mechanization, Major General Alexander

⁶ G. Macleod Ross, *The Business of Tanks, 1933 to 1945*, in collaboration with Major-General Sir Campbell Clarke (Ilfracombe, Arthur H. Stockwell, 1976), pp. 186-187.

⁷ Liddell Hart Centre for Military Archives, King's College London, Sir Albert Stern, STERN 2/9, 'Notes of an Enquiry conducted by Mr. Graham Cunningham, Director-General of Production, at the Ministry of Supply', 23 May 1942; Stern was secretary of the Landships Committee and later head of the Mechanical Warfare Supply Department during the Great War: see Lieutenant-Colonel Sir A. G. Stern, *Tanks 1914-1918: The Log-Book of a Pioneer* (Uckfield, Naval & Military Press, undated), first published 1919; for opinion on Stern: see J. P. Harris, *Men, ideas, and tanks: British military thought and armoured forces, 1903-1939* (Manchester, Manchester University Press, 1995), pp. 21, 24, 28, 38, 56 & 57, 91, 160-162.

⁸ LHCMA, STERN 2/1/1, Brown to Stern, 6 July 1939.

Davidson and the Ministry of Supply's senior military adviser, General Sir Maurice Taylor, who later relayed the details of the meeting to the General Staff.⁹

Based upon these discussions and with the outbreak of war two days earlier, the Director of Mechanization confirmed that Burgin had authorised Stern to 'explore the possibility of designing and constructing a Special Tank'. Technical data was provided by a liaison officer from the Tank Design Branch, whilst Stern recruited the designers and technicians himself.¹⁰ The Chief of the Imperial General Staff (CIGS), General Sir Edmund Ironside offered his own support for Stern's committee, which included a visit to France in November 1939 to discuss French tank development and examine General Gamelin's replica of the Siegfried Line.¹¹ The emphasis upon the Siegfried Line was later reflected in the General Staff specification for the first SVDC prototype below.

The members chosen by Stern for the SVDC were individuals he had worked alongside during the Great War with technical or organisational experience in tank design and development. To begin with there was Sir Eustace Tennyson-d'Eyncourt who had headed the Landship Committee during the Great War.¹² Next there was Major-General Sir Ernest Swinton who despite doubtful claims to have been the originator of the tank was very influential as to their requirement and potential use in battle.¹³ In respect of design, Major Walter Wilson from Self-Changing Gears Company and Sir William Tritton from the manufacturers William Foster and Company, brought their Great War experience relating to the first prototype tanks, 'Little Willie' and 'Big Willie' or 'Mother'.¹⁴ Sir Harry Ricardo brought his experience in tank engines, Major Kenneth Symes with his prior involvement in armoured plate and finally E. C. Pound who was a constructor at the Admiralty.¹⁵ Finally, Colonel W. D. Watson acted as the Liaison Officer from the Mechanization Board.¹⁶

⁹ LHCMA, STERN 2/1/1, Brown to Stern, 22 August 1939; Stern to Brown, 29 August 1939.

¹⁰ LHCMA, STERN 2/1/1, Davidson to Stern, 5 September 1939.

¹¹ LHCMA, STERN 2/1/1, appointment with General Ironside, 26 September 1939; LHCMA, STERN 2/1/2, 'Visit to France', 24-30 November 1939.

¹² Stern, *Tanks 1914-1918*, p. 11; D. Fletcher, *Landships: British Tanks in the First World War* (London, H.M.S.O., 1984), p. 4; Harris, *Men, ideas and tanks*, pp. 160-161.

¹³ P. Wright, *Tank: The Progress of a Monstrous War Machine* (London, Faber and Faber, 2001), pp. 25 & 27-29; Fletcher, *Landships*, pp. 3, 9 & 14-15.

¹⁴ Wright, *Tank*, pp. 28-29; Fletcher, *Landships*, pp. 2-3, 6, 10, 14, 21, 38-39 & 46.

¹⁵ The National Archives, Kew, AVIA 22/161, report by the S.V.D.C., 31 May 1940.

¹⁶ LHCMA, STERN 2/3/1, First Meeting of the S.V.D.C, 18 September 1939.

Given this collection of Great War experience, the series of pilot tanks developed by the SVDC were all given the prefix TOG in recognition of the members representing 'The Old Gang' from the previous war. Whilst this reference to the committee member's reputation assisted them at the outbreak of the war, it would have had negative connotations after mid-1940 when the 'old gang' of Chamberlain's government were blamed for the military reverses and evacuations from France.¹⁷ It should be recognised that unlike the members of the Chamberlain government, neither the SVDC nor the TOG tanks received the same amount of public attention, with the committee not discussed openly in parliament until 7 April 1943, as part of an overall debate on tanks.¹⁸ The characteristics of the TOG tanks will not come under discussion during this chapter as these have already been identified within the historiography. To sum up and despite the latest pilot vehicle mounting the 17-pounder gun, these tanks were extremely heavy at 68 to 80 tons, had insufficient armour protection when compared to the Churchill tank, and used a problematic electric or hydraulic transmission.¹⁹

The SVDC received the General Staff specification for the 'Super Heavy Tank' in late September 1939, which anticipated that the vehicle would have to assault the Siegfried Line and repeat the experience of trench warfare against fixed fortifications during the Great War. Essentially, the tank needed armour to withstand the latest anti-tank shell at 100 yards, be armed with a field gun to penetrate reinforced concrete, and have side sponsons each mounting a two-pounder gun and a machine-gun. The choice of sponsons was the result of the stipulation to 'cross sodden shelled ground', which therefore required an all round track for maximum surface area.²⁰ This first vehicle was designated TOG 1 and a mock-up was then formally inspected during March 1940 by the SVDC and representatives of the War Office, the Ministry of Supply, the Mechanization Board and Vickers-Armstrongs.²¹ Despite receiving War Office approval, the sponsons were questioned by the manufacturers William Foster, with the result that the SVDC approved a second mock-up without a General Staff specification, which incorporated a fully traversable turret under the designation of TOG 2.²²

¹⁷ For the reaction from parliament, the media and the public towards Chamberlain's 'old gang' see: Jefferys, *Churchill coalition*, pp. 43-44, 47, 49, 53, 55, 139-140.

¹⁸ Commons, *Debates*, 'Tanks', vol. 388, cols. 616-617, 7 April 1943.

¹⁹ P. Chamberlain and C. Ellis, *British and American Tanks of World War Two: The complete illustrated history of British, American and Commonwealth tanks, 1939-1945* (Leicestershire, Silverdale Books, 2004), pp. 78-79; J. Buckley, *British Armour in the Normandy Campaign 1944* (London and New York, Frank Cass, 2006), p. 154.

²⁰ LHCMA, STERN 2/1/1, 'Super Heavy Tank (Land Battleship)', 28 September 1939.

²¹ LHCMA, STERN 2/3/2, 'T.O.G.1: Inspection of Mock-Up at Adelphi', 11 March 1940.

²² LHCMA, STERN 2/3/1, 'Minutes of Eleventh Meeting of S.V.D.C.', 26 March 1940.

Official interest was received two days prior to the German offensive in May 1940, when Burgin confirmed to the SVDC that the Military Co-ordination Committee had authorised three TOG pilots, but without the benefit of any additional jigs or machine tools in support.²³

Rather than the TOG vehicles being 'swept aside by the crisis of the summer of 1940', as stated in the official history, the Ministry of Supply maintained an interest in the developments of the pilot tanks for a further 12 months.²⁴ During April 1941, the Deputy Director-General of Tanks and Transport, Major-General John Crawford, enquired whether the English Electric Company could build 100 TOG 2 tanks to which the firm expressed a desire if instructed.²⁵ Later during June, the Minister of Supply Sir Andrew Duncan asked Stern whether 50 TOG 2 tanks mounting the three-inch anti-aircraft gun could be produced in the spring of 1942.²⁶ Neither of these enquiries resulted in production orders as this would have displaced current tank output and conflicted with government policy during 1941, which as explained later, was to maintain the existing programme without interruption until 1943. As highlighted above, the TOG tanks were limited to the assault role against fixed fortifications, and as such the SVDC neither influenced nor contributed towards the overall tank programme discussed in the next chapter.

Without a production order the chairman of the Supply Council, William Rootes, and the next Minister of Supply, Lord Beaverbrook, decided during November 1941 that the SVDC should cease following the trials of the TOG 2 pilot later that month.²⁷ Any further TOG series development would be handled by the existing departmental structure for design and development for tanks under Oliver Lucas as the Controller-General of Research and Development.²⁸ Despite this seemingly unambiguous statement of policy from two senior government officials, Stern was permitted by Duncan, back as Minister of Supply, to continue the modifications to the existing TOG pilots on his own throughout 1942.²⁹ Whilst it could be argued that this was cost effective given Stern's working relationship with the suppliers, this experimental arrangement should have ended and any further research placed

²³ LHCMA, STERN 2/1/2, Burgin to Stern, 8 May 1940.

²⁴ M. M. Postan, D. Hay & J. D. Scott, *Design and Development of Weapons: Studies in Government and Industrial Organisation* (London, 1964), p. 314.

²⁵ LHCMA, STERN 2/1/4, 'Lunch with Mr Nelson of the English Electric Co.', note by Stern, 10 April 1941.

²⁶ LHCMA, STERN 2/1/4, Stern to Duncan, 18 June 1941.

²⁷ LHCMA, STERN 2/1/5, 'Rootes to Stern, 4 November 1941; STERN 2/12, Brown [for Lord Beaverbrook] to Stern, 17 November 1941.

²⁸ LHCMA, STERN 2/1/5, Rootes to Stern, 17 November 1941.

²⁹ LHCMA, STERN 2/1/6, Meeting with Minister, Sir William Rootes and Sir William Douglas', 25 June 1942.

under the responsible authority of Lucas. This was attempted during May 1942 when the Controller-General of Munitions Production, Graham Cunningham, was asked to investigate the activities of Stern and whether he had any future in tank development.³⁰ As a result, Stern was permitted to finish his agreed modifications at which point his involvement in TOG development was officially terminated on 30 April 1943, which was nearly 17 months after Rootes had attempted the same.³¹ The next section of this chapter will review the simultaneous events from March 1940 with the introduction of the Tank Board, together with an examination of the changes that resulted in the membership, terms of reference and authority being reformed on four further occasions.

The historiography in relation to the Tank Board has identified the limited advisory role at the beginning, the frequent changes in membership from the Ministry of Supply, the War Office and some industrialists, and that it only became effective from September 1942.³² In order to demonstrate how and why these changes in purpose, membership and effectiveness occurred, the Tank Board will be examined within the general context of the war, together with specific political and industrial considerations. In contrast to the historiography which labels one single Tank Board or only distinguishes between an advisory or executive function, each change of constitution will be divided to identify five distinct Tank Boards. This is important for the purposes of comparison between the different boards and for proper recognition later in this study.

The origins of the Tank Board can be identified within the context of the dissatisfaction by certain members of parliament regarding the organisation of British tank production efforts, three months before the German offensive in May 1940. Member of Parliament Samuel S. Hammersley, who as a Tank Corps engineer officer during the last war, expressed his concern that the dual but separate activities of the War Office and Ministry of Supply risked wasting time and effort thereby causing friction.³³ Two other members of parliament who expressed their unhappiness were Colonel Gretton and Lord Lloyd with the latter claiming that the current situation would not satisfy the army.³⁴ Stern suggested the formation of a

³⁰ LHCMA, STERN 2/9, 'Notes', 23 May 1942; STERN 2/1/6, Cunningham to Stern, 27 May 1942.

³¹ LHCMA, STERN 2/1/6, Douglas to Stern, 10 March 1943.

³² Scott and Hughes, *Administration of War Production*, pp. 221-222; Postan, et al., *Design and Development of Weapons*, pp. 331-334; Buckley, *British Armour*, pp. 164-165.

³³ TNA, AVIA 22/161, Hammersley to Minister of Supply, 15 January 1940; Hammersley to Chamberlain, 19 March 1940.

³⁴ TNA, AVIA 22/161, Sir Arthur Robinson to DGTT, 20 March 1940.

Tank Board to Burgin during March 1940, which would have a civilian chairman, representatives from the General Staff, the British Expeditionary Force and the Royal Armoured Corps, and civilian representatives of design and production.³⁵

The idea of a Tank Board with mixed representation now gained momentum with support being individually expressed to Prime Minister Chamberlain by Hammersley, Lloyd and Gretton in April. The guiding principle behind sponsoring this board was to take away the monopoly that the DGTT Peter Bennett had over tank production.³⁶ Stern expanded upon his ideas to Winston Churchill, as First Lord of the Admiralty, with the proposal that the Tank Board should be the 'central interdepartmental authority for the development of Tanks and formulating production programmes and general specifications in accordance with Army requirements'.³⁷ The reason why Stern decided to express these views to Churchill at the Admiralty, instead of the more appropriate choices in government of Chamberlain or Burgin, was because Stern aimed at eliciting the same kind of support from Churchill that he had obtained during the Great War. Stern's 1919 account of his own involvement during the last war pays particular tribute to Churchill for recognising the necessity of setting up the Landship Committee in 1915, resulting in the first development of tanks.³⁸ Stern continued to approach Churchill during the rest of the Great War in relation to the organisation of tank development and production, which he was now attempting again over 20 years later in respect of the Tank Board.³⁹

Minister of Supply Burgin brought the concept of a Tank Board to the Military Co-ordination Committee on 6 May 1940, which proposed a senior Privy-Councillor as chairman, Bennett as deputy chairman, and with three members from the War Office and three from the Ministry of Supply. This board received the support of the Secretary of State for War, Oliver Stanley, but was without independent members from industry and more importantly was purely advisory, lacking the powers to interfere or change existing contracts.⁴⁰ Upon agreement within government to set up a Tank Board, the next issue was to decide upon a

³⁵ LHCMA, STERN 2/1/2, Stern to Burgin, 18 March 1940.

³⁶ TNA, AVIA 22/161, Hammersley to Chamberlain, 1 April 1940; Lord Lloyd to Chamberlain, 2 April 1940; Gretton to Chamberlain, 4 April 1940.

³⁷ LHCMA, STERN 2/1/2, Stern to Churchill, 2 April 1940.

³⁸ Stern, *Tanks 1914-1918*, pp. 11-13, 245.

³⁹ *Ibid.*, pp. 165-167, 175-176 & 196.

⁴⁰ Nuffield College Library, Oxford, Lord Cherwell, MSS CHERWELL, CSAC 80.4.81/G.364/18-19, 'Military Co-ordination Committee. Tank Production. Statement by the Minister of Supply', for meeting on 6 May 1940; TNA, AVIA 22/161, Burgin to Churchill, 30 April 1940.

suitable chairman. As indicated, the role was going to be purely advisory and the attitude of the Chamberlain government towards the initial candidates displayed a policy of short-termism and even a lack of seriousness.

This inadequate approach towards organisational changes within Chamberlain's government was not just limited to the tank programme, as recent scholarship from Kevin Jefferys has highlighted that the government and Chamberlain in particular were accused of 'lacking both urgency and coherent leadership'. This was first demonstrated by the partial mobilisation of the British economy during the phoney war towards the organisation of war production. Later, Chamberlain rejected the creation of a powerful Minister for Economic Co-ordination during February 1940, believing that this would have undermined the position of Prime Minister and the Treasury.⁴¹

One of the first suggestions for chairman of the Tank Board that was supported by Chamberlain and Burgin was Lord Swinton, who as Secretary of State for Air from 1935 until 1938 had already laid down the foundations to provide the necessary Hurricanes and Spitfires for the Battle of Britain. It was recognised that the Tank Board might interfere with his chairmanship of the Danubian Company, but it was thought that given that DGTT Bennett would act as Deputy, Swinton could safely split his time between the two responsibilities.⁴² This demonstrated that the government did not treat the board with any great importance and were satisfied with a *de facto* part-time chairman. It would have also maintained the status quo with Bennett practically still running both an executive and advisory position in tank design and development.

At the beginning of May, Stanley recommended the alternative of Lord Lloyd for chairman, as he showed 'signs of becoming the leader in the controversy' relating to the pessimistic tank position highlighted above, and 'that there is everything to be said in favour of putting him in a position of responsibility instead of criticism'. Furthermore Stanley thought it beneficial to have a chairman who had not held office nor been associated with the current government.⁴³ This last comment was in direct reference to the perceived inadequacies of

⁴¹ Jefferys, *Churchill coalition*, pp. 19, 28 & 64.

⁴² TNA, AVIA 22/161, H. J. Wilson [Prime Minister's Office] to Robinson, 7 April 1940; Burgin to Stanley, 30 April 1940; Oxford Dictionary of National Biography, 'Lister, Philip Cunliffe-', in <http://www.oxforddnb.com.chain.kent.ac.uk/view/article/30990>, accessed 28 October 2009.

⁴³ TNA, AVIA 22/161, Robinson to Wilson, 3 May 1940.

the Chamberlain government's management of the war effort, and came from within the War Cabinet before the 'Guilty Men' thesis transformed these perceptions into an influential story after Dunkirk.⁴⁴ Discussion regarding Lloyd ended when, upon becoming Prime Minister, Churchill appointed him Secretary of State for the Colonies.⁴⁵

Whilst the changes in personnel with the new Churchill government brought about a 'greater determination and clarification to Britain's economic war effort', the original intentions regarding the authority and function of the board remained unchanged.⁴⁶ To this end, the Ministry of Supply continued to regard the Tank Board as a 'lightning conductor' to secure consultation and agreement between the Ministry and the War Office.⁴⁷ Towards the end of May the position of Tank Board chairman was eventually agreed with the appointment of Sir Alexander Roger.⁴⁸ During the last war, Roger was Director-General of Trench Warfare Supply within the Ministry of Munitions. Later he became a director and then chairman of British Insulated Cables in 1930 and joined the board of directors of Midland Bank in 1932 and chairman of Birmingham Small Arms Company before leaving this post to become chairman of the first Tank Board.⁴⁹ Given Roger's manufacturing and financial experience in business, it would be reasonable to expect that despite the advisory nature of the first Tank Board, he could bring some commercial understanding to the role.

This emphasis upon industrial experience continued with the decisions relating to the other members of the board, with the new Minister of Supply, Herbert Morrison, recommending a number of other names from industry. These consisted of: the chief engineer from the London Passenger Transport Board, Albert Durrant; the Managing Director of the Birmingham Railway Carriage and Wagon Company, Harry Moyses; and because Morrison wanted to have Trade Union representation on the board, G. W. Thomson from the General Council of the Trades Union Congress. From the Ministry of Supply, Morrison suggested DGTT Bennett, the Director of Mechanization Brigadier Crawford, and Brigadier Hollebhone

⁴⁴ Cato [M. Foot, F. Owen and P. Howard], *Guilty Men* (London, Penguin, 1998), first published 1940; the opinion of the Chamberlain government following Dunkirk will be discussed further in chapter 3.

⁴⁵ ODNB, 'Lloyd, George Ambrose', in <http://www.oxforddnb.com.chain.kent.ac.uk/view/article/34567>, accessed 28 October 2009.

⁴⁶ Jefferys, *Churchill coalition*, p. 61.

⁴⁷ TNA, AVIA 22/161, Robinson to Minister, 14 May 1940.

⁴⁸ TNA, AVIA 22/161, Robinson to Grigg, 28 May 1940.

⁴⁹ ODNB, 'Roger, Sir Alexander Forbes Proctor', found in <http://www.oxforddnb.com.chain.kent.ac.uk/view/article/47707>, accessed 7 October 2009.

from the Mechanization Board.⁵⁰ When Roger contacted Lord Ashfield from the London Passenger Transport Board to secure the services of Durrant, he was also offered their chief mechanical engineer William Graff-Baker.⁵¹ Whilst Graff-Baker was not considered for the Tank Board he was later appointed to 'take charge of the production side of Tanks' with the responsibilities of planning, progressing, material control and the study of capacity.⁵²

With regard to the War Office members, Anthony Eden, as the new Secretary of State for War, proposed the Assistant Chief of the Imperial General Staff (ACIGS), Major-General Laurence Carr and Brigadiers Arthur Kenchington and Douglas Pratt.⁵³ Kenchington came from the Royal Tank Regiment and Pratt had experience of tanks during the Great War as a company commander at the Battle of Cambrai and during 1940 in command of 1st Army Tank Brigade during the Battle of France.⁵⁴ Pratt was thus well aware of the general armour superiority of the Matilda tank, but also of the German remedy with the 88 mm anti-aircraft gun in an anti-tank role during the British counter-attack at Arras.⁵⁵

The membership of the first Tank Board was announced to the House of Commons by Morrison on 29 May 1940, against the emerging evacuations from Dunkirk.⁵⁶ The four independent industrialists were later asked by Morrison to investigate the production and design of tanks across all departments. They concluded that there was a lack of consistency in decision making for the kind and quantity of tanks required, as demonstrated by the experimentation and production of too many tank types. For economies of scale in production, there should be a limitation on the number of different designs to reduce the separate demands on materials, labour and components. The army must therefore state its unequivocal demands on armament, protection, performance and quantity through 'one focal point' from an officer with recent fighting experience from the War Office. The members asserted that the organisation of the Tanks and Transport Directorate was not 'calculated to

⁵⁰ TNA, AVIA 22/161, Robinson to Grigg, 28 May 1940.

⁵¹ TNA, AVIA 22/161, Ashfield to Morrison, 28 May 1940.

⁵² TNA, AVIA 22/161, DGTT Burton to Morrison, 28 June 1940; Morrison to Reith, 1 July 1940.

⁵³ TNA, AVIA 22/161, Grigg to Robinson, 29 May 1940.

⁵⁴ R. Lewin, *Man of Armour: A study of Lieut-General Vyvyan Pope and the development of armoured warfare* (London, Leo Cooper, 1976), pp. 45, 74, 108, 116-117.

⁵⁵ D. Orgill, *The Tank: Studies in the Development and Use of a Weapon* (London, Heinemann, 1970), pp. 160-161.

⁵⁶ Commons, *Debates*, 'Tanks (Constitution of Board)', vol. 361, col. 542, 29 May 1940.

produce the best results', and as such the responsibilities should be transferred to someone with experience in commercial production methods to meet the demands for high output.⁵⁷

The report laid out clearly the current difficulties and provided suitable and realistic remedies to improve matters. The report was accepted in principle by Morrison and Eden, although with the proviso that any action must not interfere with production for three to four months. One point of disagreement that demonstrated the controversial mixture of civilian and military personnel within the Ministry of Supply from its very creation was whether the report should be generally released. The Ministry wanted the report limited for risk of splitting 'the Ministry from top to bottom' as the military personnel were 'already very restless' and would take offence at the criticisms. As a result, consideration was given to reassure General Davidson and Brigadiers Crawford and Hollebone that the restructuring was not an indictment of them either as soldiers or as Ministry officials, but instead a realisation of the need to involve business leaders with production experience.⁵⁸

By the middle of June, Peter Bennett had resigned as DGTT and based upon the recommendations from the four independent industrialists in May, was replaced by an industrialist and General Manager from the British Small Arms Company, Geoffrey Burton.⁵⁹ This research has not explicitly identified the reason for Bennett's departure, although based upon the diary of Major-General Vyvyan Pope, Bennett may have resigned having lost the confidence of the War Office following the joint meeting on 5 June to discuss future armoured policy. Essentially, when the meeting compared the design and capabilities of German tanks in France to the British programme, a heated discussion ensued which gave neither Pope as the Director of Armoured Fighting Vehicles (DAFV) nor ACIGS Carr the assurances that Bennett fully understood user requirements.⁶⁰

The opening meeting of the first Tank Board took place on 24 June 1940 with Roger as chairman, the independent members of Durrant, Moyses and Thomson and Ministry of Supply members Burton and Crawford. The War Office members were limited to just Brigadier Pratt as the experienced tank user and Major-General Pope as DAFV to act as the

⁵⁷ TNA, AVIA 22/161, Roger, Durrant, Moyses and Thomson to Morrison, 7 June 1940.

⁵⁸ TNA, AVIA 22/161, Robinson to Minister, 8 June 1940.

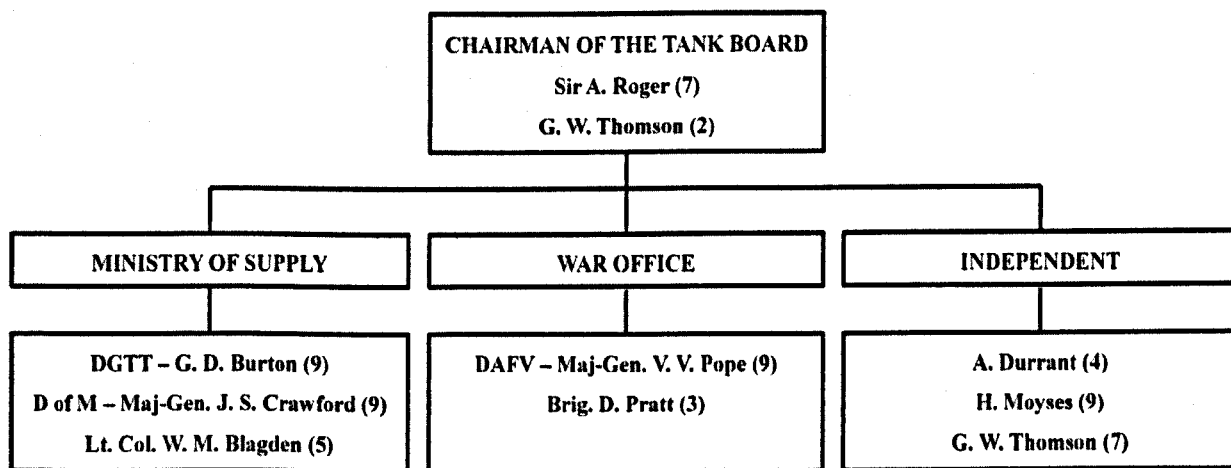
⁵⁹ TNA, AVIA 22/161, Robinson to Grigg, 15 June 1940.

⁶⁰ Undated diary entry found in Lewin, *Man of Armour*, pp. 125-126.

'one focal point'.⁶¹ Pope gained experience in the Royal Tank Corps during the 1920s, the War Office during 1930s, and briefly became Inspector of the Royal Armoured Corps in April 1940.⁶² Following the German offensive in May 1940, Pope was assigned to Lord Gort's staff as Adviser on Armoured Fighting Vehicles and was involved in planning the counter-attack at Arras. Pope remained with the expeditionary force until evacuated on 28 May and became DAFV prior to the opening meeting of the first Tank Board.⁶³

Lieutenant-Colonel William Blagden was added to the board at the first meeting to act as liaison between the War Office and Ministry of Supply.⁶⁴ With this appointment Blagden brought his experience as the Experimental Officer at the Mechanization Experimental Establishment in 1935, which was part of the Mechanization Board discussed in the previous chapter. During the war, Blagden served as Assistant Director of Mechanization with the British Expeditionary Force prior to the first Tank Board, and later Deputy Director of Armoured Fighting Vehicles in the Middle East discussed in chapter 5. From January 1943, Blagden became Deputy Director-General of Fighting Vehicles at the Ministry of Supply.⁶⁵

Figure 2.1 Membership of the first Tank Board, 24-Jun to 25-Nov-40⁶⁶



The organisational structure for the members of the first board is provided in Figure 2.1, together with the number of meetings that each member attended in brackets. After three meetings War Office membership on the Tank Board was reduced to just DAFV Pope, as

⁶¹ TNA, AVIA 22/161, Grigg to Robinson, 20 June 1940; Lewin, *Man of Armour*, p. 127.

⁶² Ibid., pp. 57-60, 73-75, 95-96, 98-102, 107; obituary, *The Times*, 9 October 1941.

⁶³ Lewin, *Man of Armour*, pp. 107-122 & 127.

⁶⁴ TNA, WO 185/8, 'First Meeting of the Tank Board', 24 June 1940.

⁶⁵ Obituary, *The Times*, 2 December 1949.

⁶⁶ TNA, WO 185/8, Tank Board meetings, 21 June to 25 November 1940.

Brigadier Pratt was sent to the United States as part of the Dewar Tank Mission and his representation on the board remained vacant. The attempts to incorporate North American industry into the British tank programme from 1940 are examined in chapter 5. These resulted in cash orders for the American Grant tank and components for British tanks, although production of the Crusader or Matilda tank in the United States was unsuccessful.

The lack of representation from the War Office directly linked to the CIGS, such as with the prior suggestion of ACIGS Carr, could suggest a lack of seriousness in the function of the board from the General Staff. It was more likely a consequence of the board's advisory nature and therefore reluctance by the senior General Staff to devote any time when there were more pressing matters following Dunkirk and the continuing evacuations along the French coastline.⁶⁷ Either way, any recommendations or questions raised during the meetings would have had to be referred to the senior General Staff later thus taking additional time.

The terms of reference given to the first Tank Board provide some key insights into government policy during a time when the army had experienced military reverses and evacuations from France. An early draft suggested that the board was meant to 'consider the whole situation regarding the design and production of Tanks' and to advise the Minister of Supply regarding future action. This very general remit was jointly amended by the War Office and Ministry of Supply at the end of May to state production before design, thus reaffirming that continued uninterrupted 'production' of existing tanks took precedent over the 'design' of new models.⁶⁸ With heavy losses in equipment following the Dunkirk evacuations, this tank policy was later strengthened on 19 June by the Cabinet Defence Committee, which advocated that the maximum number of all weapons should be provided to the army, even at the expense of quality.⁶⁹ Therefore criticism of the first Tank Board must recognise both its advisory nature and, similar to that being adopted for other munitions programmes, the specific requirement not to interrupt current output.

The formation of the first Tank Board against the deteriorating military situation on the Continent, was similarly repeated by the Canadian government by the introduction of a Joint Committee on Tank Development for greater co-ordination on tank policy. The involvement

⁶⁷ P. Warner, 'The Forgotten Evacuations', in *The Battle of France, 1940: 10 May – 22 June* (London, 2002).

⁶⁸ TNA, AVIA 22/161, 'Draft suggested Press Notice', late May 1940; Robinson to Grigg, 28 May 1940.

⁶⁹ D. French, *Raising Churchill's Army: The British Army and the War against Germany 1919-1945* (Oxford, Oxford University Press, 2001), p. 107.

of Canadian industry in supporting the British war effort will be discussed in the following chapters, including the particular importance of supplying Valentine tanks on behalf of Britain's political obligations towards Russia. To demonstrate the increased activity by the Canadian government, the Cabinet War Committee responded to the German offensive on 10 May 1940 by meeting eight times until the end of the month, compared to six times since December 1939, and none during the Norwegian campaign.⁷⁰ During August 1940, the Minister for National Defence, Colonel James Ralston, suggested to the Minister of Munitions and Supply, Clarence Howe, that the two departments combine their resources based upon 'information and experience' with the creation of a 'Tank Committee'.⁷¹ Howe fully supported the proposal by stating that whilst 'our officers have been working with your officers . . . I feel that a formal committee will be most helpful' on the issue of tank production.⁷² This committee continued for 25 meetings until December 1941, whereby it was terminated and replaced by the Army Engineering Design Branch. This new organisation was capable of discussing the issues raised during the tank committee meetings, and was better placed to expedite matters through direct contact with the army authorities and the Production Branch.⁷³

Whilst the Joint Committee on Tank Development was a joint venture, the Canadian official history points out that after Dunkirk, the Department of Munitions and Supply was moved into 'the forefront of the war effort and much in the limelight' when compared to the Department of National Defence. According to the official history, part of the reason for this situation was because 'only a relatively small proportion of the war material produced in Canada went to the Canadian Forces'.⁷⁴ This outcome was the result of underlying organisational reasons that provided the Department of Munitions and Supply with more responsibility for war production and thus an actual or perceived greater contribution towards Canada's war effort. The role of the Department of Munitions and Supply was highlighted by the new Chief of the General Staff Lieutenant-General Kenneth Stuart in December 1941, whilst approving the abolition of the Joint Committee on Tank Development above. In essence, as of July 1941 the Ministry of Munitions and Supply became responsible for the

⁷⁰ C. P. Stacey, *Arms, Men and Governments: The War Policies of Canada, 1939-1945* (Ottawa, Queen's Printer, 1970), pp. 31-32.

⁷¹ Library and Archives Canada, Ottawa, RG 24, volume 2596, file HQS-3352-3, part 1, Ralston to Howe, 23 August 1940.

⁷² LAC, HQS-3352-3, part 1, Howe to Ralston, 27 August 1940.

⁷³ LAC, HQS-3352-3, part 1, 'Twenty-Fifth Meeting', 11 December 1941.

⁷⁴ Stacey, *Arms, Men and Governments*, p. 486.

Army Engineering Design Branch under the direction of an “experienced and qualified engineer”, who was ultimately accountable to Minister Howe. In order to maintain the liaison with other branches, an “Inter-departmental Advisory Committee on Army Engineering Design” was set up to include a representative from the General Staff, the Master-General of the Ordnance and the Quartermaster General. The committee chairman was the Director-General of Army Engineering Design, who likewise reported to Minister Howe in respect of ‘matters relating to Army engineering design and industrial production’.⁷⁵

Despite the first Tank Board having a vigorous start from 24 June 1940 with five meetings during its first two weeks, by August only two more meetings were held before Roger departed as chairman in order to head up the new Mission to India.⁷⁶ Trade Union leader Thomson took over as chairman for the following eighth and ninth meetings which took place at the end of September and November respectively, representing a passing of almost 16 further weeks with little collective discussion. Given this clearly unsatisfactory situation the board was reconstituted into a more effective body following the introduction of the new Minister of Supply, Sir Andrew Duncan. The organisational capabilities of Duncan were shown in 1934 when he was appointed independent chairman of the Iron and Steel Federation with the task of co-ordinating the diverse interests of the different members. At the outbreak of war Duncan became the controller of iron and steel under the Ministry of Supply and later appointed to Chamberlain’s cabinet as President of the Board of Trade in January 1940, before becoming Minister of Supply that October.⁷⁷

The Tank Board re-organisation instigated by Duncan was based upon the recommendations of his friend and advisor Lord Weir, who had experience in the expansion of aircraft production during rearmament, and later became Director-General of Explosives at the Ministry of Supply in 1939.⁷⁸ During October 1940, Weir agreed with Duncan to change his duties to an experimental consultation and supervisory role across a variety of areas.⁷⁹ Thus through this new *ad hoc* role, Weir produced his report on tank production that recommended that the Tank Board should be ‘the supreme authority responsible to the Minister’ for all

⁷⁵ LAC, HQS-3352-3, part 1, Stuart to the Minister, 27 December 1941.

⁷⁶ TNA, WO 185/8, 7th Meeting of the Tank Board, 6 August 1940.

⁷⁷ S. H. Friedelbaum, ‘The British Iron and Steel Industry: 1929-49’, *The Journal of Business of the University of Chicago*, Vol. 23, No. 2 (Apr., 1950), pp. 120 & 123; obituary, *The Times*, 31 March 1952.

⁷⁸ S. Ritchie, *Industry and Air Power: The Expansion of British Aircraft Production, 1935-1941* (London and New York, Routledge, 2007), pp. 45, 49-50, 59, 62, 85 & 115.

⁷⁹ Churchill College Archives, Cambridge, 1st Viscount Weir, WEIR 20/5, Weir to Duncan, 16 October 1940.

matters relating to tanks. The membership needed to include ‘the main executive officers of the Tank Division’, the General Staff, ‘some outside men of recognised and authoritative technical and industrial capacity’ and one labour member.⁸⁰ During November 1940, Duncan proposed to Churchill that Sir James Lithgow take on the simultaneous role as chairman of the second Tank Board and as the new Controller-General of Mechanical Equipment.⁸¹

The choice of Lithgow was logical given his friendship with Duncan, his experience as chairman of steel manufacturer William Beardmore, and during February 1940 he had been appointed by Churchill to be the Controller of Merchant Shipping and Repairs at the Admiralty.⁸² Upon becoming Tank Board chairman, J. M. Reid correctly argues that at this time ‘no sweeping or really satisfying improvements were possible. All that could be done was to take firm decisions and to introduce some order into the existing possibilities for production’.⁸³ In order to establish the reasons for this situation, the next section identifies and examines the different issues that the second Tank Board had to deal with.

Together with Lithgow on this new board were: James Weir, as Director-General of Design and Development (Mechanical Equipment); Geoffrey Burton now as Director-General of Supply (Mechanical Equipment); the Director of Artillery, Major-General E. M. C. Clarke; Sir Albert Stern for his ‘experience and imagination’; and G. W. Thomson again to act as the labour representative.⁸⁴ The technical role from industry was once again filled by Moyses and now Commander E. R. Micklem from Vickers-Armstrongs.⁸⁵ Major-General Crawford continued to attend the second Tank Board and later became the Deputy Director-General of Tanks and Transport (DDGTT).⁸⁶

With regards to the War Office, with the continued absence of Brigadier Pratt in the United States above, ACIGS, Major-General Gordon Macready, and the Inspector of Royal Armoured Corps, Major-General Kenneth Stewart, became members in addition to Major-

⁸⁰ TNA, AVIA 11/5, ‘Tanks’, by Weir, 5 November 1940.

⁸¹ TNA, AVIA 11/5, Duncan to Churchill, 7 November 1940.

⁸² J. M. Reid, *James Lithgow, Master of Work* (London, Hutchinson & Co., 1964), pp. 43, 169, 192, 194 & 203.

⁸³ *Ibid.*, p. 209.

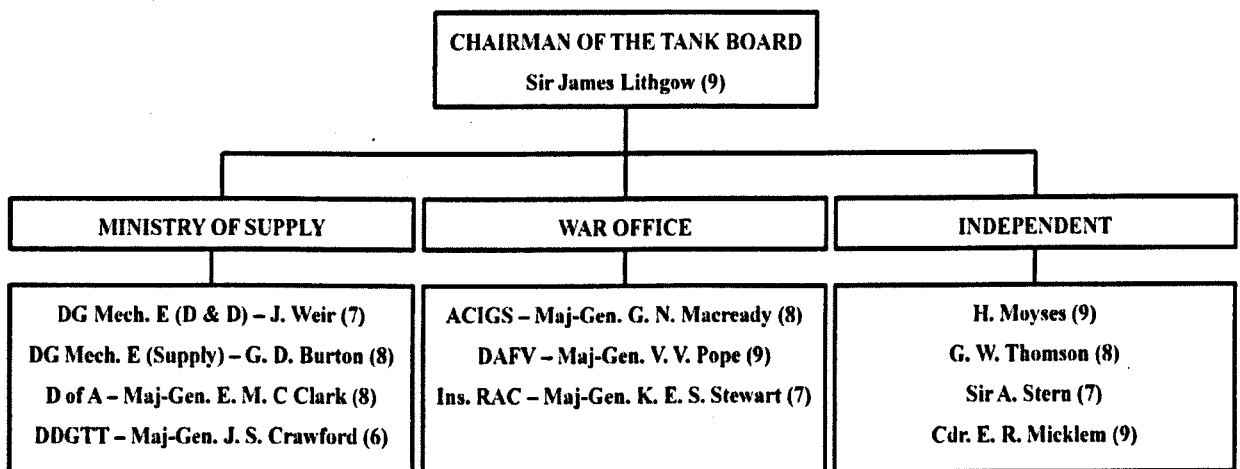
⁸⁴ TNA, AVIA 11/5, Duncan to Churchill, 7 November 1940; AVIA 22/1019, Ministry of Supply Memo No. 208, ‘Part II – Organisation of the Department of the Controller General of Mechanical Equipment’, 19 February 1941.

⁸⁵ TNA, AVIA 22/161, Brown to Grigg, 9 January 1941.

⁸⁶ Obituary, *The Times*, 8 June 1978.

General Pope as before.⁸⁷ Macready was a General Staff Officer from 1934 until becoming Deputy Director of Staff Duties at the War Office from 1936. In 1938 he became Chief of the British Military Mission to the Egyptian Army and was later appointed ACIGS in October 1940.⁸⁸ The experience that Stewart brought to the second Tank Board was based upon a history of service with the Royal Tank Corps during the inter-war period, including that of a Senior Instructor.⁸⁹ The organisational structure for the second Tank Board is shown below.

Figure 2.2 Membership of the second Tank Board, 17-Jan to 11-Jul-41⁹⁰



The first meeting of this second Tank Board took place on 10 January 1941 which was over seven weeks since the last meeting of the first Tank Board. This board now had representation on design and production together with the introduction of artillery and Stern's experimental activities from the Ministry of Supply and with senior War Office and tank user personnel. The second Tank Board was also an executive body with terms of reference:

- (i) To consider the design, development and production of Armoured Fighting Vehicles, including their armament and equipment, and to take decisions thereon in order to meet as expeditiously as possible the requirements of the War Office.
- (ii) To advise the Minister on such questions as he may refer to them.⁹¹

At the first meeting Duncan emphasised that Churchill, acting as Minister of Defence, insisted upon 'securing the maximum production of existing' tank models for 1941, with the 'minimum of interference with production by changes of design'. For 1942, the second Tank

⁸⁷ TNA, AVIA 22/161, War Office to Secretary, Ministry of Supply, 14 December 1940.

⁸⁸ *London Gazette*, 13 April 1934, 6 October 1936, 30 September 1938 and 12 November 1940.

⁸⁹ *London Gazette*, 14 November 1924 and 10 October 1933.

⁹⁰ TNA, WO 185/8, Tank Board meetings, 17 January to 11 July 1941.

⁹¹ TNA, WO 185/8, '10th Meeting of the Tank Board', 17 January 1941.

Board had to 'give close attention to design and development' as this was intended to be a different programme.⁹² A contradiction seemed to exist between the stated necessity of the Board to meet War Office requirements but only if these did not affect the production programme for at least twelve months. In reality there was very little that the second Tank Board could do over this time to meet new War Office requirements. Following the battles experienced in France and the Western Desert, the War Office at this stage of the war changed their requirements from a slightly greater number of Infantry tanks, to that which concentrated upon a much larger overall proportion of Cruiser tanks for greater tactical and operational mobility. However, because the existing production programme was weighted in favour of the Infantry tank, the War Office had to accept more of these slower tanks than they ideally required.⁹³ Thus the limitations of the second Tank Board to meet War Office requirements were more to do with the inability of industry to switch production to the desired Cruiser tanks, than as a result of Churchill's insistence upon minimal 'interference' in current output. Based upon their new executive function, the Board took it upon themselves to establish a small Tank Board Executive consisting of chairman Lithgow, Burton, Weir and Pope to decide on questions and agenda items before each board meeting.⁹⁴

During the latter stages of the second Tank Board, a series of four meetings were conducted across a seven week period from 5 May to 19 June 1941, following the suggestion of Churchill to set up a 'Tank Parliament' to consider tank and anti-tank questions. Churchill's aim was to have a parliamentary style discussion between the Ministry of Supply, the War Office and the various armoured divisional commanders to 'express their individual views with complete freedom'.⁹⁵ Within the historiography, Peter Beale draws the conclusion that the four meetings were simply a waste of time and a forum for just 'platitudes and posturing'.⁹⁶ Ronald Lewin gives the concept the benefit of the doubt by describing how the opportunity for an open discussion was 'nullified' by Lieutenant-General Giffard Martel as Commander Royal Armoured Corps.⁹⁷ Lewin draws attention to how Martel openly admitted in his memoirs to assembling his divisional commanders before each meeting, to prepare pre-

⁹² Ibid.

⁹³ TNA, WO 185/8, '11th Meeting of the Tank Board', 14 February 1941.

⁹⁴ TNA, WO 185/8, '10th Meeting', 17 January 1941.

⁹⁵ TNA, PREM 3/426/2, Churchill to General Ismay, 21 April 1941; CAB 120/52, Churchill to Secretary of State for War and Minister of Supply, 23 April 1941.

⁹⁶ Beale, *Death by Design*, pp. 166-167.

⁹⁷ Martel will also be discussed in chapter 3 in respect of Crusader tank reliability issues and in chapter 6 in relation to the policy of 'appeasement' towards Russia and as head of the Military Mission to Moscow.

determined responses to probable areas of discussion. The exception to the rule was Major-General Percy Hobart who was not prepared to play along with Martel's scheming.⁹⁸ As for Martel, the rejection of the Tank Parliament concept was principally because he did not 'want other peoples' views about organisation or technique' concerning the Royal Armoured Corps, beyond that decided at the highest levels. Whilst Martel considered that the second meeting was 'valuable and produced results' in respect of the discussions relating to the co-operation between armoured forces and the Royal Air Force, he 'wanted no interference' on matters relating to the structure of the Corps.⁹⁹

The meetings themselves were well attended with Churchill, Lord Beaverbrook, senior members from the Ministry of Supply and War Office together with the commanders of the 1st, 6th, 8th, 9th and 11th Armoured Divisions. Even taking into account Martel's attempts to block an open forum from divisional commanders, the minutes still reveal the types of issues relating to the tank programme that will be examined in the following chapters. The first meeting considered it unwise to destroy the 'rhythm of production' by attempting a short term acceleration of output. It was therefore deemed essential to continue with present designs and avoid modifications, whilst recognising the importance and expectations of Lend-Lease through greater standardisation with the United States.¹⁰⁰ In addition to co-operation with the air force above, the second meeting considered that the problems in respect of repair and maintenance consisted of organisation, man-power and spare parts. In relation to the shortage of skilled labour, Duncan hoped that the army would no longer draw upon existing civilian resources and that the Ministry could help trace those skilled workers that had already been called up instead.¹⁰¹ The third meeting considered tank and anti-tank weapons with the decision that Beaverbrook and the War Office should decide upon which types should cease production and which types should form future requirements.¹⁰² The final meeting highlighted the amount of time wasted on newly delivered tanks by armoured units in order to rectify design or production faults. It was decided that the Ministry and War Office should jointly record the condition of tanks held by the army and the time taken on overhauls and repairs on a weekly basis.¹⁰³ Whilst this 'parliament' was short-lived, it

⁹⁸ Lewin, *Man of Armour*, p. 134.

⁹⁹ Lieut-General Sir G. Martel, *An Outspoken Soldier: His Views and Memoirs* (London, Sifton Praed, 1949), pp. 175-178.

¹⁰⁰ TNA, CAB 120/52, 'Tank Parliament', 1st Meeting, 5 May 1941.

¹⁰¹ TNA, CAB 98/20, 'Tank Parliament', 2nd Meeting, 13 May 1941.

¹⁰² TNA, CAB 98/20, 'Tank Parliament', 3rd Meeting, 27 May 1941.

¹⁰³ TNA, CAB 120/52, 'Tank Parliament', 4th Meeting, 19 June 1941.

brought the users into regular and direct contact with those in authority at different levels of government, to highlight particular or common concerns and made everyone aware of the potential remedies. Following the fourth meeting of the Tank Parliament, the second Tank Board met for the last time on 11 July 1941 having completed nine meetings over six months.

As before, a change of direction and Tank Board membership followed the introduction of the new Minister of Supply, Lord Beaverbrook, at the end of June 1941 with Duncan returning to the Board of Trade. This 'Reconstituted' or third Tank Board was dramatically reduced with Lithgow, Weir, Clarke, Stern, Moyses, Micklem and Thomson all departing. As examined later, the reason for this considerable reduction in membership was probably a combination of Beaverbrook's general dislike of committees and individual resignations similar to that of Lord Weir from the Ministry upon the arrival of Beaverbrook. Figure 2.3 below displays the organisational structure for this new board under the chairmanship of Geoffrey Burton. The Ministry of Supply members incorporated two new industrialists, namely Oliver Lucas from Lucas & Company of Birmingham for design and development, and George Usher from International Combustion for production as Director-General of Tank Supply (DGTS).¹⁰⁴ DDGTT Crawford continued to attend Tank Board meetings as before and later became Deputy Director-General of Armaments Production during 1943.¹⁰⁵

The War Office representatives continued with ACIGS Major-General Macready with Major-General Ronald Weeks as his deputy. Major-General Pope remained as DAFV until replaced by Major-General Alexander Richardson in November 1941, following Pope's accidental death outside Cairo before the Crusader offensive.¹⁰⁶ Richardson was previously a member of the Royal Tank Corps and gained further experience with mechanized equipment between 1928 and 1930, when he commanded the Mechanical Warfare Experimental Establishment under the Mechanical Warfare Board discussed during the previous chapter.¹⁰⁷

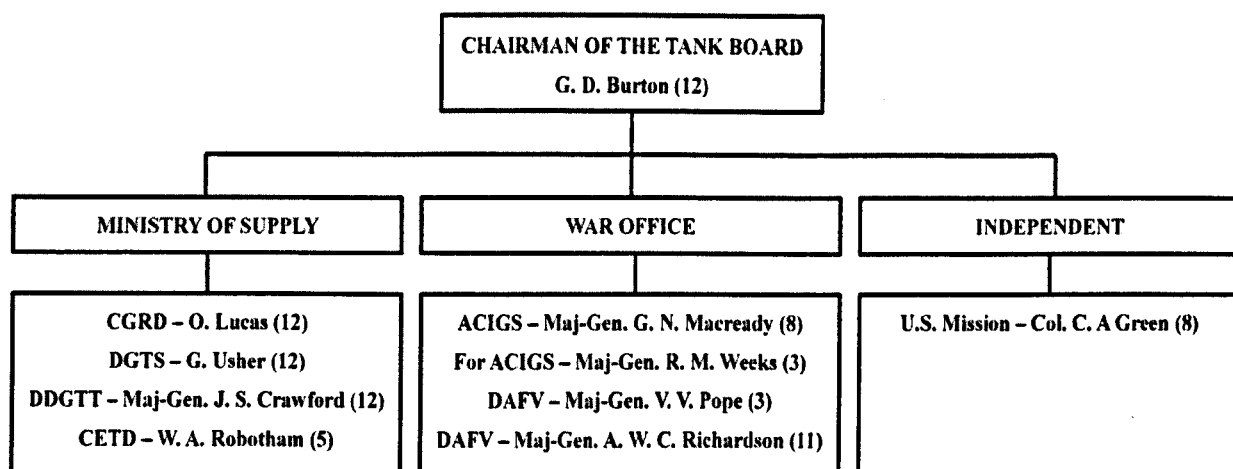
¹⁰⁴ TNA, AVIA 22/161, 'Press Notice', 26 July 1941.

¹⁰⁵ Obituary, *The Times*, 8 June 1978.

¹⁰⁶ Lewin, *Man of Armour*, p. 139; TNA, AVIA 22/161, War Office to Ministry of Supply, 11 November 1941.

¹⁰⁷ *London Gazette*, 13 April 1928 and 30 September 1930.

Figure 2.3 Membership of the third Tank Board, 1-Aug-41 to 17-Feb-42¹⁰⁸



A part-time member was also added with U.S. Army Colonel G. A. Green from the Harriman Mission, with the dual task of advising the board on design and production issues and acted as Liaison Officer for the United States.¹⁰⁹ As discussed in chapter 5, the involvement of Colonel Green before the entry of the United States into the war in December 1941, was part of an overall policy of mutual exchange and co-operation between Britain, Canada and the United States. This 'collaboration' continued throughout the war and brought about increased liaison between the Western Allies in respect to tank policy, with particular benefits on tank research and development, and general information relating to industrial processes.

This new board remained executive in function with initial terms that were similar to the second board, but with the exception of no longer meeting 'as expeditiously as possible the requirements of the War Office'. In essence, whilst the General Staff requirement consisted of Cruiser tanks mounting the six-pounder gun together with a smaller proportion of similarly armed Infantry tanks, the 'first duty of the Board was to consider the programme for the immediate future'.¹¹⁰ This meant an increase in the production of the Matilda, Covenanter and Crusader tanks until replaced by reliable Churchill tanks and the later Cromwell designs:

- (i) To consider the design, development and production of armoured fighting vehicles including their armament and equipment and to take decisions thereon.
- (ii) To advise the Minister on such questions as he may refer to them.¹¹¹

¹⁰⁸ TNA, WO 185/8, Tank Board meetings, 1 August 1941 to 17 February 1942.

¹⁰⁹ *The Times*, 28 July 1941.

¹¹⁰ TNA, WO 185/8, 'First Meeting of the Tank Board (Reconstituted)', 1 August 1941.

¹¹¹ *Ibid.*

Furthermore, the Ministry instructed that the board should not only concentrate on expanding tank output, but accelerate 'the introduction of necessary modifications' on existing models.¹¹² The design and development role of Oliver Lucas was formalised at the end of August 1941 when he became Controller-General of Research and Development (CGRD).¹¹³ At the beginning of November, Beaverbrook changed the organisational structure of tank development and the terms of reference of the third Tank Board:

- (i) To consider general staff specifications, types and programmes of Armoured Fighting Vehicles, including their armament and equipment, and to take decisions thereon.
- (ii) To receive design and production progress reports.
- (iii) To advise the Minister on such questions as he may refer to them.¹¹⁴

The pendulum had now swung back again by placing War Office requirements at the forefront of the third Tank Board's *raison d'être*. With regard to the organisational changes, Lucas, still as CGRD, became the executive head of Tank Design and Development which now included another industrialist, William Robotham from Rolls-Royce, to assume the role of Chief Engineer and occasional member on the third Tank Board. Robotham had very broad responsibilities of advising Lucas on all engineering matters, controlling engineering policy and being in charge of all research work. In respect of General Staff requirements, Robotham advised Lucas of those that were practicable or referred them back to the War Office for amendment and re-submission. Specification approved by Robotham was then forwarded to Usher to instigate production of the tank by selecting a suitable 'parent' firm in conjunction with the Director of Tank Design, Albert Durrant.¹¹⁵ The third Tank Board met a respectable twelve times between the first meeting on 1 August 1941 and 17 February 1942, whereby it was dissolved following the return of Andrew Duncan to the Ministry of Supply earlier that month. Following an eleven week gap, the board was again reconstituted under Lord Weir, with another change in both its function and terms of reference.

With the return of Duncan it is not surprising that Lord Weir would return again given their extremely close working relationship. In fact, Weir had resigned his *ad hoc* advisory position

¹¹² Ibid.

¹¹³ LHCMA, STERN 2/5/79, changes to Ministry of Supply and Tank Board, note by Stern, 9 October 1942.

¹¹⁴ TNA, WO 185/8, '6th Meeting of the Tank Board (Reconstituted)', 7 November 1941.

¹¹⁵ TNA, WO 185/8, '6th Meeting of the Tank Board (Reconstituted), Appendix 'A', A.F.V. Design Procedure', by Lucas, 6 November 1941.

at the Ministry shortly after Beaverbrook took over from Duncan as Minister of Supply at the end of June 1941. Weir stated that his resignation was simply to give Beaverbrook the freedom to appoint whomever he wanted without being tied to any prior arrangement, which was entirely logical given that any new minister has the right to appoint their own team.¹¹⁶ However based upon the Oxford biography of Lord Weir and the evidence within Weir's papers of the aversion that others had towards the appointment of Beaverbrook, the underlying reason was almost certainly because Weir disliked Beaverbrook as a Minister.¹¹⁷

This reluctance to work with Beaverbrook in government was no doubt partly attributable to the reputation that he gained during his appointment as head of the new Ministry of Aircraft Production in 1940. A. J. P. Taylor describes Beaverbrook's approach and attitude as 'working through individuals, not through committees, and ready to fight every rival'.¹¹⁸ Historians have noted that Taylor's biography was affected by his close friendship with Beaverbrook to remain objective.¹¹⁹ Furthermore, Evelyn Waugh argues that Tom Driberg failed to consider the 'deep malevolence' and 'full villainy' of Beaverbrook when writing his sympathetic 1956 biography.¹²⁰ In light of this different opinion, Kevin Jefferys describes how 'Beaverbrook's ruthlessness in obtaining men and materials' resulted in numerous conflicts with ministers Ernest Bevin and Herbert Morrison.¹²¹ Whilst Sebastian Ritchie agrees that Beaverbrook's emergency measures at the ministry did not produce any long-term benefits for aircraft production, the successful expansion of the aircraft repair organisation was 'the most significant exception'.¹²² As the Minister of Supply, Taylor points out that Beaverbrook's impact was 'less sensational' because the ministry was already operational, and that he was distracted by the sudden need to promote and co-ordinate the supply of aid to Russia as discussed during chapter 6.¹²³

By taking into account the experience gained with the previous tank boards, the setting up of the fourth Tank Board was the most confused and disjointed. To begin with, Churchill was

¹¹⁶ CCA, WEIR 20/4, Weir to Beaverbrook, 7 July 1941; Weir to Churchill, 8 July 1941.

¹¹⁷ CCA, WEIR 20/4, unidentified to Weir, 4 July 1941; ODNB, 'Weir, William Douglas', found in <http://www.oxforddnb.com.chain.kent.ac.uk/view/article/36818>, accessed 14 October 2009.

¹¹⁸ A. J. P. Taylor, *Beaverbrook* (London, History Book Club, 1972), p. 415.

¹¹⁹ G. P. Marchildon, *Profits and politics: Beaverbrook and the gilded age of Canadian finance* (Toronto, University of Toronto Press, 1996), p. 5.

¹²⁰ M. Amory (ed.), *The Letters of Evelyn Waugh* (London, Penguin, 1982), p. 467.

¹²¹ Jefferys, *Churchill coalition*, p. 49.

¹²² Ritchie, *Industry and Air Power*, p. 234.

¹²³ Taylor, *Beaverbrook*, pp. 479-480.

sceptical of appointing Weir believing that he had 'passed his effective period' and positively stated that he 'could not agree to placing him at the head of the Tank Board'.¹²⁴ Although the new Secretary of State for War, P. J. Grigg, was reportedly in support of Weir becoming chairman, Weir stated to Churchill that he considered that naval and merchant ships together with aircraft production were 'much more directly urgent problems'.¹²⁵ Even with these mutual doubts concerning Weir, he was chosen to chair the fourth Tank Board which still had Lucas and Usher and now with Sir William Rootes as chairman of the Supply Council.¹²⁶ 'Dynamic salesman' William Rootes, together with his 'sage administrator' brother Reginald, formed vehicle manufacturer Rootes Group to become one of the 'big six' producers during the 1930s and post-war years, that included Morris, Austin, Ford, Vauxhall and Singer.¹²⁷ During the rearmament Rootes Group became a 'Shadow' firm for the production of airframes and aero engines, which continued throughout the war under the direction of Reginald once William departed for the Ministry of Supply from 1941 to 1942.¹²⁸

The General Staff representation on this fourth Tank Board expanded to include new areas of the War Office relating to mechanical equipment. After attending 18 meetings as ACIGS across the second, third and fourth Tanks Boards, Lieutenant-General Macready was sent to the United States during June 1942 to become the Chief of the British Army Staff.¹²⁹ Macready was replaced by Major-General Daril Watson, with Major-General Richardson remaining on the board as DAFV. Major-General Weeks was added to the board as Director-General of Army Equipment and later Deputy Chief of the Imperial General Staff (DCIGS), which he held until June 1945.¹³⁰ Finally, Major-General Eric Rowcroft was added to the board as the Director of Mechanical Engineering (DME). Rowcroft had held the position of Inspector of Tanks at the War Office between 1932 and 1936 and eventually became a full Member of the Institution of Mechanical Engineers.¹³¹

¹²⁴ TNA, PREM 4/87/1, Oliver Lyttelton to Churchill, 27 March 1942, with handwritten comment by Churchill, 29 March 1942.

¹²⁵ CCA, WEIR 20/4, Weir to Churchill, 30 March 1942.

¹²⁶ TNA, AVIA 11/27, 'Tank Board', Ministry of Supply Memo No. 440, 2 May 1942.

¹²⁷ M. Thomas, *Out on a Wing: An autobiography* (London, Michael Joseph, 1964), p. 167; S. Bowden, 'The motor vehicle industry', in Millward and Singleton, *Political economy of nationalisation*, pp. 90 & 103.

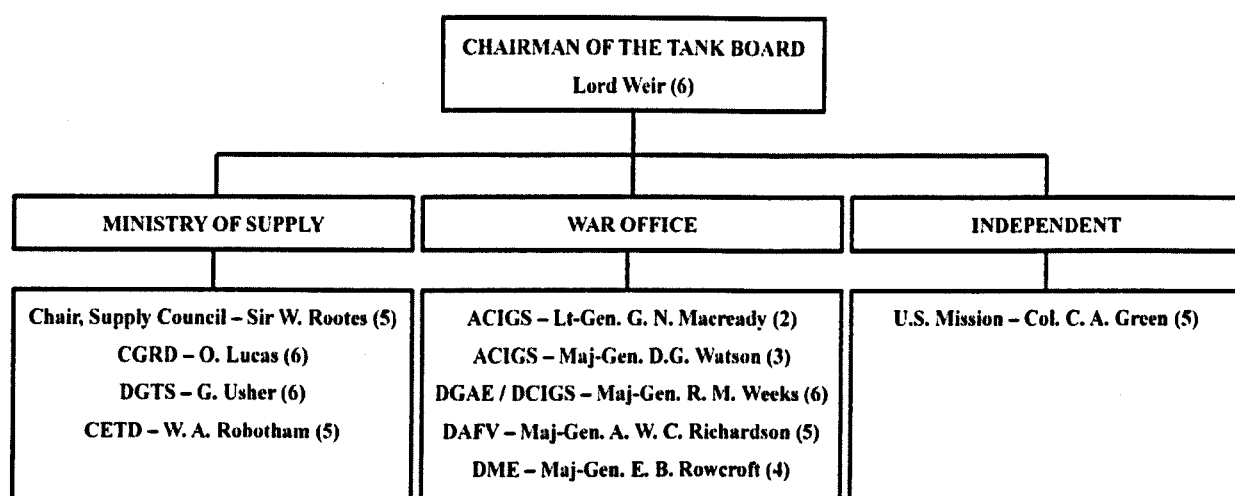
¹²⁸ Ritchie, *Industry and Air Power*, pp. 59-60 & 102; obituary for William Rootes: *The Times*, 14 December 1964; for Reginald Rootes: 21 December 1977.

¹²⁹ *The Times*, 12 June 1942.

¹³⁰ *London Gazette*, 28 March 1941; obituary, *The Times*, 20 August 1960.

¹³¹ *London Gazette*, 19 October 1943; obituary, *The Times*, 28 December 1963.

Figure 2.4 Membership of the fourth Tank Board, 7-May to 4-Aug-42¹³²



As shown by Figure 2.4 for the organisational structure, Colonel Green continued as liaison officer for the United States on the fourth Tank Board, which first met on 7 May 1942 under the terms of reference to:

be responsible to the Minister for the settlement of all major questions of policy in regard to development and production of tanks and armoured fighting vehicles. The Board will give particular attention to the qualitative aspects of the tank programme, e.g., reliability, mobility, armour and armament.¹³³

Whilst these terms were less general than before and instructed the board to consider specific qualitative characteristics of tank design and development, it forced the Board back to an advisory state again with the emphasis upon the Ministry of Supply and made no reference to War Office requirements. In respect of Weir as chairman, the press notice regarding the new board stated that he had been given the 'fullest authority' to remain in 'touch with all phases of tank supply activity and with user experience and requirements'.¹³⁴ However a deliberate Ministry policy did not permit this full 'authority' to allow Weir to 'discharge any departmental administrative or executive functions'.¹³⁵ This meant that whilst the board was made up of members of senior authority in their respective fields, it was without a chairman that could make executive decisions based upon the different priorities of those members.

¹³² TNA, WO 185/8, Tank Board meetings, 7 May 1942 to 4 August 1942.

¹³³ TNA, AVIA 11/27, 'Tank Board', Memo. No. 440, 2 May 1942.

¹³⁴ TNA, AVIA 22/161, 'Press Notice', May 1942.

¹³⁵ TNA, AVIA 11/27, 'Tank Board', No. 440, 2 May 1942.

This restriction in executive authority was supported by Weir, who later stated that 'under no circumstances' would he have taken on 'a heavy full-time executive responsibility'.¹³⁶

In addition to having an under-strength chairman, the fourth Tank Board was further hindered by a disagreement between Weir and DGTS George Usher regarding the position that Chief Engineer William Robotham had with CGRD Oliver Lucas. Whilst the technical ability of the engineer was not disputed, Usher questioned the authority that Robotham had on the Tank Board and the level of influence that he had upon future tank policy. Usher believed that Lucas should limit the Chief Engineer to just a research and development role, whereas both Lucas and Weir appreciated the 'imaginative and practical work' conducted by Robotham towards providing 'sound progressive development' on tank design. As a result of the failure to resolve this dispute, Usher resigned his position in charge of tank supply on 6 August 1942.¹³⁷ The sudden departure of Usher together with the continuing non-executive and part-time role as chairman contributed to the resignation of Lord Weir from the board the following day, thereby dissolving the fourth Tank Board after only six meetings.¹³⁸

As discussed in the next section and in contrast to the fourth board, the start of the fifth and final Tank Board in September 1942 had both a much stronger organisational structure and an executive chairman with greater authority than before. When putting the strength of this new board into context with the other developments in the administration of the British war effort, the fifth Tank Board had a much greater chance of becoming successful. To begin with, in addition to the return of Duncan to the Ministry of Supply during February 1942, the Ministry of Production was created under Oliver Lyttelton, following the two-week appointment of Beaverbrook.¹³⁹ These changes within government were complemented by the completion of other programmes within British war planning, all of which contributed towards managing production more effectively. Kevin Jefferys summarises the results of this transformation as:

By 1942 the major features of the wartime economy were in place: government controls over capital and industry; the direction of labour and the conscription for war work of both men and women; the regulation of civilian consumption through a

¹³⁶ CCA, WEIR 21/1, Weir to Duncan, 28 August 1942.

¹³⁷ CCA, WEIR 21/2, Weir to Minister, 6 August 1942; WEIR 21/1 Usher to Weir, 8 August 1942.

¹³⁸ CCA, WEIR 21/1, Weir to Duncan, 7 August 1942.

¹³⁹ O. Lyttelton, Viscount Chandos, *The Memoirs of Lord Chandos* (London, Bodley Head, 1962), pp. 277-285; Cmd. 6337, *Office of the Minister of Production* (London, H.M.S.O., February 1942).

comprehensive rationing system; and elaborate planning mechanisms which included not only new government ministries but also the growth of regional co-ordination.¹⁴⁰

Upon comparing the operation of the previous four boards above, the fifth Tank Board was the most successful by operating 28 meetings from 16 September 1942 until 24 April 1945, with very few changes in membership give this time frame. Aside from this *prima facie* evidence and as discussed in greater detail in the following chapters, the fifth Tank Board benefited from political, strategic and industrial changes over the same period, which gave fewer occasions for the board to change as before. As described in chapter 3, by the end 1942 the tank programme was eliminating obsolete tanks for the transfer to new designs from 1943 onwards, or in the case of the Valentine tank discussed in chapter 6, reduced the level of output to meet Russian demand. The examination of tank production in chapters 4 and 5 demonstrates how industry had transformed to producing tanks of good quality, supported by the dependency upon the United States to supply large numbers of battleworthy tanks to fulfil General Staff requirements. Whilst these factors certainly contributed, the remainder of this chapter will highlight that the fundamental reasons for the success of the fifth Tank Board were intrinsically linked to the organisational changes.

To begin with, Commander Micklem returned from Vickers to act as chairman and whilst this position was full-time within the Ministry of Supply, Micklem was still available for consultation on company affairs that were not connected to his duties with the Ministry.¹⁴¹ This therefore allowed Vickers to still benefit from Micklem's experience but guarded against any risk of favouritism on tank related matters. The appointment of Micklem followed yet another, but this time more comprehensive and stronger re-organisation of the different tank departments. Micklem became the Executive Head of both the fifth Tank Board and of the new Armoured Fighting Vehicle (AFV) Division which brought together the separate departments of Research, Development and Design, of the Proving Establishment, of Supply and of Inspection.¹⁴²

¹⁴⁰ Jefferys, *Churchill coalition*, pp. 61-62; David Edgerton also highlights the importance of production discussed during 1942: D. Edgerton, *Britain's War Machine: Weapons, Resources and Experts in the Second World War* (London, Allen Lane, 2011), pp. 124-129 & 335n.

¹⁴¹ Cambridge University Library, Manuscripts Department, Vickers-Armstrongs, VICKERS 1226, Minute Book No. 5, Minutes of Meeting of Directors, '2918, Board of Directors - Commander E. R. Micklem', 30 September 1942.

¹⁴² TNA, CAB 66/28/17, War Cabinet, 'Reorganisation of the Armoured Fighting Vehicle Division of the Ministry of Supply', 28 August 1942.

In respect of the membership of the fifth Tank Board, the position of tank supply previously held by George Usher above was now taken by Archibald Boyd and Managing Director of existing tank manufacturer, Metropolitan-Cammell Carriage and Wagon Company.¹⁴³ Upon receiving a 12 months 'leave of absence' by the Directors, Boyd undertook the new position within the AFV Division and on the fifth Tank Board as Director-General of Fighting Vehicle Production.¹⁴⁴ Whilst Boyd's secondment to the AFV Division was due to finish in September 1943, Minister of Supply Duncan was reluctant to release the Managing Director and requested 'time to consider the matter in all its aspects'. This extension was brought to an end by the intervention of the chairman of Vickers Limited, which part owned Metropolitan-Cammell, whereby Duncan agreed that Boyd would return during December 1943.¹⁴⁵ The position of CGRD had ceased and Lucas remained on the board as the new Director-General of Fighting Vehicle Research, Development and Design.¹⁴⁶

Lucas remained in this position until he was assigned in September 1943 to chair the mission to the United States to correlate AFV design, development and production. Claude Gibb, who was currently the Director-General of Weapons and Instruments Production, replaced Lucas on the fifth Tank Board.¹⁴⁷ When Boyd returned to Metropolitan-Cammell as planned during December 1943, Gibb was given the all-encompassing responsibility for both the design and production branches, as Director-General Armoured Fighting Vehicles.¹⁴⁸ Graham Cunningham, as the Controller-General of Munitions Production, replaced Rootes on the board in January 1943, and brought the greater 'co-ordination of tank policy with other sections of the Ministry'.¹⁴⁹ The organisational structure of the fifth Tank Board is shown in Figure 2.5 below which was further strengthened by the appointment of the Director-General of Artillery, Major-General Clarke from June 1944.¹⁵⁰

¹⁴³ TNA, PREM 4/87/1, Lyttelton to Churchill, 22 September 1942.

¹⁴⁴ Birmingham Archives and Heritage, Birmingham Central Library, Metropolitan-Cammell Archives, MS 99/2006/024, '712. A. J. Boyd', 21 October 1942.

¹⁴⁵ BAH, MS 99/2006/024, '785. A. J. Boyd', 18 August 1943; '793. A. J. Boyd', 17 November 1943.

¹⁴⁶ TNA, AVIA 22/161, 'Organisation for the provision of Armoured Fighting Vehicles', Ministry of Supply Memo No. 527, 9 October 1942

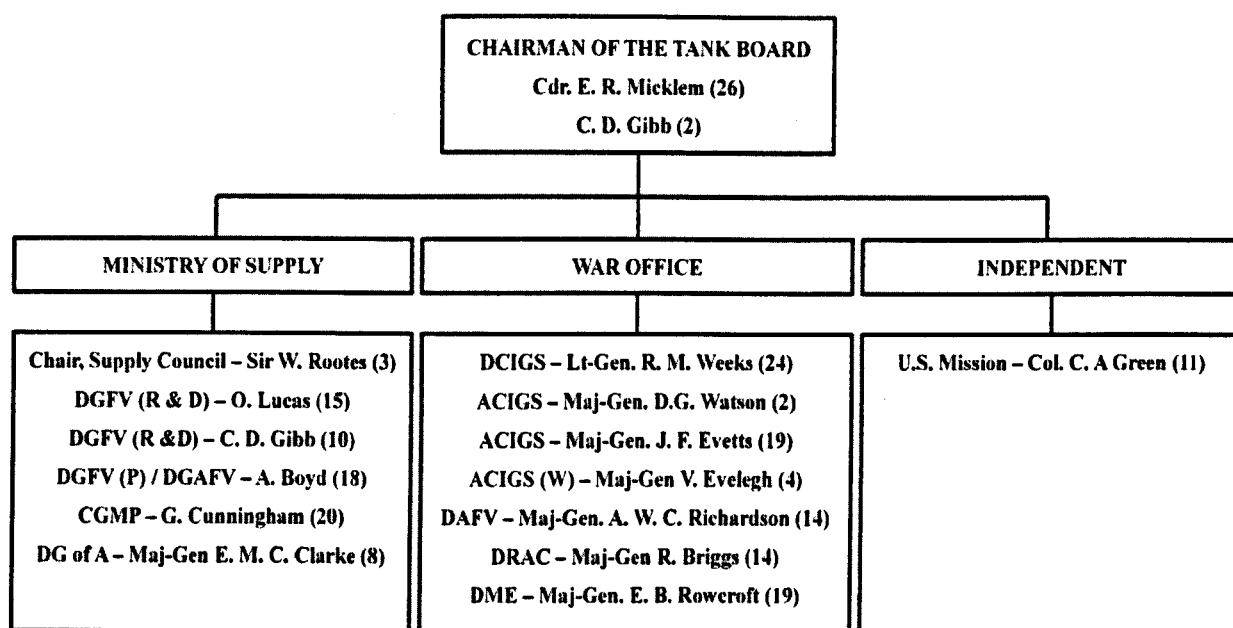
¹⁴⁷ TNA, AVIA 22/161, 'Ministry of Supply Memo No. 662', by William Douglas, 15 September 1943.

¹⁴⁸ TNA, AVIA 22/161, 'Ministry of Supply Memo No. 694', by William Douglas, 15 December 1943.

¹⁴⁹ TNA, WO 185/8, '25th Meeting of the Tank Board', 25 January 1943.

¹⁵⁰ TNA, AVIA 22/161, 'Ministry of Supply Memo No. 748', by William Douglas, 30 May 1944.

Figure 2.5 Membership of the fifth Tank Board, 16-Sep-42 to 24-Apr-45¹⁵¹



The War Office members on the board continued with Lieutenant-General Weeks as DCIGS and Major-General Watson as ACIGS until Watson was replaced by Major-General John Evetts late in 1942. From this point onwards the changes to the War Office representatives now incorporated men with recent command and combat experience. This resulted in greater understanding of the type of tanks necessary to successfully remain operationally offensive against an increasingly defensive Germany. To demonstrate, Evetts had commanded the 6th Infantry Division in North Africa during 1941 and remained as ACIGS until 1944 when he became senior military adviser to the Minister of Supply.¹⁵² Evetts was replaced by Major-General Vyvyan Evelegh who had earned his reputation as commander of the 78th Infantry Division in North Africa, Sicily and Italy and received the Distinguished Service Order for his actions during the fighting on the Sangro River in 1943. Evelegh then commanded the 6th Armoured Division from Cassino to Florence before becoming ACIGS (Weapons) in August 1944 until the last Tank Board meeting.¹⁵³ Major-General Rowcroft continued as DME as did Major-General Richardson as DAFV before being replaced on the board by Major-General Raymond Briggs as Director, Royal Armoured Corps (DRAC).¹⁵⁴ Having served in the Royal Tank Corps, in January 1936 Briggs was appointed Deputy Assistant Director of

¹⁵¹ TNA, WO 185/8, Tank Board meetings, 16 September 1942 to 24 April 1945.

¹⁵² TNA, AVIA 22/161, Schlich [Ministry of Supply] to Under-Secretary of State, War Office, 9 January 1943; S. Brooks (ed.), *Montgomery and the Eighth Army* (London, Bodley Head, 1991), p. 398.

¹⁵³ *London Gazette*, 23 March 1944; TNA, AVIA 22/161, War Office to Secretary, Ministry of Supply, 6 September 1944; obituary, *The Times*, 28 August 1958.

¹⁵⁴ TNA, AVIA 22/161, Beer [Ministry of Supply] to Under-Secretary of State, War Office, 31 August 1943.

Mechanization and then became a General Staff Officer at the War Office during October 1937.¹⁵⁵ During the war, Briggs fought in the North African campaign and rose to command the 2nd Armoured Brigade early in 1942 and then the 1st Armoured Division into 1943, after which he returned to the War Office to become DRAC until 1947.¹⁵⁶ Colonel Green remained on the board as before until 22 November 1943.¹⁵⁷

The last two recorded meetings of the fifth Tank Board, during January and April 1945 respectively, were chaired by Gibb following the resignation of Micklem for his return to Vickers. It was agreed between Duncan and Gibb that a press notice was not to be released regarding this change in chairman so matters continued unannounced.¹⁵⁸ Whilst the papers do not extend beyond the April 1945 meeting, the board continued, perhaps in name only, until 31 December 1945 when it was dissolved and succeeded by an "A" Vehicle Committee under a new chairman and membership.¹⁵⁹

The final area of government intentions and actions towards the discussion and control of tank production was carried out by an Armoured Fighting Vehicle Liaison Committee during the fifth Tank Board. This included senior members from the new AFV Division under chairman Micklem and from the War Office under DCIGS, Lieutenant-General Weeks. In total 43 meetings were carried out between 20 October 1942 and 27 April 1944 on a weekly or sometimes bi-weekly basis.¹⁶⁰ With many of the members also sitting on the executive fifth Tank Board, the Liaison Committee empowered themselves with the authority to take decisions on minor matters of tank policy, whilst putting forward recommendations to the board for discussion on the major issues. The guiding authority of what constituted a 'minor' or 'major' issue was consolidated under Micklem, so there was no confusion from within or through interference from outside. This liaison model was also designed to reduce the number of memoranda being passed between the separate officials at the War Office and the Ministry of Supply, thus creating a stronger discussion based system for decision making,

¹⁵⁵ *London Gazette*, 10 January 1936 and 22 October 1937.

¹⁵⁶ Obituary, *The Times*, 6 April 1985.

¹⁵⁷ TNA, PREM 4/87/1, 'Tank Board Composition', 23 September 1943; WO 185/8, '36th Meeting of the Tank Board', 22 November 1943.

¹⁵⁸ TNA, AVIA 22/161, 'Draft. Press Notice. Tank Board', January 1945; unidentified to Departmental Secretary, 26 January 1945.

¹⁵⁹ TNA, AVIA 22/161, Ministry of Supply and Ministry of Aircraft Production, Memo No. 7, 'I. Tank Board', December 1945.

¹⁶⁰ TNA, WO 185/7, Armoured Fighting Vehicles Liaison Committee meetings, 1942-1944.

supported by a mutually agreed set of minutes.¹⁶¹ The fifth Tank Board confirmed these self-imposed terms of reference and maintained overall authority, whereby the Liaison Committee's minutes were subjected to a critical review by the board for overruling or adoption.¹⁶² The distinctiveness between the function of the Liaison Committee and that of the fifth Tank Board avoided any serious duplication of discussion and instead provided for a system that kept senior members up to date and promoted prompt decision making.

In conclusion, the centralised control of British tank design and production fluctuated during the course of the war as a result of the changes in direction brought about by each new Minister of Supply. Whilst the War Cabinet and Churchill in particular provided the medium and long-term strategic considerations for the tank programme at the macro-level, greater accountability can be properly attributed to the actions of each Minister of Supply at the micro-level. This resulted in the pendulum of priorities swinging between meeting the requirements of the War Office or the Ministry of Supply. These two departments were rarely compatible with the War Office concerned about the volume and condition of tanks for the troops, whilst the Ministry had to balance this demand against government munitions policy generally and changes to industrial capacity, materials and labour.

To begin with, the first Minister of Supply, Leslie Burgin, formed the Special Vehicle Development Committee at the outbreak of war to meet the General Staff requirement of providing an assault tank to engage the German Siegfried Line, with the expectation of trench warfare again. A small number of pilots were built in accordance with continuing instructions and once production orders had not materialised by November 1941, all further work on the TOG tanks by the SVDC or individually by Sir Albert Stern should have ceased. Instead the Ministry of Supply, under both Beaverbrook and Duncan, permitted further TOG development over the next 17 months instead of passing these experimental models to Oliver Lucas as the authority on tank research and development to decide upon any additional work. When put into context, the SVDC had a very minor role in respect of the British tank programme and should not be overestimated, especially when compared to the production of Infantry and Cruiser tanks examined in the next chapter. As discussed in chapter 4, the General Staff maintained a demand for an assault tank from 1943 with the Tortoise, and similar to the TOG tanks above, these vehicles did not progress further than the pilot stage.

¹⁶¹ TNA, WO 185/7, 'A.F.V. Liaison Meeting, Minutes of first meeting', 20-21 October 1942.

¹⁶² TNA, WO 185/8, '20th Meeting of the Tank Board', 26 October 1942.

The origins and increasing support for the first Tank Board came from individual Members of Parliament and people like Stern, as much as it did from within government before the 1940 German offensive. The desire to introduce a Tank Board was therefore not a spontaneous reaction to German advances on the battlefield, but instead in response to the perceived failures of the Chamberlain government to manage the existing tank programme. This was demonstrated by the intended role of the Tank Board chairman fluctuating between having some underlying political purpose to actually fulfilling a practical function, albeit in an advisory capacity. Whilst the change in government in May 1940 did not alter the authority or function of the board, the emphasis upon including members from industry remained.

With the formation of the first Tank Board, this chapter has demonstrated the progression of Ministry of Supply and War Office representation on each subsequent board, as illustrated by a comparison of membership between Figures 2.1 and 2.5. Whilst these changes caused some disruption as new members were introduced, it is unrealistic to expect an inter-departmental organisation not to change in composition from its creation in June 1940 until April 1945. Furthermore, there was always the likelihood of military promotion, the transfer of members to 'Missions' overseas, and that firms understandably wanted the return of their directors. These successive changes in board membership actually strengthened the overall capabilities of the board, by incorporating more representatives of executive authority from both the Ministry of Supply and War Office. In respect of the Tank Parliament, this provided the attendees with a greater understanding of the issues faced by each other, and despite Martel's obstructiveness, the meetings made everyone aware of the potential solutions.

The transformation of the Ministry of Supply from the pre-war organisation to the necessities of wartime was initially highly contentious and contradictory. Emphasis was placed upon not offending the existing military personnel within the Ministry, whilst simultaneously transferring greater control from the military to industrial leaders. The changes in membership from the Ministry transformed the policy of using industrialists as independent advisers to becoming executive Director-Generals within the tank programme. This decision culminated in Commander Micklem becoming the Executive Head of the all-encompassing Armoured Fighting Vehicle Division, including chairman of the fifth Tank Board. The change in War Office representation went from a purely 'focal point' to incorporating senior members of the General Staff to provide direction and make decisions based upon their recent command and battle experience. This was later widened to include the Directors of the Royal

Armoured Corps and of Mechanical Equipment respectively, together with the vital liaison on tank production efforts from the United States following the introduction of Lend-Lease.

The fourth Tank Board under Lord Weir was the exception to the rule of progress in relation to the role of the chairman, and was created by Duncan out of his friendship with Weir. The board under Weir during the middle of the war resulted in a seven month interruption of an executive chairman between the end of the third and the beginning of the fifth Tank Board. An executive chairman was necessary to make decisions having considered the different pressures and priorities of the Ministry of Supply and War Office. Furthermore, it was no coincidence that the fifth Tank Board was the most effective and continued the longest, as the Minister of Supply and as such the board's terms of reference did not change.

Whilst the membership generally grew in strength and authority, one area of inconsistency brought about by the changes in terms of reference was the relationship that the various Tank Boards had with the War Office. This position alternated between specifically meeting the demands of the General Staff on the one hand, to that of only an implied statement of supporting the 'user' by increasing tank output or improving quality. The actual effects of this fluctuating responsibility will be examined in the following chapters, when the decisions of the different Tank Boards are placed in the context of actual production efforts.

During the course of the war, the various changes by each new Minister of Supply resulted in an accumulative 192 days of lost discussion time in between each consecutive board. When compared against the overall period of four years and ten months between June 1940 and April 1945, this represented a loss of 11 per cent during which a Tank Board did not operate at all. In respect of executive decision making, 16 per cent of the time when a Tank Board was actually constituted was spent as an advisory body or with a non-executive chairman.

Finally, the efforts of the different Tank Boards and changing membership culminated with the creation of the Armoured Fighting Vehicle Liaison Committee under the executive control of the fifth Tank Board. This demonstrated the level of importance that the members considered the issues of tank design and production with their regular and complementary meetings. In this way, the General Staff under DCIGS Weeks for the 'user' and the AFV Division under Micklem for the 'supplier', jointly made the best decisions in respect of executing the tank programme during the second half of the war.

Chapter 3

Tank Production, 1939 to 1942

Having examined how the wartime government centralised the control of the tank programme in the previous chapter, this chapter will review decisions taken by the five Tank Boards against the military, industrial and strategic influences that affected tank production during the first half of the war. The tank programme during 1939 maintained the policy of quantity production in respect of the Light Mark VI B tank, whilst continuing to introduce new tanks of the Infantry and Cruiser types as discussed during chapter 1. With the substantial losses of equipment and threat of imminent invasion following the defeat of France, the British tank programme was given an understandable greater emphasis that demanded a general policy of quantity production from industry. As highlighted in chapter 2, the plan to re-equip and expand Britain's armoured formations after June 1940 was in accordance with the overall decision by the Cabinet Defence Committee, to provide the army with the maximum number of weapons of all types at the expense of quality.

During November 1940, Prime Minister Churchill confirmed the continuing relevance of quantity output when he stated: "At this stage in tank production numbers count above everything else. It is better to have any serviceable tank than none at all".¹ Whilst taking into account that this decision would deliberately affect the quality of the tanks under production, the success of this strategy is demonstrated by the annual production figures in Appendix 1. To sum up, overall tank output increased by over six times during this period from 1,379 in 1940 to 4,837 in 1941, and then to a wartime peak of 8,622 in 1942.

In order to give these headline figures and general commentary greater context, this chapter will highlight and examine the five stages that constitute the tank production life span. The first stage will review General Staff requirements for new Cruiser and Infantry tanks, resulting in orders with the 15 firms by June 1940. The priority system for all three services will be discussed to emphasise the dominant position of aircraft and anti-aircraft production. The continuation of air raid precautions and factory dispersal will be examined for the different methods, costs and government reimbursement, together with the expansion of industrial capacity to meet the growing demand for increased tank output.

¹ Quoted from M. M. Postan, D. Hay & J. D. Scott, *Design and Development of Weapons: Studies in Government and Industrial Organisation* (London, H.M.S.O., 1964), p. 322.

The second stage of the production life span will review the difficulties encountered when constructing a new factory and how these delayed the start of Covenanter production at Leyland Motors. The third stage will continue with the review of industry by examining the effects that labour shortages, the expansion of dilution, female conscription, and the transfer of labour between firms had upon the factories. The effect that an on-going shortage of tank components had upon monthly output will be studied in relation to Churchill production.

The fourth stage will consider the situation once the tank had been delivered to highlight the issues of poor workmanship and inspection in relation to the Crusader tank. The growth of official inspectors at the Tank Department will be compared against the expansion of the tank design section, and the shortage of tank spares from 1941 to 1943 will be reviewed to highlight the number of tanks that were deemed 'unfit for action'. The fifth and final stage examines how continuation orders for unwanted tanks were necessary to avoid inactive production and that the cancellation of an obsolete tank might delay the introduction of the new design from entering mass production.

The first stage of the production life span began by the General Staff specifying the requirements for Light, Infantry and Cruiser tanks as a proportion of the tank programme. The parity that the General Staff sought between Infantry and Cruiser tanks during June 1939 was replaced in December, with two-thirds of the tank programme favouring the Infantry tank.² Near equality was sought again in August 1940 by the General Staff before changing the tank programme that December, and in a reversal of the year before, to require 70 per cent Cruiser tanks, 21 per cent Infantry tanks, with Light tanks the remainder. As the requirement for Light tanks diminished to negligible levels by June 1941, the percentage of Infantry tanks desired by the General Staff increased to 30 per cent, with Cruiser tanks remaining the preferred type at 69 per cent.³ When comparing these demands against the actual production in Appendix 1, only the small number of Light tanks met the desired outcome. The output of tanks during 1941 was still meeting the requirement of December 1939, with Infantry tanks at 69 per cent and Cruiser tanks at 29 per cent. Despite a modest improvement during 1942 of 61 and 39 per cent respectively, this was still well short of the desired greater production of Cruiser tanks.

² The National Archives, Kew, AVIA 46/188, 'W.O. Requirements 1936 - 1940', draft official history narrative by D. Hay, after 1950, p. 44.

³ TNA, WO 185/8, 'Third Meeting of the Tank Board (Reconstituted)', 9 September 1941.

To justify these fluctuating requirements, the Assistant Chief of the Imperial General Staff, Major-General Macready, explained to the executive third Tank Board, that the 'change of policy was dictated by the rapid change from the expected warfare of fixed positions in Europe to a state of mobile warfare in the Middle East'. Whilst the War Office could alter their requirements to meet the changes in combat tactics and fighting environment, the Tank Board chairman Geoffrey Burton confirmed that 'the Ministry's programme could only be changed very slowly'. This was noted by attendees Minister of Supply Lord Beaverbrook and Secretary of State for War David Margesson, which prompted the Minister to state that 'he was compelled to say that the 1942 programme must stand'. As a result, production of the problematic Covenanter tank was permitted to continue until October 1942, with the Matilda tank expecting to complete as late as February 1943.⁴ However due to the production difficulties highlighted below, the Covenanter did not complete until January 1943 with Matilda output extending until August, thereby delaying the introduction of the later Cruiser tanks designed to replace them.⁵

The fighting in France during May 1940 provided the General Staff with combat experience on which to prioritise their required tank characteristics. These 'user' demands were summarised by the Director of Armoured Fighting Vehicles, Major-General Pope during the opening meeting of the advisory first Tank Board as: '(1) Heavier armouring; (2) a good gun; and (3) absolute reliability'. Furthermore, Pope 'would sacrifice speed to some extent' in order to obtain the demands upon armour and reliability.⁶ As highlighted in the previous chapter, Pope based these priorities upon the recent experience he gained in France whilst serving on Lord Gort's staff, including the planning of the British counter-attack at Arras. The method in which these requirements reached the Tank Board in the form of a new tank design was not agreed until March 1941 under the procedure:

- (i) The preparation by the General Staff of an operational specification followed by
- (ii) preparatory discussions between the General Staff and technical officers of the Ministry of Supply and the production of a full General Staff specification.
- (iii) Consideration of this specification by the Tank Board.⁷

⁴ Ibid.

⁵ TNA, CAB 120/355, 'A.F.V. Production', 3 February 1943 and 26 August 1943.

⁶ TNA, WO 185/8, 'First Meeting of the Tank Board', 24 June 1940.

⁷ TNA, WO 185/8, '12th Meeting of the Tank Board', 14 March 1941.

These requirements were developed further during August 1942 when the General Staff provided the fourth Tank Board, under the non-executive chair of Lord Weir, with the desired priority of tank 'qualities'. This in effect reversed the three characteristics identified by Pope in June 1940: 1) Reliability; 2) Armament; 3) Speed; 4) Radius of action and 5) Armour.⁸

The continued high priority status for armament has been disputed by Brigadier Macleod Ross, who has argued that the General Staff continued to support the two-pounder gun in later tanks, despite the availability of the six-pounder gun.⁹ On the other hand, John Buckley points out that the General Staff wanted the six-pounder during 1940 and 1941, but the prospect of losing 600 two-pounders to gain only 100 six-pounders was clearly unacceptable when quantity output was required. Buckley balances the argument by highlighting that this decision did result in hindering the development of British tanks with greater firepower, and contributed towards the tank 'armament shortfall' during the Normandy campaign in 1944.¹⁰

The distribution of orders to meet General Staff requirements for Cruiser and Infantry tanks from January 1938 until June 1940 is shown in Figure 3.1, incorporating 15 manufacturers, with five undertaking orders for both types. These orders totalled 5,498 tanks, with 3,350 or 61 per cent meeting the increased demand for Infantry tanks following the General Staff requirement from December 1939, with Cruiser tanks representing 2,148 or 39 per cent. The total number of tanks requested from industry also included a number of continuation orders as an immediate response to the sudden loss of equipment on the Continent during the recent German offensive and the evacuations from France. For example, the Valentine order with Vickers-Armstrongs increased by a further 300 tanks on 29 May 1940, from the original order of 275 tanks placed on 6 May 1939.¹¹ Similarly, Birmingham Railway Carriage and Wagon Company received a new order for 300 tanks on 12 June 1940 to add to their original order of 225 tanks, placed on 29 June 1939.¹²

⁸ TNA, WO 185/8, '18th Meeting of the Tank Board', 4 August 1942.

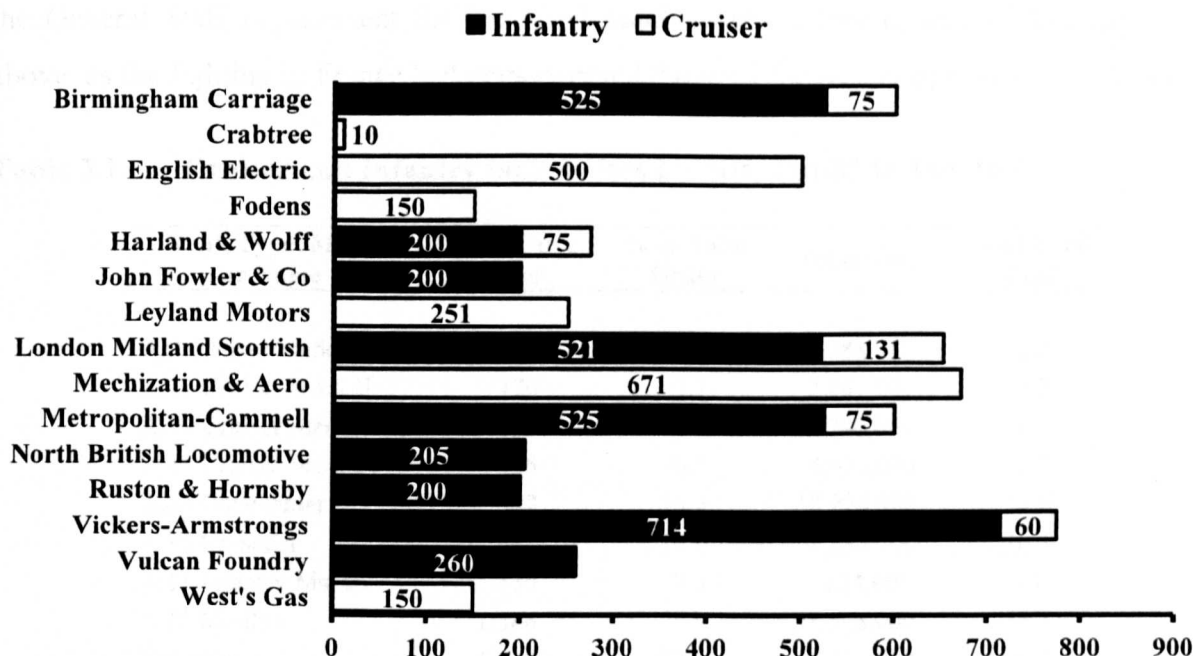
⁹ G. Macleod Ross, *The Business of Tanks, 1933 to 1945*, in collaboration with Major-General Sir Campbell Clarke (Ilfracombe, Arthur H. Stockwell, 1976), pp. 40 & 138-139.

¹⁰ J. Buckley, *British Armour in the Normandy Campaign 1944* (London and New York, Frank Cass, 2006), pp. 144 & 245n.

¹¹ Cambridge University Library, Manuscripts Department, Vickers-Armstrongs, VICKERS 744, 'Armoured Fighting Vehicles 1937 to 1959', 7 September 1959.

¹² Staffordshire Record Office, Stafford, Birmingham Railway Carriage and Wagon Company, D831/4/2/16, 'Order book for new work, 1939-1940', pp. 5 & 136.

Figure 3.1 Total Cruiser and Infantry tank orders by firms, Jan-38 to Jun-40¹³



These continuation orders were placed without the benefit of any operational experience, as the first deliveries of the Valentine tank did not commence until June 1940 from Vickers and in August from both Birmingham Railway and Metropolitan-Cammell.¹⁴ On the other hand, continuation orders for the Matilda tank were made in the knowledge of recent battlefield experience. The Director of Mechanization, Major-General Alexander Davidson, was keen to emphasise this connection when he contacted Vulcan Foundry in June 1940:

We have by now had some conversations with officers who handled the A.12 tanks during the recent fighting in Flanders. You will be glad to hear that these tanks proved themselves of first-class value as fighting machines and the confidence that we have in their value is shown by the fact that further orders are being placed.¹⁵

This optimistic opinion was later tempered during the opening meeting of the advisory first Tank Board, when Major-General Pope reported on the overall experience of British tanks in France as highlighted above. In respect of the Matilda, the standard of armour was considered satisfactory and the two-pounder gun 'had put out of action any type opposed to it'. The tank was however found to be unreliable as it had been 'driven for long distances by

¹³ TNA, WO 194/57, Sixth and Final Report of the Mechanization Board, 1939 to 1940, Para. 18; AVIA 46/188, 'First Contracts and First Deliveries', p. 67.

¹⁴ TNA, AVIA 46/188, 'Monthly Deliveries on Infantry and Cruiser Tanks by Firms, 1939-1943', p. 269.

¹⁵ Bodleian Library, Department of Special Collections and Western Manuscripts, Oxford, Vulcan Foundry, MS. Marconi 2739, Board minutes, 1934-40, 'A.12 Tanks', 11 June 1940.

road before coming into action, a use for which it had not been designed'.¹⁶ This reaffirmed the General Staff requirement for increased numbers of Cruiser instead of Infantry tanks above, as the fighting in France had demonstrated the need for greater operational mobility.

Table 3.1 Cruiser and Infantry tank orders by cost, Jan-38 to Jun-40¹⁷

Tank Type, Mark or Name	Total Tank Order	% of Total Order	Total Cost £	% of Total Cost
A.9 Cruiser Mark I	125	2.3	1,588,750	2.0
A.10 Cruiser Mark II	170	3.1	2,201,500	2.7
A.13 Cruiser Mark III	65	1.2	780,000	1.0
A.13 Cruiser Mark IV	335	6.1	4,623,000	5.7
A.13 Covenanter	852	15.5	10,224,000	12.6
A.15 Crusader	601	10.9	8,233,700	10.1
A.11 Infantry Mark I	139	2.5	834,000	1.0
A.12 Matilda	1,586	28.8	28,548,000	35.1
Valentine	1,625	29.6	24,212,500	29.8
Total Cruiser Order	2,148	39.1%	£ 27,650,950	34.0%
Total Infantry Order	3,350	60.9%	£ 53,594,500	66.0%
Total Order	5,498	100.0%	£ 81,245,450	100.0%

The cost of the Cruiser and Infantry tank programmes in Britain from 1938 until June 1940 amounted to over £81 million as displayed by Table 3.1. This demonstrates the greater emphasis on the new and expectant Valentine, Covenanter and Crusader programmes, whilst continuing to support the existing and well established Matilda tank. The higher basic cost price of the Matilda and Valentine meant that whilst Infantry tanks represented 61 per cent of the total order, and just short of the General Staff requirement for December 1939 above, they accounted for 66 per cent of the total cost. The basic cost price for each tank is identified in Table 3.2 below, together with the reduction from March 1941 following a change in the pricing structure adopted by the contracts branch of the Ministry of Supply. Whilst these changes demonstrate that there was no uniform reduction by percentage across the different tanks, the first four obsolete Cruiser marks were reduced to a flat £7,500 each, as production had already or would very shortly end. With regard to those tanks where production expanded after March 1941 and continued into 1943, the fall in prices displayed an average reduction of nearly 40%. With regards to the amount of profit on work completed during 1943, Birmingham Railway negotiated a rate of 4.75 per cent with the Ministry of

¹⁶ TNA, WO 185/8, 'First Meeting of the Tank Board', 24 June 1940.

¹⁷ TNA, WO 194/57, Sixth Report, para. 18; AVIA 46/188, 'Orders placed by June 1940: by Industrial Group', p. 59.

Supply during November for all work done during that year, rather than being based upon a 'cost plus' a fixed percentage at the beginning of the contract.¹⁸

Table 3.2 Comparison of basic cost price of tanks pre and post-March 1941¹⁹

Tank Designation	Basic Cost Price to March 1941	Basic Cost Price from March 1941	Percentage Reduction
	£	£	%
A.9 Cruiser Mark I	12,710	7,500	40.99 a
A.10 Cruiser Mark II	12,950	7,500	42.08 a
A.13 Cruiser Mark III	12,000	7,500	37.50 a
A.13 Cruiser Mark IV	13,800	7,500	45.65 a
A.13 Covenanter	12,000	6,840	43.00 b
A.15 Crusader	13,700	8,500	37.96 b
A.27 Centaur / Cromwell	-	10,000	- d
A.11 Infantry Mark I	6,000	5,000	16.67 a
A.12 Matilda	18,000	11,180	37.89 b
Valentine	14,900	8,710	41.54 b
A.22 Churchill	-	11,150	- c

- Key:**
- a Production ended or shortly to complete after March 1941.
 - b Production expanded after March 1941 and continued into 1943.
 - c Production commenced June 1941.
 - d Production commenced December 1942.

In addition to placing tank orders in Britain and before the German offensive in May 1940, the Ministry of Supply sought to enlarge the British tank programme by incorporating the production of the Valentine tank in Canada. This section will review the initial discussions that were designed to benefit the British war effort, with chapter 6 examining how Canadian Valentine tanks were ultimately supplied to Russia. The first attempt to instigate Valentine production in Canada was in October 1939, when the British Purchasing Commission in Ottawa ordered 100 hulls from the Angus Shops of the Canadian Pacific Railway Company in Montreal.²⁰ By December 1939 the Ministry of Supply suggested the production in Canada of up to 200 complete Valentine tanks, together with a similar output to equip the Canadian Army Tank Battalions being offered to Britain, which could not otherwise be

¹⁸ SRO, D831/1/6/2/M, Minutes of directors' minutes, 1943-44, '6236: Ministry of Supply Rate of Profit', 23 November 1943.

¹⁹ TNA, AVIA 46/188, 'Note on cost as an index of tank production', p. 284

²⁰ Historical Section, Army Headquarters, Report No. 38, 'Tank Production in Canada', 27 July 1950, pp. 1-2, found in National Defence and the Canadian Forces at <http://www.forces.gc.ca/site/home-accueil-eng.asp>, accessed 30 September 2010; the British Purchasing Commission is discussed later in chapter 5.

supplied from British production.²¹ At the beginning of 1940 the Ministry of Supply offered the necessary drawings for the jigs and fixtures to support this programme.²²

The Canadian Valentine programme was halted during March 1940 when the Director of Mechanization Brigadier Crawford and the Canadian Purchasing Board, agreed to consider production of the Infantry Mark IV tank instead, based on the A.20 prototype at Harland & Wolff. The seriousness of this suggestion was confirmed by the offer of drawings, that the Purchasing Board should inspect the mock-up tank at Woolwich, and that engineers from Canada should 'come over immediately' to view the prototype under production in Belfast.²³ Based upon the available evidence in all likelihood these site visits did not take place, although the drawings were provided and the Canadian Purchasing Board confirmed during April that production of Mark IV components in Canada was practicable.²⁴ Many of the features on the A.20 prototype were retained by the draughtsmen of Vauxhall Motors and the Mechanization Board for the design of the Churchill tank.²⁵ Given the overall similarities, the decisions relating to the possibility of producing the Mark IV tank in Canada based upon the Harland & Wolff A.20 prototype, can also extend to the Churchill production tank.

With regards to British opinion, Crawford stated on 22 May that Canadian firms could produce Mark IV components such as engines, gear boxes, suspensions, tracks and gun mountings, for the assembly of complete tanks in Canada before shipment to Britain. Additionally, Canadian firms could also supply the same components for the assembly of the Mark IV in Britain, with the advantage of saving the amount of shipping required for sending these components instead of complete vehicles.²⁶ As a result of the deteriorating military situation in France during May and early June 1940, the programme to produce the Mark IV tank and components in Canada, and potentially for the Churchill tank later, was suspended and replaced by an order for 300 Valentine tanks. The General Staff made this decision because the 'satisfactory performance' of the first production Valentine from Vickers during June highlighted above, met the requirements for 'rapid production' now being demanded

²¹ Library and Archives Canada, Ottawa, RG 24, volume 9377, file 38/TANKS/1, Canadian Military Headquarters, London to Department of National Defence, Ottawa, 20 December 1939.

²² LAC, 38/TANKS/1, CMH to DND, 6 January 1940.

²³ LAC, 38/TANKS/1, 'Record of a meeting held at the Ministry of Supply', 21 March 1940.

²⁴ LAC, 38/TANKS/1, CMH to DND, 5 April 1940.

²⁵ P. Chamberlain and C. Ellis, *British and American Tanks of World War Two: The complete illustrated history of British, American and Commonwealth tanks, 1939-1945* (Leicestershire, Silverdale Books, 2004), pp. 66-67.

²⁶ LAC, 38/TANKS/1, Crawford to British Supply Board, Ottawa, 22 May 1940.

from industry following the loss of equipment on the Continent.²⁷ This demand for quantity production following the events in Europe was repeated in Canada, with the Minister for National Defence authorising the production of 488 Valentine tanks in order to equip a Canadian army tank brigade.²⁸

To demonstrate where in the United Kingdom tanks were assembled, Figure 3.2 below displays the regional location of 27 tank firms that now included the introduction of Churchill production and the expansion of the Crusader programme examined below. Overall, the geographical distribution of these tank firms supported the greater capacity for manufacturing in the northern Home Counties, the Midlands, and in the north of England where London Midland Scottish carried out tank assembly in both regions. With the exception of Vickers, the firms represented a wide range of civilian work, including private, commercial and agricultural vehicles, railway carriages and locomotives, ship building and specific engineering firms.

Whilst there may have been political reasons behind the locations of particular tank orders, this was not necessarily the case during the period of rearmament and first months of war. Richard Croucher highlights that North British Locomotive received their tank contracts during the late 1930s when the Clydeside region had high unemployment and presumably the labour capacity.²⁹ Similarly, the decision to give Harland & Wolff the A.20 prototype during November 1939 was because this firm had the required amount of unused machinery, and therefore was not due to political reasons to provide the Belfast area with tank work.³⁰

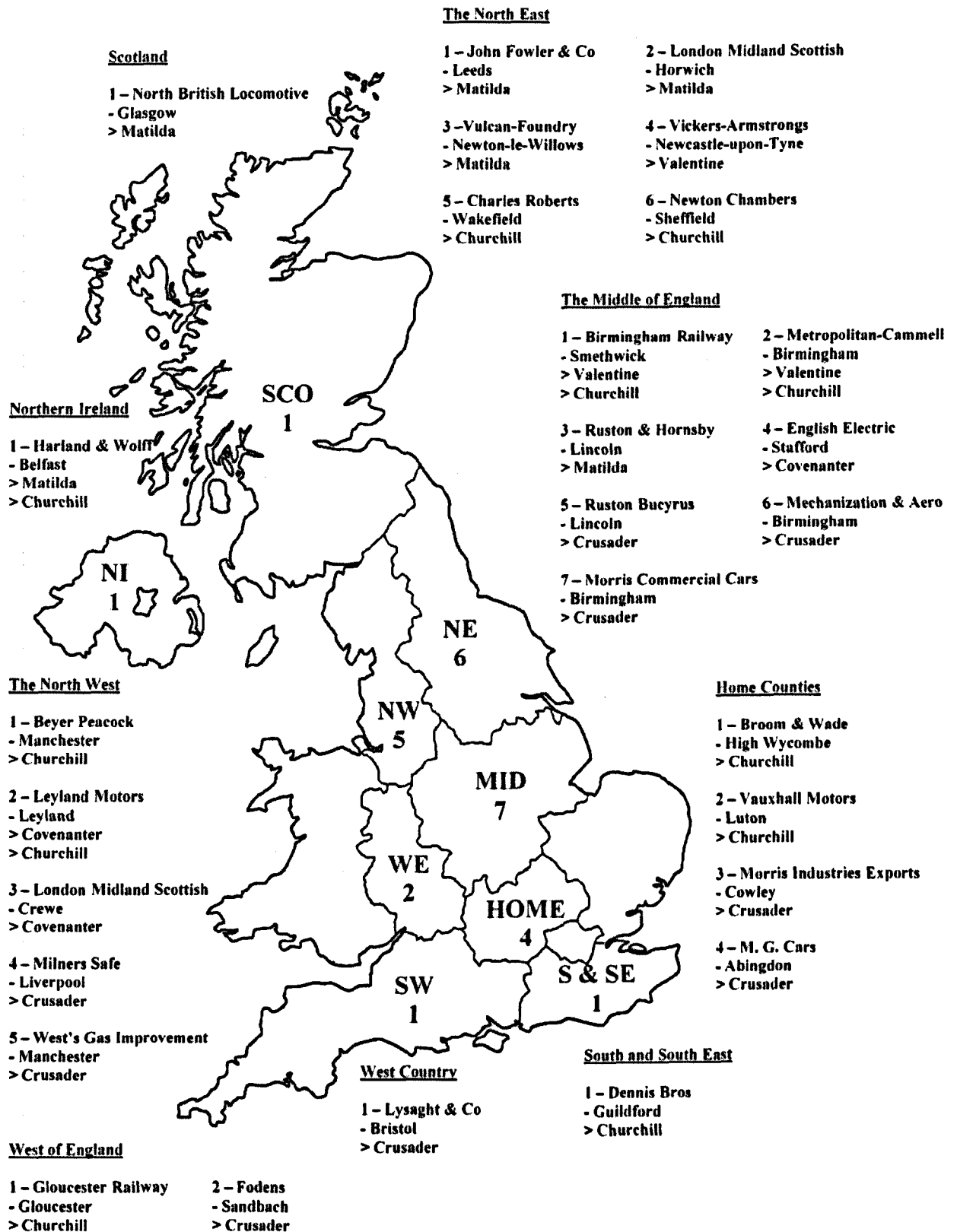
²⁷ LAC, 38/TANKS/1, W. A. Robinson, Secretary of the Ministry of Supply to Lt. Col. J. H. M. Greenly, British Purchasing Commission, Ottawa, 7 June 1940.

²⁸ Historical Section, 'Tank Production in Canada', 27 July 1950, pp. 1-2.

²⁹ R. Croucher, 'Communist Politics and Shop Stewards in Engineering, 1935-46' (PhD thesis, University of Warwick, 1977), pp. 306-307.

³⁰ M. M. Postan, D. Hay and J. D. Scott, *Design and Development of Weapons: Studies in Government and Industrial Organisation* (London, H.M.S.O., 1964), p. 319.

Figure 3.2 Location of 27 assembly firms at April 1941 for the latest Infantry and Cruiser tank programmes³¹

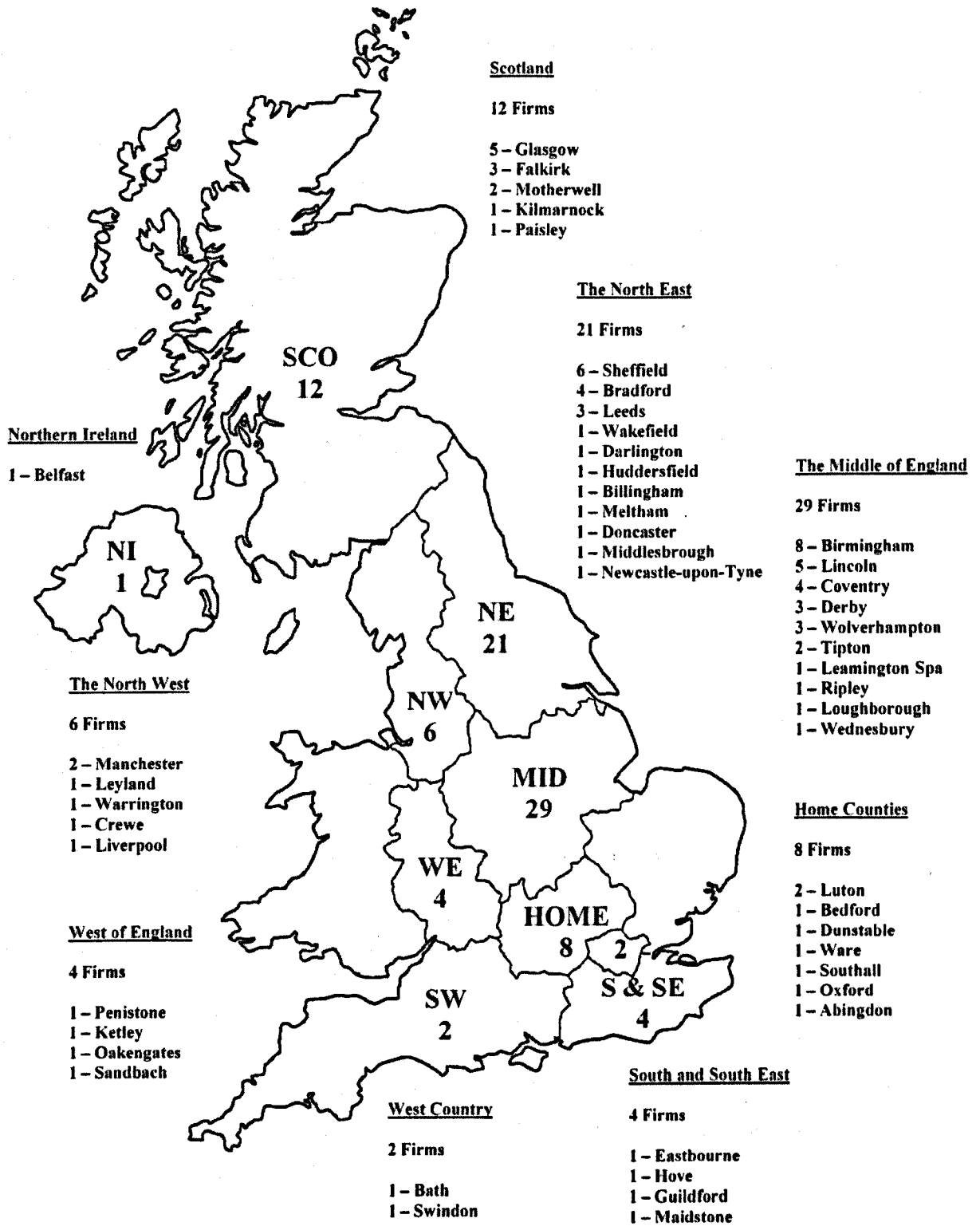


³¹ TNA, AVIA 22/454, 'Major Tank and Tank Component Contractors', 11 April 1941; Map outline taken from http://english.freemap.jp/europe_e/uk.html, accessed 1 February 2011.

The total output for each tank model by each manufacturer identified on the map is provided in Appendix 3 for the first half of the war. This shows that six firms were added to the existing Crusader programme and seven firms added to the new Churchill programme, that were without prior tank production experience as part of the policy to expand industrial capacity examined later. The Parent for each tank model is also outlined and was not always the firm with the highest output, but as highlighted below, was the firm with the greater administrative and design capacity.

To demonstrate the diversification of industry in supporting the material requirements of the tank programme, Figure 3.3 below provides the geographical distribution of the component manufacturers for the latest tanks under production or design as at April 1941. With the exception of an increased involvement in Scotland, the regional division of these orders was similar to that examined above for tank assembly, with particular importance given to the Midlands and the North East. The identification of these 89 contractors is provided in Appendix 4, which highlights the particular tank component supplied to each tank model by each firm. Upon reviewing the table some firms supplied the same component to more than one tank programme, such as with the tracks for the Covenanter and Crusader tanks. Parent firms Mechanization & Aero and Vauxhall Motors, supplied a number of different components to the tank programme that they were co-ordinating, thereby making them jointly responsible for organising and providing many of the material requirements. A number of contractors have been duplicated as they supplied different components to different tank programmes from the same location, such as with Harland & Wolff, Self-Changing Gear, Leyland Motors, AEC, F. H. Lloyd, and Henry Meadows. A further duplication is found with London Midland Scottish and David Brown who also supplied different components to different tank programmes, but this time from different locations.

Figure 3.3 89 main component contractors for Covenanter, Crusader, Matilda, Valentine and Churchill programmes, divided by region and location³²



³² TNA, AVIA 22/454, 'Major Tank', 11 April 1941; Map: http://english.freemap.jp/europe_e/uk.html, accessed 1 February 2011.

The combination of these overlapping commitments by each firm is displayed in Table 3.3 for the number of different contracts for each component for each tank programme. Whilst some of the information is incomplete with the omission of Infantry tank turrets and in some cases for smoke mortar mountings and machining bullet proof plate, the table can still show the varying supply requirements for the assembly of each tank. For example, engines and gear boxes for all tank programmes were supplied from only a few firms, whereas the Matilda was dependent upon more sources to supply steering and final drive units. The Matilda and the Valentine programmes had the least number of separate track contracts when compared to the other tanks which were supplied from 11 to 14 firms. The Valentine programme was also the least dependent upon the different supply of armour plate, castings and bullet proof plate and had the smallest number of component firms overall.

Table 3.3 Total number of firms supplying components for the latest tank designs

	Covenanter	Crusader	Matilda	Valentine	Churchill
Engines	2	2	1	1	2
Gear Boxes	2	2	3	1	2
Steering Unit and Final Drive	4	2	7	4	4
Suspension	2	5	-	1	2
Power Traverse	1	1	1	1	1
Turrets	4	6	-	-	-
Tracks	12	14	2	1	11
Armour, Castings, Bullet Proof	7	8	10	3	6
Gun Mountings	2	7	2	5	4
Smoke Mortar Mountings	4	6	-	3	-
Machining Bullet Proof Plate	3	-	-	-	-
	43	53	26	20	32

Having raised these orders to meet General Staff requirements, the progress and eventual completion of each tank contract still had to compete against the demand for other munitions in respect of resources and the production priority within firms. In response to the increasing German threat to Western Europe following the invasion and occupation of Norway and Denmark, the Chiefs of Staff Committee reviewed the 'strategical situation' in a report dated 4 May 1940 that recommended:

- (a) That every possible step, should be taken to hasten the production of anti-aircraft equipment, particularly Bofors guns, bomber and fighter aircraft and fully trained crews, even at the temporary expense of our long-term programme.³³

³³ TNA, CAB 66/7/25, War Cabinet, 'Review of the strategical situation on the assumption that Germany has decided to seek a decision in 1940', 4 May 1940.

With the fighting now in France and Flanders, this recommendation clearly formed the basis of the 'Priority of Production Directive' on 31 May that provided production firms with the order in which their efforts should be directed for each of the services. This gave top or 1 (a) priority to: fighter, bomber or trainer aircraft; instruments or equipment for such aircraft; anti-aircraft equipment; small arms and small arm ammunition; and bombs. The next level of priority or 1 (b) included: anti-tank weapons; field artillery; tanks; machine guns; and relevant ammunition. Furthermore and given the on-going evacuations from France, other vital weapons or ammunition which could be completed by 1 September 1940 or Admiralty requirements by 1 May 1941, received priority except when this interfered with those items mentioned above.³⁴ As examined in chapter 1, this priority situation reflected the strategic reality of Britain during the early stages of the war, with air defence and attack receiving priority over land weapons and the navy.

The official history contends that despite being necessary, such a strict priority system made the long-term planning for an 'orderly and flexible progress of war production' practically impossible.³⁵ The more immediate concern highlighted by AEC during July 1940, was that the shortage in the supply of materials meant that the firm could not run one night-shift per week, against the planned 24-hour shift work, seven days a week. This meant that despite the majority of AEC contracts being classified as 1 (a), the new priority system would take time before producing an increased output.³⁶

The consequences upon aircraft production of elevating the production of tanks to 1 (a) was considered in July 1940 by the Production Council, following the request of Churchill and the supply Defence Committee. This highlighted that a conflict in respect of labour was not anticipated, but problems would arise with regard to the availability of alloy steel and drop forging capacity. Given the 'great importance' that Churchill had placed upon expanding the tank programme, the council 'agreed in principle' to raising tank production to 1 (a) priority, although 'no amending Direction' was issued as a result. The delay was to permit the Ministry of Supply to make the necessary preparations and to allow expert officers to discuss the impact upon the other service programmes of giving tank production a higher priority.³⁷

³⁴ TNA, AVIA 22/2642, 'Priority of Production', 14 June 1940.

³⁵ W. K. Hancock and M. M. Gowing, *British War Economy* (London, H.M.S.O., 1949), p. 283.

³⁶ Modern Records Centre, Warwick, Associated Equipment Company, MSS.226/AE/1/1/12, Minutes of Board and General Meetings, 1935-1960, '5605. Works Manager's Report', 1 July 1940.

³⁷ TNA, CAB 21/1544, 'Meeting of the Production Council', 25 July 1940.

This discussion occurred at the end of July and considered that a four-fold increase in tank production would have little effect upon general industry, as the firms employed on tank assembly, engine and gun production were different. It was thought that skilled labour within tank firms could expand upon their existing establishments without affecting other labour demands. The existing general shortage of machine tools in Britain meant that the transfer of tank production to 1 (a) was considered immaterial. The problem of shortages in alloy steel was reiterated, although the capacity for rolling armoured plate was deemed adequate following the reduction of the capital ship programme for the Royal Navy. The main concern was the impact upon the drop stamping capacity and that a greater priority for tank production would adversely affect both the aircraft and anti-aircraft programmes.³⁸

The prospect of weakening Britain's air defence whilst the Battle of Britain was being fought simultaneously overhead was clearly unacceptable and hence unlikely. Furthermore, winning this battle would forestall the threat of invasion and thus no longer require Priority 1 (b) equipment to be used on British soil. Churchill confirmed this overriding position to the Minister of Aircraft Production Lord Beaverbrook, when he stated that 'if it came to a choice between hampering Air Production or Tank production, I would sacrifice the Tank'.³⁹ The case for increasing the priority for tanks was further weakened during the War Cabinet meeting in the following week. Essentially, not only did the Ministry of Supply consume 40 per cent of drop forging capacity each week when compared to 32 per cent required for the Air Ministry, the majority of this land equipment was to produce unarmed wheeled vehicles. Churchill suggested that tanks be given 1 (a) status except when the requirements conflicted with aircraft, but Beaverbrook did not accept this as the result would be a reduction in aircraft production through a redirection of resources. In an attempt to redistribute drop forging capacity more appropriately, the War Cabinet agreed to relegate motor cars and lorries from all the services to Priority 2, however tank production remained at 1 (b).⁴⁰

In November 1940 the Director General of Tanks and Transport, Geoffrey Burton, asserted that the lack of 1 (a) priority would not affect existing production tanks like the Matilda and Valentine, as much as it would the tanks entering production, such as the Covenanter,

³⁸ TNA, CAB 21/1544, Report by the Chairman of the Sub-Committee of Principal Priority Officers, 'Tank Production', 2 August 1940.

³⁹ TNA, CAB 21/1544, Churchill to Beaverbrook, 9 August 1940.

⁴⁰ TNA, CAB 65/8/41, 'Meeting of the War Cabinet', 16 August 1940.

Crusader and Churchill.⁴¹ By March 1941, the executive second Tank Board had suggested otherwise by stating that unless tank engines were given 1 (a) priority, Valentine deliveries would be limited to 100 instead of the forecasted 130 tanks per month until August.⁴² The production figures across the four months to August averaged 120 per month and whilst this was greater than expectations, the effect of the lower priority status certainly occurred.⁴³

By July 1941 the arguments against lifting tank priority to 1 (a) remained, although the role of Beaverbrook had now reversed with him arguing in favour of the change as the new Minister of Supply.⁴⁴ Despite a continued shortage of drop stamping capacity, agreement was reached to give tank and tank spares priority 1 (a) status, under a scheme that was reminiscent of the one that Beaverbrook had rejected in August 1940. Rather than issuing a new direction, manufacturers were advised of the change in priority but with the caveat that aircraft production took precedence in the case of conflict. The reason for not superseding the June 1940 directive was to prevent the suspected 'psychological impetus' of contractors producing tank components that were already of good supply, at the expense of items that were in high demand.⁴⁵ This changed on 14 November 1941 with a new Priority of Production Directive that gave 1 (a) priority to: service aircraft; airborne equipment; bombs, anti-aircraft weapons and ammunition; small arms and small arms ammunition; armour-piercing ammunition; tanks and anti-tank guns. The new 1 (b) priority included: field artillery; mortars; and other anti-tank weapons and ammunition not included under (a). The understanding behind this new priority system was to achieve the delivery of all top priority items, but to prevent the production of these items expanding beyond requirements and thus hampering the output of lower priority items.⁴⁶

The next section within the first stage of the production life span will consider the response by government and industry towards taking further air raid precautions (ARP), particularly in the period before and on the outbreak of war. The programme of ARP instigated by industry during 1938 and 1939 discussed during chapter 1, now extended to discussions concerning the prospect and likely reimbursement by the government for the costs incurred. During January 1939 the board of Austin Motors considered that their existing covered trenches were

⁴¹ TNA, CAB 21/1544, DGTT to Lt. Col. Jacob, 6 November 1940.

⁴² TNA, WO 185/8, '12th Meeting of the Tank Board', 14 March 1941.

⁴³ TNA, AVIA 46/188, 'Monthly Deliveries', p. 269.

⁴⁴ TNA, CAB 21/1544, Beaverbrook to Churchill, 4 July 1941.

⁴⁵ TNA, CAB 21/1544, Bevin to Churchill, July 1941.

⁴⁶ TNA, BT 168/78, 'Priority of Production Directive', 14 November 1941

inadequate for the workers and discussed the adoption of tunnels as an alternative, plus an underground room for storing important documents. The Board agreed to provide full details to the authorities 'so that if any payment is made by the Government to Firms in respect of A.R.P. expenditure we shall participate in the distribution'.⁴⁷

In March 1939 both the Austin and Rover companies noted that the government had announced the availability of an 'Exchequer grant' for ARP expenditure, which was equivalent to the 27.5 per cent standard rate of income tax.⁴⁸ One aim of the grant was to accelerate the level of ARP undertaken following the concern at the time, and highlighted by a recent study, that some employers had been procrastinating.⁴⁹ Leyland Motors is an example of this deferment whereby despite the appointment of ARP Officers at the different Leyland works in September 1938, actual preparations were not sanctioned until August 1939. This delay resulted in the completion of only 50 to 70 per cent of the trenches necessary to accommodate all personnel at each factory at the outbreak of war. However, inexpensive precautions had been carried out such as marking out evacuation routes.⁵⁰ To put these differing efforts into context, Table 3.4 below displays the sanctioned or actual expenditure incurred by a selection of 13 firms during the period 1938 to 1940, with a combined ARP cost of over £1.3 million.

⁴⁷ MRC, Austin Motor Company, MSS.226/AU/1/1/2, Board Meetings and AGMs, 1930-1942, 'A.R.P. Expenditure for Car Works', 25 January 1939.

⁴⁸ *The Times*, 17 March 1939; MRC, MSS.226/AU/1/1/2, 'A.R.P. Expenditure for Car Works', 22 March 1939; Rover Company, MSS.226/RO/1/1/6, Board Minutes, 1936-1943, '(12) 6613: Air Raid Precautions', 22 March 1939.

⁴⁹ H. Jones, *British Civilians and the Front Line: Air Raids, productivity and wartime culture, 1939-45* (Manchester, Manchester University Press, 2006), pp. 60-62.

⁵⁰ British Commercial Vehicle Museum, Leyland, British Leyland Motor Corporation, M639 143/11, General Manager's Meeting 1938-1940, 'Works Defence', September 1939.

Table 3.4 Air Raid Precautions, sanctioned and actual expenditure, 1938 to 1940

Firm	1938 and 1939		1940		Total	%
	Sanctioned	Actual	Sanctioned	Actual		
	£	£	£	£	£	%
AEC ⁵¹	20,000				20,000	1.5
Austin Motors ⁵²	53,540		50,000		103,540	7.7
English Steel Corporation ⁵³		100,000			100,000	7.5
Leyland Group ⁵⁴	50,000				50,000	3.7
Metropolitan-Cammell ⁵⁵	40,000				40,000	3.0
M. G. Car Company * ⁵⁶		1,423		1,631	3,054	0.2
Morris Commercial Cars * ⁵⁷		30,663		14,434	45,097	3.4
Morris Motors * ⁵⁸		18,201		42,010	60,211	4.5
Nuffield Exports * ⁵⁹		1,121		2,679	3,800	0.3
Mechanization & Aero * ⁶⁰		6,059		5,507	11,566	0.9
Riley Motors * ⁶¹		6,830		3,741	10,571	0.8
Rover Company ⁶²				50,013	50,013	3.7
Vickers-Armstrongs ⁶³		399,852		439,480	839,332	62.8
Total Expenditure	£163,540	£564,149	£50,000	£559,495	£1,337,184	100.0

Key: * Part of the Nuffield Group totalling £134,299 and 10% of total expenditure.

With regard to particular firms, the response by Vickers at nearly 63 per cent of the total amount incurred is not unexpected given the extensive involvement of the firm in armaments production. The importance of the production of steel, drop forgings, castings and armoured plate for all three services is reflected by the English Steel Corporation representing another 7.5 per cent. The majority of the remainder was incurred by the motor manufacturers, with Austin Motors at eight per cent and the combined total of the six firms within the Nuffield Group at ten per cent. An example of the major areas of individual expenditure is displayed in Figure 3.4 below for Morris Motors, highlighting that sandbags were needed only initially,

⁵¹ MRC, MSS.226/AE/1/1/12, '5426: Air Raids Precautions Scheme', 3 May 1939.

⁵² MRC, MSS.226/AU/1/1/2, 'A.R.P. Expenditure for Car Works', 22 February 1939; 'A.R.P. Tunnel', 25 September 1940; 'Air Raid Precautions', 27 November 1940.

⁵³ CUL, VICKERS 1226, Minutes of Meeting of Directors, '2328 - English Steel Corporation, Air Raid Precautions', 26 October 1939.

⁵⁴ BCVM, M639 143/11, 'Works Defence', September 1939.

⁵⁵ Birmingham Archives and Heritage, Birmingham Central Library, Metropolitan-Cammell, MS 99/2006/024, '491: Air Raid Precautions', 18 October 1939.

⁵⁶ MRC, M. G. Cars, MSS.226/MG/2/1/5-6, 'Profit and Loss Account', 1939 and 1940.

⁵⁷ MRC, Morris Commercial Cars, MSS.226/MC/2/1/6-7, 'Profit and Loss Account', 1939 and 1940.

⁵⁸ MRC, Morris Motors, MSS.226/MO/2/2/6-7, 'Profit and Loss Account', 1939 and 1940.

⁵⁹ MRC, Nuffield Exports, MSS.226/NE/2/1/5-6, 'Profit and Loss Account', 1939 and 1940.

⁶⁰ MRC, Nuffield Mechanization & Aero, MSS.226/NM/2/1/5-6, 'Profit and Loss Account', 1939 and 1940.

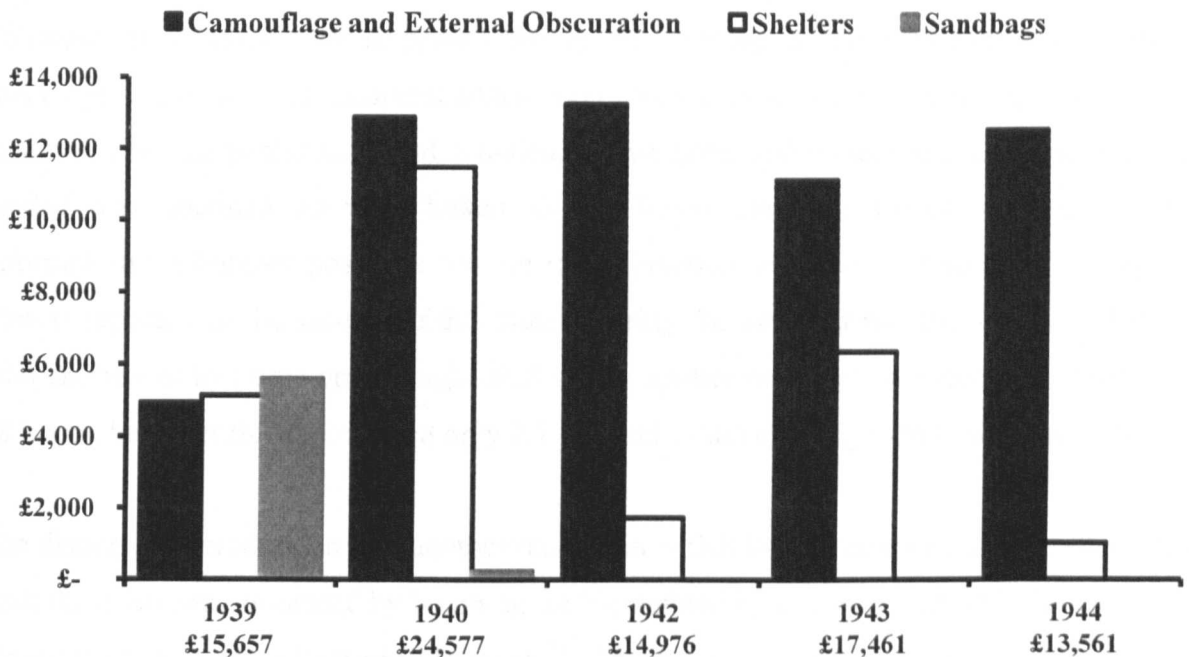
⁶¹ MRC, Riley Motors, MSS.226/RI/2/1/2-3, 'Profit and Loss Account', 1939 and 1940.

⁶² MRC, MSS.226/RO/1/1/6, '(10) 6899: A.R.P.', 12 December 1940.

⁶³ CUL, VICKERS 1226, Minutes of Meeting of Directors, '2648 - Air Raid Precautions', 14 May 1941.

whilst shelters and maintaining the blackout through ‘camouflage’ remained a necessity throughout the war.

Figure 3.4 Morris Motors – major ARP expenditure, 1939-1940 and 1942-1944⁶⁴



NB: The accounts for 1941 are missing.

The effect that the outbreak of war had upon the workers can be seen by two contrasting experiences. In the case of the Nuffield Group the outbreak of war resulted in staff redundancies as a result of ‘wartime requirements’, whereby the organisation decided to compensate both men and women equally for each completed year of service.⁶⁵ Rover highlighted that these ‘unavoidable’ redundancies were because of the cuts in working hours with the reduction in the manufacture of cars from 250 to 100 per week. The firm did manage to limit these redundancies by redirecting some employees on to ARP work.⁶⁶ At Gloucester Railway Carriage and Wagon Company, the completion of ARP was bolstered by the out-of-hours weekend work of 74 employees, who volunteered to blackout windows and build shelters between 9 and 10 September.⁶⁷ Whilst this voluntary work was done to benefit the workers themselves by increasing the level of protection against bombing, it can also be seen as an example of coming together in the face of adversity, by taking personal responsibility towards the demands of the war effort. A further example of volunteerism has

⁶⁴ MRC, MSS.226/MO/2/2/6-10, ‘Profit and Loss Account’, 1939 to 1944 inclusive.

⁶⁵ MRC, MSS.226/MO/1/2/1, ‘Staff Reductions due to Wartime Requirements’, 18 September 1939.

⁶⁶ MRC, MSS.226/RO/1/1/6, ‘(8) 6678: Rover Factories: (1) Car Production’, 20 September 1939.

⁶⁷ Gloucestershire Archives, Gloucester, Gloucester Railway Carriage and Wagon Company, D4791/8/3, Board Meeting Reports and Papers, Secretary to Chairman, 12 September 1939.

been highlighted by Ian Beckett, that during May 1940 industrial workers responded in their thousands to join the new Local Defence Volunteers or Home Guard, with some firms forming individual units such as the 10th Surrey (Vickers Armstrong) Battalion.⁶⁸

To avoid unnecessary work stoppages during the bombing, a voluntary roof spotter system was employed to warn of imminent attack upon specific areas, thereby allowing production to continue after the public siren had sounded. Some firms and government authorities jointly funded and operated schemes linked to the Royal Observer Corps, to gain detailed information on bomber positions for use in conjunction with the roof spotters.⁶⁹ Leyland Motors reported on the success of this system during the first four months of 1941, when the total amount of lost time on the night-shift due to spotter warnings was recorded at just over 38 hours, however this represented only 2.7 per cent of the total night-shift hours worked.⁷⁰

The dispersal of production was another method in which the government and industry could limit the interruptions caused by bombing, as highlighted by Adam Tooze with the successful dispersal of the tank industry in Germany.⁷¹ Dispersal was dependent upon the size of the firm as demonstrated by English Electric during February 1940, who considered themselves 'less vulnerable' than other firms because they had spread production across their four factory locations.⁷² Whilst dispersal was deemed essential to avoid an industrial disaster during the early years of war, the official history points out that this was simultaneously incompatible with the requirement for a large increase in the scale of production.⁷³ In essence, long-term and efficient mass production could only be achieved through concentration not separation. This concern was qualified by the new Minister of Supply Andrew Duncan to the Lord President's Committee at the end of December 1940, in which a complete transfer of activities away from a heavily bombed area was not advocated:

- (1) There is no reason to suppose that any industrial area will, in the long run, be safer from attack than another.

⁶⁸ I. F. W. Beckett, *The Amateur Military Tradition: 1558-1945* (Manchester, Manchester University Press, 1991), pp. 266 & 278-279.

⁶⁹ For more on the spotter system see Jones, *British Civilians and the Front Line*, 'Roof Spotters'.

⁷⁰ BCVM, M632 143/5, General Manager's Meeting 1941-1943, 'Air Raid Warnings', April 1941.

⁷¹ A. Tooze, *The Wages of Destruction: The Making and Breaking of the Nazi Economy* (London, Allen Lane, 2006), p. 434.

⁷² BLO, English Electric Company, MS. Marconi 2393, Minutes of Board meetings, 1939-41, Minute Book No. 8, '4: Annual Accounts, (a) Dislocation of Works by enemy action', 8 February 1940.

⁷³ W. Hornby, *Factories and Plant: A History of the Second World War* (London, H.M.S.O., 1958), p. 35.

- (2) Complete transfers to new areas must have an adverse effect on production, because of the difficulty of transferring and housing labour and because of the effect upon the morale of the workers.
- (3) For defence reasons it is undesirable to distribute vital production outside the areas that are now defended.

This realistic assessment was qualified by the preference for localised dispersal when there was 'undue concentration on specialised production in one place'.⁷⁴ With regard to the Ministry of Aircraft Production under Beaverbrook, dispersal factories represented 23 per cent of the productive floor space within the airframe industry by December 1941. As a direct influence upon output during the war, in the case of Vickers' Weybridge factory between 1940 and 1943, dispersal caused an increase in the number of non-productive workers when compared to the employment of productive workers.⁷⁵

Vickers had detailed discussions with the Ministries of Aircraft Production and Supply during 1941 in respect of reimbursing the firm for the costs of this dispersal. The Ministries paid the costs of relocating the 'Crown plant' and Vickers' employees to the new premises, together with any new buildings, plant and equipment and air raid shelters. On-going expenses such as rent, rates, insurance and maintenance of the new premises were recoverable by Vickers under 'Overhead Charges'. The Ministries disputed the reimbursement relating to Vickers' own plant, including the costs of dismantling and installation at the new premises, and then the later re-installation back at Vickers' works when the period of dispersal had ended.⁷⁶

Up to the end of April 1941, the cost to Vickers in carrying out this dispersal was estimated at a substantial £680,000, with £414,000 having been spent to date, although £205,000 had been recovered from the Ministry concerned.⁷⁷ To put these costs into perspective an alternative form of factory dispersal was available with the relocation to underground shelters, however these were uncommon due to the particular costs and intensive preparations involved.⁷⁸ Germany had similar problems when early in 1944 Adolf Hitler demanded the construction

⁷⁴ Churchill College Archives, Cambridge, 1st Viscount Weir, WEIR 20/6, 'Dispersal of Factories', by Duncan, 24 December 1940.

⁷⁵ S. Ritchie, *Industry and Air Power: The Expansion of British Aircraft Production, 1935-1941* (London and New York, Routledge, 2007), p. 236.

⁷⁶ CUL, VICKERS 723, Dispersal of Factories, 'Basis of Recovery', March 1941.

⁷⁷ CUL, VICKERS 723, 'Dispersal of Manufacture', 19 June 1941.

⁷⁸ Jones, *British Civilians and the Front Line*, p. 29.

of 'six gigantic underground shelters' in response to the Allied bombing, but this would have been at the expense of all other construction projects and in any event never commenced.⁷⁹

The final part within the first stage of the production life span considers the government programme of industrial expansion which provided capital assistance to support the increases in war production, which the official history calculates at £1 billion from 1936 to 1945. A quarter of this cost went to directly-operated government establishments, such as Royal Ordnance Factories, with a further quarter going to government factories operated by commercial firms on an agency basis, such as the 'Shadow' aircraft factories. The remaining half provided extensions to contractors' works, such as with the sample of five tank firms shown in Appendix 5, for building work at £15,222 and for new plant and equipment at £836,530.⁸⁰ Government policy towards the costs of these particular alterations was driven by the avoidance of enhancing the firm at taxpayers' expense, although the particular agreements changed over the course of the war.

As quantity production became necessary after mid-1940, the agreements for new plant and equipment transformed from providing an individual government grant to each firm, into a fixed 60 per cent reimbursement with the firm retaining ownership. From 1941 until 1944, the agreements provided the firm with full reimbursement but with the Ministry retaining ownership until the end of the contract, whereby each firm could negotiate the cost of retaining the plant and equipment. The cost of new building work was met by the Ministry in full from 1942 until 1944, together with an agreement that the firm would pay the Ministry at the end of the contract an amount which reflected the increased value of the buildings. Birmingham Railway reached such an agreement with the Ministry in November 1946, resulting in the firm paying 44 per cent of the value of building work, and 32 per cent of the cost to retain the additional plant and equipment.⁸¹ Similarly, English Electric purchased much of the plant it had operated during the war for aircraft production at Preston and tank production at Stafford.⁸² When an end to the war appeared more likely early in 1945, the agreements for new building work avoided these post-war negotiations by the firm receiving

⁷⁹ A. Speer, *Inside the Third Reich, Memoirs by*, first published 1969, trans. R. and C. Winston (London, Book Club Associates, 1971), pp. 336-337.

⁸⁰ W. Ashworth, *Contracts and Finance* (London, H.M.S.O., and Longmans, Green, 1953), pp. 226-227 & 252.

⁸¹ SRO, D831/1/6/3, Plant and Machinery, 'Agreements to buy Ministry of Supply Buildings, Plant and Machinery', 19 November 1946.

⁸² D. Edgerton, 'The British arms industry 1920-50', in R. Millward and J. Singleton (eds.), *The political economy of nationalisation in Britain 1920-1950* (Cambridge, Cambridge University Press, 1995), p. 182.

immediate ownership at a cost of 50 per cent of the value. The difference between this value and the 44 per cent agreed by Birmingham Railway probably reflected the increased depreciation and hence this firm received a lower degree of enhancement.

Following the inability to secure Crusader production in the United States by November 1940 discussed in chapter 5, the Crusader programme was expanded from 20 to 60 tanks per week, by increasing the capacity from three tank firms to eight. In order to meet the planned increase in total Crusader deliveries from 600 to 2,062 tanks by May 1942, three of these new firms and four additional firms became component contractors by collectively providing turrets, suspension units, engines and gear boxes.⁸³ A summary of the expected maximum weekly output across the different production items by each firm is provided in Table 3.5 demonstrating the diversification of the tank programme. This diversity will be expanded upon in greater detail below when discussing the third stage of the production life span and the effect of material shortages upon output.

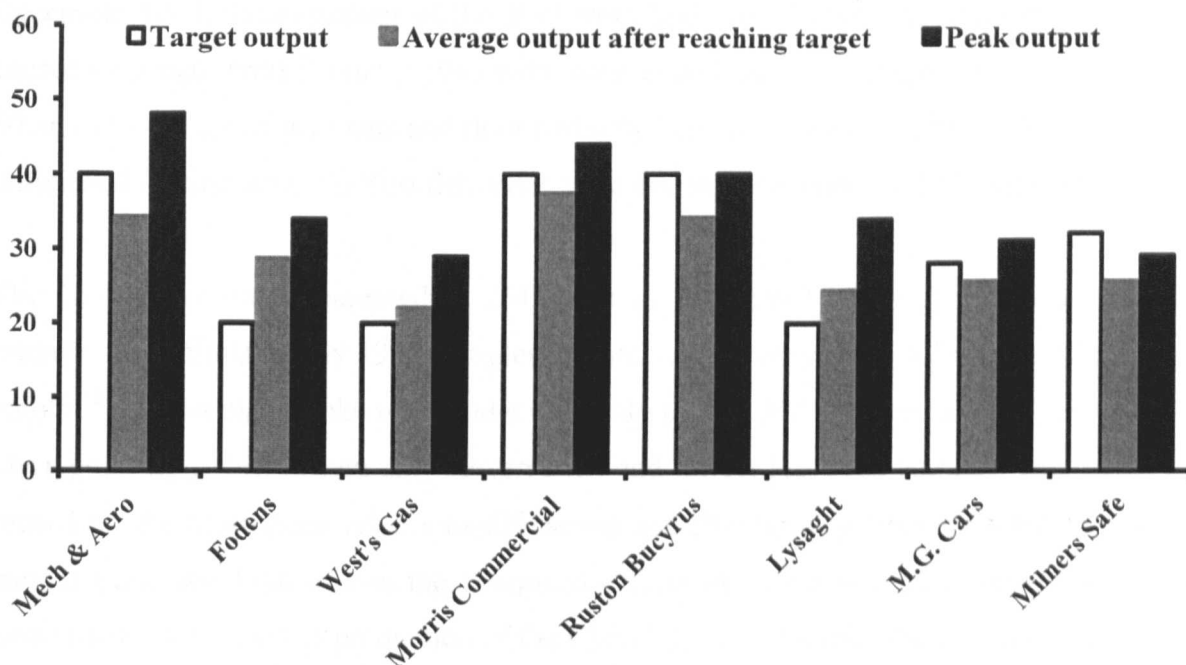
Table 3.5 Crusader tank expansion programme, weekly forecast, Nov-40

	Tank Assembly	Suspension	Final Drive	Hull Parts	Turrets	Engines and Clutches	Gearboxes	Steering Unit
<i>Original Firms</i>								
Mechanization & Aero	10	10	10	10	10	20	20	
West's Gas	5	5	5	5	5			
Fodens	5	5	5	5	5			
<i>Expansion Firms</i>								
Morris Commercial Cars	10	10	10	10	10			
M. G. Cars	7				7			
Ruston-Bucyrus	10				13			
John Lysaght	5							
Milners Safe	8							
Morris Engine Branch						40	40	40
Wolseley Motors		30	30	30				
W. G. Allen					10			
Daimler and Others								20
Total Weekly Production	60	60	60	60	60	60	60	60

⁸³ CCA, WEIR 20/40, 'Cruiser Tank Mark VI (A.15), Expansion Programme', 7 November 1940.

The result of this expansion scheme is shown in Figure 3.5 for the eight firms involved, which compares the required monthly tank output against the average output upon reaching this target, and the peak output. The peak output in this chart demonstrates that on at least one occasion all but one firm reached or well exceeded their monthly forecast, which in each case was achieved after approximately 14 months of production activity. Whilst the average monthly output after reaching this target did fall below requirements in five out of the eight firms, the programme was later enhanced by the addition of Morris Industries Exports during mid-1942. The success of the expansion programme is displayed in Appendix 1, with a combined 2,992 Crusaders delivered during 1941 and 1942, representing 13.5 and 27.1 per cent of total tank production activity respectively.

Figure 3.5 Crusader expansion programme – target, average and peak monthly output, Nov-40 to Jun-43⁸⁴



The second stage of the production life span will review the different influences upon initiating a tank programme by highlighting the experience of industry in relation to Covenanter and Crusader production. To begin with, the five firms new to Crusader production above were expected to make their first tank deliveries during either May or June 1941, however in each case this did not start until seven months later during December or January 1942.⁸⁵ The production history of the Covenanter tank with Leyland highlights a

⁸⁴ TNA, AVIA 46/188, 'Monthly Deliveries', pp. 269-271.

⁸⁵ CCA, WEIR 20/40, 'Cruiser Tank', 7 November 1940; TNA, AVIA 46/188, 'Monthly Deliveries', pp. 269-271.

number of factors that can account for this delay. Historians have been universally critical of the Covenanter and in particular how the continued modifications necessary to resolve the defective cooling system meant that production tanks were relegated to training purposes.⁸⁶ Whilst this study does not alter this opinion, Appendix 1 shows that a total of 1,770 Covenanters were delivered under the programme, representing 15.4 and 11.4 per cent of total production during 1941 and 1942 respectively. Therefore given the size of the Covenanter programme an examination of Leyland Motors will highlight the production issues that would have affected the other tank programmes around the same period.

When Leyland received their first order for 151 Covenanter tanks in September 1939, the construction of a new 'B/X Factory' was necessary in order to meet the requirement of 24 tanks per month and the expectation that deliveries would commence in July 1940. By December 1939, three-quarters of the steel work had been completed, although heavy snow caused stoppages until February 1940 with material and labour shortages. By March between 50 and 75 per cent of the walls and floor had only been completed, but the building remained unfinished in June when the first deliveries were due to commence the following month.⁸⁷

The Covenanter order increased to 251 tanks in June 1940, although Leyland could not promise the optimistic July 1941 completion date, nor the maximum delivery of 33 tanks per month.⁸⁸ Whilst eight tanks were under assembly in July 1940, progress during August was 'disappointingly slow' when only eleven hulls and turrets had been started. This delay was caused by the continuous vehicle modifications and shortages of 'free issue' items, such as armour plate and final drives, the continued effects of which will be examined in greater detail below in relation to production of the Churchill tank. Despite these difficulties the first production model was expected during September 1940 although this was too optimistic and later exacerbated by the effects of bombing at the end of 1940, which delayed the first tank for three months until December.⁸⁹ These continuing delays can be further illustrated in Figure 3.6 below which demonstrates that the production of 251 tanks was not achieved until February 1942, and seven months after the required completion date. Separate from bombing

⁸⁶ Postan, et al., *Design and Development of Weapons*, pp. 313 & 315; J. D. Scott, and R. Hughes, *The Administration of War Production* (London, H.M.S.O., and Longmans, Green, 1955), p. 283; Buckley, *British Armour*, p. 83.

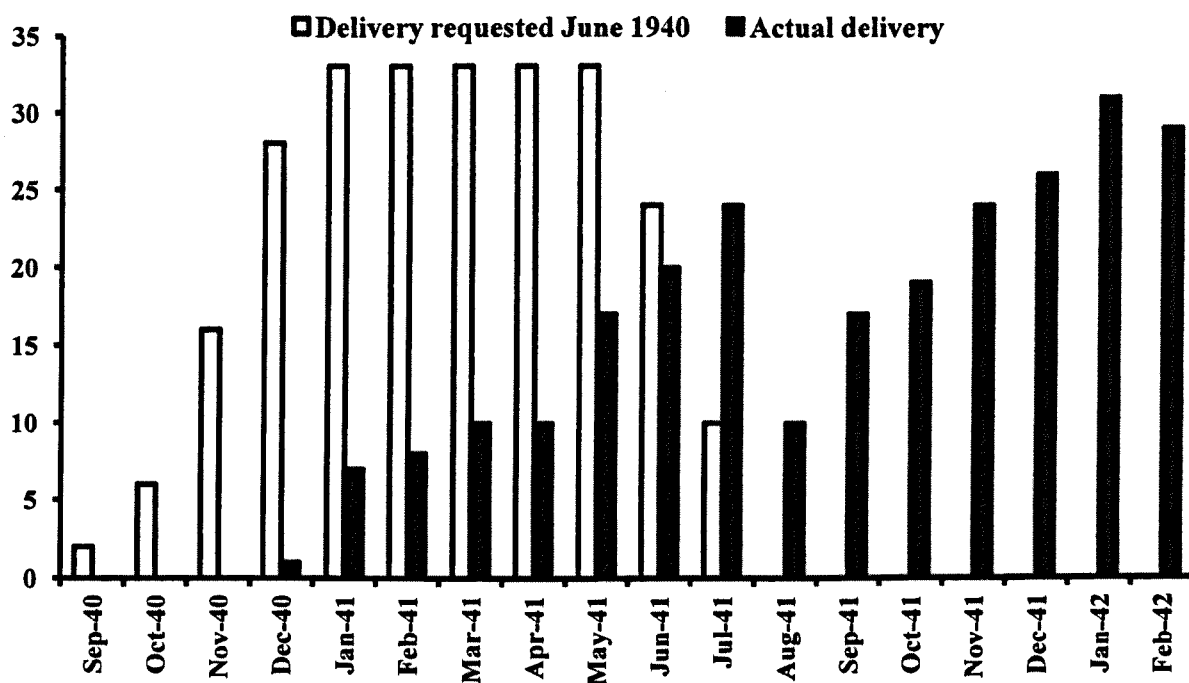
⁸⁷ BCVM, M639 143/11, 'Summary report', September 1939 to June 1940 inclusive.

⁸⁸ BCVM, M639 143/11, 'Summary report', June 1940.

⁸⁹ BCVM, M639 143/11, 'Production Issues', August 1940; M632 143/5, 'Mark V', January 1941; TNA, AVIA 46/188, 'Monthly Deliveries', pp. 269-270.

and material shortages, the drop in production for August 1941 was caused by a 'slowing up on the assembly line', to make preparations to introduce the modifications necessary to the Coventanter cooling system.⁹⁰

Figure 3.6 Leyland Motors, deliveries of 251 Coventanter tanks against target⁹¹



NB: The requested schedule has been estimated based upon the likely rise to 33 tanks per month before declining and completing in July 1941.

The effect that bomb damage had upon output was particularly acute when blackout discipline was compromised, as experienced by West's Gas and production of the Crusader tank following the bombing during December 1940. In this case, damage to the factory roof had resulted in the suspension of work during the longer winter nights, and permitted just six-and-a-half hours of work per day for several weeks until repairs were completed.⁹² This was clearly a serious situation given the emphasis on quantity production, with the Nuffield Group deciding at the end of 1940 to create a reserve stock of roofing material at all factories, in order to avoid similar delays in the future.⁹³

The actual effect that this bombing had upon West's Gas can be highlighted when compared against the other two firms from the original Crusader programme. During the last two

⁹⁰ BCVM, M632 143/5, 'Mark V', August 1941.

⁹¹ BCVM, M632 143/5, 'Mark V', January 1941; TNA, AVIA 46/188, 'Monthly Deliveries', pp. 269-270.

⁹² Heritage Motor Centre Motor Museum, Gaydon, Sir Miles Thomas, 80/20/1/1 & 2/1, Sir Frederick West to Thomas, 28 February 1941.

⁹³ MRC, MSS.226/MO/1/2/1, 'Air Raid Damage to Factories', 23 December 1940.

months of 1940, Mechanization & Aero and Fodens had delivered one production tank each, thus declaring themselves ready to begin mass production during 1941. The tank forecast for the end of 1940 projected Crusader production to start with four tanks in both November and December, thereby indicating that West's Gas was also expected to form part of this output.⁹⁴ However West's Gas did not deliver their first tank until January 1941 following the effects of bomb damage, and displayed only a gradual increase in output before reaching a rate similar to Fodens in April 1941.⁹⁵ This slow rate of growth was because West's Gas had underestimated the amount of labour required, coupled with the greater demand for aircraft production that had taken the local supply of skilled labour.⁹⁶

Overall, the time taken to construct or prepare new factory space and the shortages of materials and bomb damage meant that Leyland delivered their first Covenanter tank 15 months after the order date, with West's Gas needing 16 months for their first Crusader. By comparison, both English Electric and Fodens required 14 months for the output of their first Covenanter and Crusader tanks respectively, which was very respectable when considering that experienced tank firm Vickers required 13 months to deliver their first Valentine tank.⁹⁷

The third stage of the production life span will review the issues that affected the ability of industry to fulfil the demands under the tank contract. To begin with, the lack of available skilled labour indicated by West's Gas above was another continuation from the rearmament period and remained a common problem amongst the selection of firms examined in this study. The manpower situation came under greater centralised control from April 1939 with the introduction of peacetime conscription, and whilst the General Staff consider compulsory military service as a low priority in the short-term, they had recognised it as 'inevitable in the long run'.⁹⁸ Industrial conscription did not start until after May 1940 with the new coalition government and the Emergency Powers Act, which gave the new Minister of Labour Ernest Bevin the power to direct any person to perform any service.⁹⁹ By reviewing the experiences of industry during this time, the necessity for directing manpower can be justified.

⁹⁴ TNA, AVIA 11/5, 'Tanks: Forecast of Production', 5 August 1940.

⁹⁵ TNA, AVIA 46/188, 'Monthly Deliveries', p. 270.

⁹⁶ HMC, 80/20/1/1 & 2/1, West to Thomas, 28 February 1941.

⁹⁷ TNA, AVIA 46/188, 'First Contracts', p. 67.

⁹⁸ J. P. Harris, 'The War Office and Rearmament, 1935-1939' (PhD thesis, King's College London, 1983), pp. 137-138.

⁹⁹ Croucher, 'Communist Politics and Shop Stewards', p. 165.

During June 1939, AEC reported that the difficulties in obtaining adult labour had resulted in the average number of employees per week during April 1939 as 120 fewer than those recorded in April 1938.¹⁰⁰ In order to resolve this shortfall, AEC increased the proportion of 'boys' to 16 per cent of production personnel, with the result that the employment figures for May 1939 were now slightly greater than 12 months before.¹⁰¹ Leyland experienced similar problems in May 1939, when they reported that the shortage of skilled labour in the day shift was resolved by transferring workers from the night shift to fill the vacancies. The number of workers on the late shift had not increased over the same period, so this solution was presumably to the detriment of the night-shift work.¹⁰² By the end of 1939, Leyland warned that because the system of dilution had already given priority to the best semi-skilled workers, the quality of skilled work would likely deteriorate with each subsequent transfer. This impact upon production was measured by an anticipated reduction in piecework earnings and an increase in the level of scrap, presumably through improper wastage with later workers expected to be less proficient.¹⁰³

These concerns did not prevent the continuation of dilution and following the introduction of women into the Leyland works from June 1940, the firm increased the transfer of semi-skilled male workers to satisfy the labour requirements.¹⁰⁴ As a direct result of the growth in women workers, Leyland changed from a two-shift system of 90 hours per week, to a continuous three-shift system of 135 hours over six days.¹⁰⁵ From April 1942, and probably due the recent introduction of conscription for women, the increase in the intake of female workers enabled key areas of plant to work continuously seven days a week.¹⁰⁶

The introduction of women into the workplace compelled industry to make a number of changes and improvements to factory conditions. During December 1940, Gloucester Railway offered the widow of the former Works Manager the salaried position of 'welfare supervisor' as soon as the firm began employing women workers, and decided to grant the

¹⁰⁰ MRC, MSS.226/AE/1/1/12, '5441: Labour – Numbers Employed', 5 June 1939.

¹⁰¹ MRC, MSS.226/AE/1/1/12, '5458: Labour – Numbers Employed – Percentage of Boys', 3 July 1939.

¹⁰² BCVM, M639 143/11, 'Headquarters Works', May 1939.

¹⁰³ BCVM, M639 143/11, 'Labour', December 1939.

¹⁰⁴ BCVM, M639 143/11, 'Dilution', May 1940; 'Labour', June 1940.

¹⁰⁵ BCVM, M639 143/11, 'Labour', July 1940.

¹⁰⁶ BCVM, M632 143/5, 'Labour', April 1942; P. Summerfield, *Women Workers in the Second World War: Production and Patriarchy in Conflict* (London, Croom Helm Ltd, 1984), pp. 35-36.

existing canteen facilities to all employees.¹⁰⁷ By August 1941, Metropolitan-Cammell had spent £15,000 for the construction and equipping of canteens at three of their works, plus £500 for completing the women's 'Lavatory, Rest and Cloakroom' at the one site that had been lacking these facilities.¹⁰⁸ Richard Croucher and Penny Summerfield identify that Ernest Bevin was the instigator behind these improvements, although the canteen operation by each firm was still subject to employee criticism regarding the quantity and quality of food, the standard of service, the cost and whether management was making a profit.¹⁰⁹

Whilst female conscription could support continuous working, the Vice-Chairman of the Nuffield Organisation, Sir Miles Thomas, highlighted that the compulsory removal of female office staff to the forces or the production line, would adversely affect the efficient operation of the Parent system. The concern was that Mechanization & Aero had the responsibilities of buying, material control, spares allocation and the dissemination of information, on behalf of the whole Crusader Group and thus required greater administrative support.¹¹⁰

From September 1941 industry received an increase in manpower following the temporary release of 8,000 skilled and semi-skilled airmen from the Air Ministry. This decision was designed to compensate for the existing shortage in similar workers after Churchill had asked the Ministry of Aircraft Production for a 32 per cent increase in bomber output during the period from July 1941 until July 1943.¹¹¹ The Ministry of Labour and National Service reacted with surprise upon receiving this offer from the Air Ministry, especially since Bevin "had been emphasising the deficiency of skilled men in the RAF".¹¹² Whilst these workers were meant to support aircraft production, a small number of airmen were provided to tank firms. Ruston-Bucyrus enthusiastically reported in January 1942, that whilst they were short of 300 personnel for the Crusader programme, the '91 R.A.F. men' were 'rapidly making

¹⁰⁷ GAG, D4791/6/19, Directors' Minute Books, 1939-1944, '410. Employment of Women Workers and their Welfare Supervisor'; 411. Canteen for Women Workers', 13 December 1940.

¹⁰⁸ BAH, MS 99/2006/024, '649. Canteen (works)'; '650. Women's Lavatory', 27 August 1941.

¹⁰⁹ R. Croucher, *Engineers at War, 1939-1945* (London, Merlin Press, 1982), pp. 14 & 265-266; Summerfield, *Women Workers in the Second World War*, pp. 101, 120n.

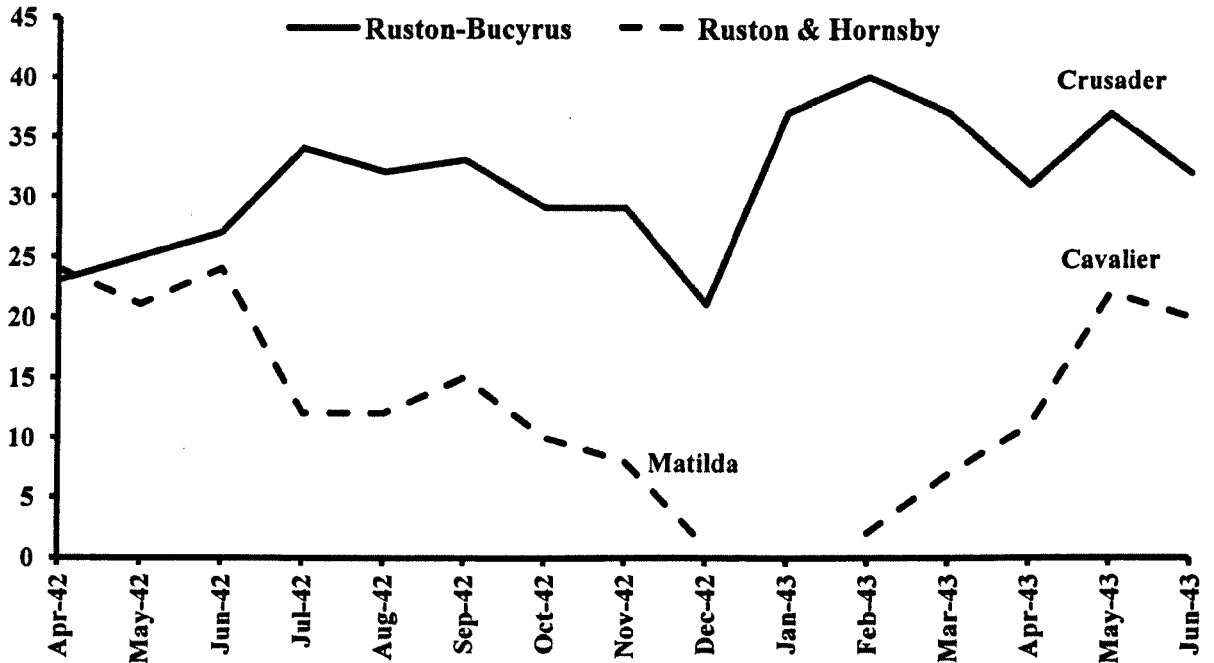
¹¹⁰ HMC, 80/20/6/38 & 39/16, Thomas to E. W. Baltrop, Ministry of Labour and National Service, 14 July 1942.

¹¹¹ N. Nakamura, 'Women, Work and War: Industrial Mobilisation and Demobilisation, Coventry and Bolton, 1940-1946' (PhD thesis, University of Warwick, 1984), p. 84.

¹¹² Quote from letter of reply from F. Tribe, Ministry of Labour and National Service to J. B. Abraham, Air Ministry, in *ibid.*, p. 84n.

themselves useful'.¹¹³ Leyland received three men from the 'R.A.F Engineering Section', and in February 1942 similarly reported that 'whilst these men are not fully skilled they have shown great versatility and will soon become useful additions to machine shop personnel'.¹¹⁴

Figure 3.7 Tank deliveries from Ruston-Bucyrus and Ruston & Hornsby¹¹⁵



Once the loan of R.A.F. workers had ended at Ruston-Bucyrus at the end of 1942, the firm stated that 50 to 60 semi-skilled workers were immediately required for the existing Crusader programme and that a further 200 to 300 were needed by April 1943.¹¹⁶ In order to minimise the loss in output, Ruston & Hornsby loaned workers from their declining Matilda programme to Ruston-Bucyrus for Crusader production, before returning to start production on the new Cavalier tank.¹¹⁷ This temporary reallocation of workers to meet the changes within the tank programme is demonstrated in Figure 3.7. This shows how Crusader output declined towards the end of 1942 with the return of the airmen workers, followed by an increase in production with the transfer of Ruston & Hornsby personnel at the conclusion of the Matilda programme. Crusader output then decreased again as these workers returned to Ruston & Hornsby to begin work on the new Cavalier tank.

¹¹³ HMC, 80/20/6/38 & 39/16, Thomas to S. J. Egerton-Banks, 10 January 1942; 80/20/1/7 & 8/7, C. J. Hyde-Trutch, Ruston-Bucyrus to Thomas, 12 February 1942.

¹¹⁴ BCVM, M632 143/5, 'B/X Factory', February 1942.

¹¹⁵ TNA, AVIA 46/188, 'Monthly Deliveries', p. 271.

¹¹⁶ HMC, 80/20/1/7 & 8/7, V. W. Bone, Ruston-Bucyrus to Thomas, 23 December 1942.

¹¹⁷ HMC, 80/20/1/7 & 8/7, Bone to Major A. G. Church, Ministry of Supply, 1 March 1943.

As identified with Covenanter production above, shortages of 'free issue' items affected the assembly line when continued and uninterrupted output was required. One way of minimising the level of disruption to the assembly line as a result of these shortages, was adopted by Sir Miles Thomas in relation to Crusader production by taking the matter outside of the Parent system highlighted above. Tank firms Milners Safe and West's Gas both reported during May 1942 that the lack of armour plate affected their ability to meet production targets, with the latter describing this as the 'chief bottle-neck'.¹¹⁸ In response, Thomas arranged for firms within the Group to have direct contact with the Ministry of Supply regarding the issue of armour plate, therefore delegating this particular Parent responsibility to the specific demands of the firms concerned.¹¹⁹

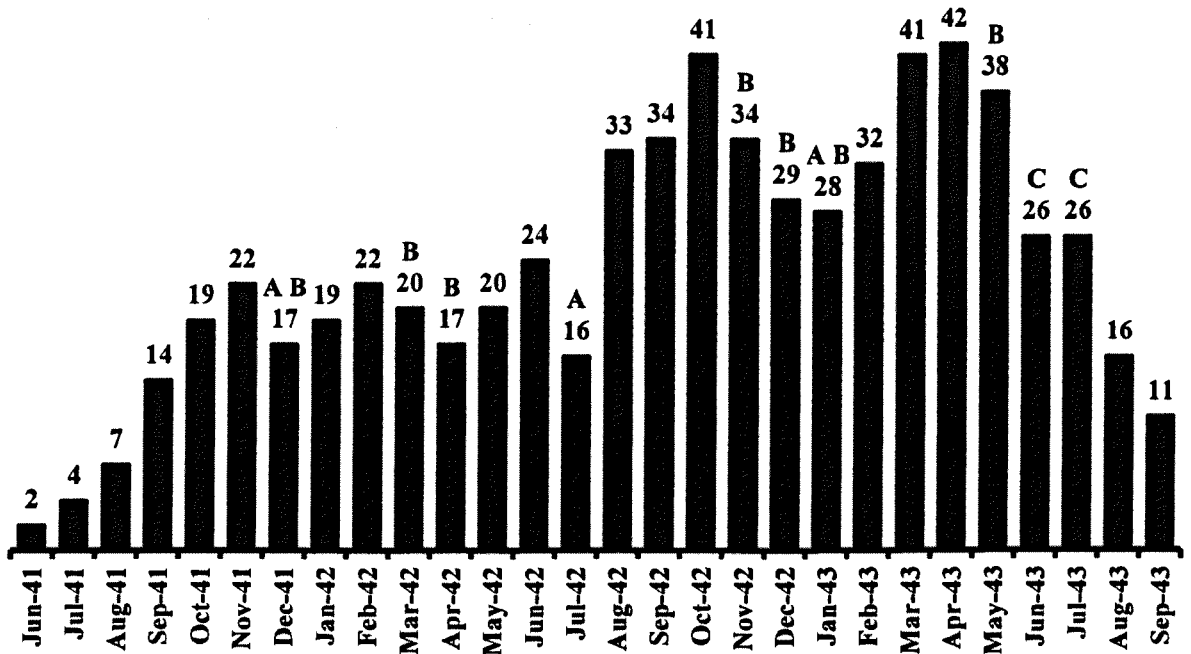
By comparing the production reports from Leyland Motors for the duration of their Churchill tank contract against the monthly deliveries, the effect of these fluctuations in output are exposed in Figure 3.8 below. To begin with and to put this production into perspective, Appendix 1 shows that a total of 3,781 Churchills were delivered from 1941 until 1943, representing 18.1 per cent of total production over the three years. When the overall material situation improved after July 1942 a general increase in output is displayed in the chart. However, when material shortages occurred, these produced a fall in output of 23 per cent between November and December 1941 and again between February and April 1942. A much greater decline of nearly one-third was experienced across the periods of June to July 1942; across the final quarter of 1942; and finally from April to July 1943 before the contract completed in September. Overall, the effect that these shortages and delays in production material had upon the Leyland contract can be measured by the expectation in March 1943 that the final tank would be delivered in July, rather than in September as shown below.¹²⁰

¹¹⁸ HMC, 80/20/1/1 & 2/1, Ernest West to Thomas, 14 May 1942; 80/20/1/7 & 8/8, F. C. Hitches, Milners Safe to Thomas, 19 May 1942.

¹¹⁹ HMC, 80/20/1/1 & 2/1, Thomas to West, 8 June 1942; 80/20/1/5 & 6/7, Thomas to R. G. Foden, Fodens, 8 June 1942.

¹²⁰ BCVM, M632 143/5, 'Churchill', March 1943.

Figure 3.8 Leyland Motors, monthly production of 654 Churchill tanks¹²¹



Key: A Shortages of Bogie Suspension Units
 B Shortages of Final Drives
 C Shortages of unspecified large range of materials, likely to include those above

The fourth stage of the production life span examines the problems that followed the delivery of completed tanks to armoured units in Britain and the Middle East. To begin with this section will not consider the Valentine tank as this vehicle was praised by the end of the North African campaign for being an 'extremely dependable tank and mechanically superior' to either the American Grant or Sherman. However, the fighting ability of the Valentine was rightfully doubted due to the slower speed, inadequate firepower and insufficient armour.¹²² The majority of tank problems in the Middle East related to Crusader production, with David Fletcher highlighting how poor workmanship resulted in complaints from tanks crews regarding the level of unreliability and unnecessary losses during the Desert fighting.¹²³ Whilst mechanical breakdown had caused the majority of tank losses amongst a sample of unserviceable Crusader tanks following Operation Crusader, Jonathan Fennell emphasises that tank crews were more concerned about the German 88 mm anti-tank gun.¹²⁴

¹²¹ TNA, AVIA 46/188, 'Monthly Deliveries', pp. 270-271; BCVM, M632 143/5, reports for Jan-41 to Sep-43.

¹²² Nuffield College Library, Oxford, Lord Cherwell, MSS CHERWELL CSAC 80.4.81/G.368/4-14, 'Special Supplement to A.F.V. Technical Report No.12, Fighting Efficiency', para. 3, 6 February 1943.

¹²³ D. Fletcher, *The Great Tank Scandal: British Armour in the Second World War, Part 1* (London, H.M.S.O., 1989), pp. 85-86.

¹²⁴ J. Fennell, *Combat and Morale in the North African Campaign: The Eighth Army and the Path to El Alamein* (Cambridge, Cambridge University Press, 2011), pp. 73-76.

In response to the claims of Crusader unreliability Thomas suggested to Lieutenant-General Giffard Martel in February 1942 that by sending their chief test driver to the Middle East he could 'differentiate' between necessary servicing and 'unnecessary tinkering'.¹²⁵ Martel accepted the suggestion although emphasised that the issues of unreliability related to the fan drive and water pump after 200 miles, and with oil leaks due to inadequate inspection on first assembly.¹²⁶ Based upon the Liberty engine tests at the experimental establishment in Farnborough, Thomas was not prepared to attribute the problems to the oil leaks and instead stated that damage was caused when the engine was removed for replacement or overhaul in the field.¹²⁷ As reviewed in the next chapter, the reduction in the amount of essential repair or replacement of tank components in the field contributed to the increase in reliability. General Claude Auchinleck, as the Commander-in-Chief Middle East, provided the most relevant opinion on this issue in June 1942, when he identified that Crusader faults had to have originated during production and that these delayed operational requirements:

Careless assembly in manufacture of new (repeat new) crusader tanks still very prevalent. Principle examples are nuts of oil and water joints at inaccessible positions not properly tightened resulting in serious leakage and consequential mechanical damage. First batch of new tanks from W.S.17 required average of two hundred (R) two hundred man hours each to get tanks in a mechanical condition fit for fighting. Faulty workmanship usually manifests itself during first hundred and fifty (R) hundred and fifty miles. Consequently have to drive tanks that distance before sending forward. Vital battle requirements thus being held up. Can you insist on rigid inspections and tests on assembly lines at makers works.¹²⁸

The Department of Tank Design experienced similar results during July, when it recorded the mileage at which a defect caused different British tanks to fail under British environmental conditions. The comparative outcome is shown in Figure 3.9 that clearly demonstrates the extent of Matilda and Valentine reliability during this stage in the respective programmes. With regards to the Churchill tank, the 'Rework' scheme had doubled the mileage before an engine or transmission defect had caused the tank to fail, however this improved result was still far behind the other two Infantry tanks. Whilst the test results in Britain showed that the Crusader had operated for a greater mileage than that reported by Auchinleck in the Middle East, comparatively this tank was still the least reliable.

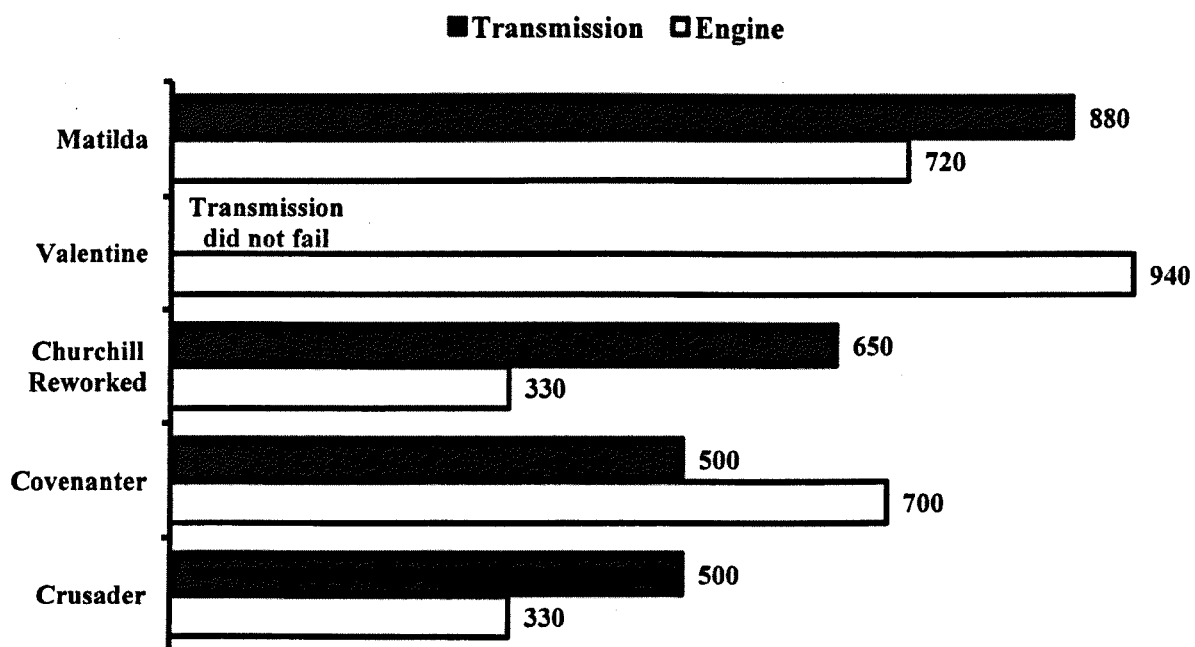
¹²⁵ HMC, 80/20/1/1 & 2/18, Thomas to Martel, H.Q. Royal Armoured Corps, 20 February 1942.

¹²⁶ HMC, 80/20/1/1 & 2/18, Martel to Thomas, 23 February 1942.

¹²⁷ HMC, 80/20/1/1 & 2/18, Thomas to Martel, 26 February 1942.

¹²⁸ TNA, WO 185/6, C. in C. Middle East to War Office, 30 June 1942.

Figure 3.9 Mileage when defect caused involuntary stop of vehicle or repair occupying three hours or more, during trial over 1,000 miles, July 1942¹²⁹



The question of maintenance for these tanks can be demonstrated by contrasting the Valentine and Churchill instruction books for models similar to those tested. To begin with, both tanks required the oil in the gear box to be changed after 2,000 miles following weekly checks to maintain the prescribed level. This interval seems very high based upon the results above even allowing for the Valentine's greater reliability. Whilst the level of engine oil needed to be checked on a daily basis for both tanks, the mileage before requiring a complete oil change was 500 miles for the Churchill Bedford engine, whereas the Valentine General Motors (GMC) engine was 1,000 miles.¹³⁰ This highlights the different expectations by each manufacturer regarding the quality of their respective engines. The periodic checks were retained for the later Cromwell Mark VII from 1945, although the gear box required an oil change at the more reasonable 1,000 miles, whilst the change in engine oil increased to every 1,500 miles thus reflecting the greater reliability of the Meteor engine.¹³¹

In order to give these different vehicles some greater context, it should be noted that pre and post-war motor cars in Britain had similar or even greater servicing requirements. In 1939, the Austin Ten could have required a complete change of engine oil after 1,000 miles, as part

¹²⁹ HMC, 80/20/1/5 & 6/4, Department of Tank Design, TD.7830, 'AFV Comparative Reliability Chart (1000 mile basis)', 12 July 1942.

¹³⁰ *Churchill III and IV Instruction Book*, 'General Summary of Routine Maintenance', July 1942; *Valentine X: Service Instruction Book*, 'Lubrication Chart', December 1943.

¹³¹ *Handbook for the Cromwell VII*, 'Lubrication Chart', January 1945.

of the after sales care recommended by the manufacturer.¹³² After the war, the engine and gear box on the Riley 100 H.P. required an initial oil change after the first 500 miles, after which the engine oil was replaced every 1,500 miles and the gear box oil every 5,000 miles with checks at 2,000 mile intervals.¹³³ Whilst taking into account the basic similarities between the mechanical components used in both British tank and motor manufacturing, the standard of tank design, production and maintenance was quite remarkable when considering the vast differences in size, weight and operational usage.

The concerns regarding the poor performance of British tanks in the Middle East, in terms of firepower, armour and reliability was given high profile attention when they were discussed in the Houses of Parliament at the beginning of July 1942.¹³⁴ This was unwelcome publicity for the Crusader manufacturers, especially when Thomas considered many of the complaints to have been 'inaccurate' and 'for reasons of security could not be publicly corrected'. In writing to the Crusader production group and Lord Beaverbrook, Thomas highlighted how the Liberty engines were damaged at the dockside in Britain when the tanks were 'run "dry" with the radiators drained' of water. Furthermore, Thomas stated that whilst there might be 'other contributory causes', investigations revealed that the faults experienced in the Middle East were reproduced when running an engine on a test bed without water for ten minutes.¹³⁵

Another cause of the Crusader problems discovered upon arrival in the Middle East was that tanks were inadequately prepared for the sea voyage, resulting in corrosion due to exposure and physical damage through vehicle collisions on deck.¹³⁶ These problems did not just affect British shipments, as a report from February 1943 revealed that despite careful packing beforehand, the new Grant and Sherman tanks from the United States arrived with defects that were partly attributed to damage sustained *en route*. As examined in greater detail in chapter 5, a further similarity with Britain was identified when the report considered the defects were also the result of 'excessive haste in manufacture', following the 'same degree of political pressure' in the United States to produce tanks in greater quantity.¹³⁷

¹³² *The New Austin Ten*, 'After Sales Service' (Birmingham, J. C. Ltd., 1939).

¹³³ *Riley Instruction Book for the 100 H.P. 2½ litre Model*, 'Maintenance Summary' (Oxford, Nuffield Press, undated), approximately 1950.

¹³⁴ House of Commons, *Parliamentary Debates*, 'Central Direction of the War', vol. 381, cols. 224-476, 1 July 1942; House of Lords, *Parliamentary Debates*, 'Conduct of the War', vol. 123, cols. 619-690, 2 July 1942.

¹³⁵ HMC, 80/20/1/1 & 2/1, Thomas to West; 80/20/1/5 & 6/7, Thomas to Foden; 80/20/1/7 & 8/7, Thomas to Bone and 80/20/6/38 & 39/9, Thomas to Beaverbrook, all 6 July 1942.

¹³⁶ Fletcher, *Great Tank Scandal*, p. 111.

¹³⁷ NCL, MSS CHERWELL CSAC 80.4.81/G.368/4-14, 'Special', para. 22, 6 February 1943.

The matter of inadequate inspection within factories was highlighted to Thomas by the Deputy Chief of the Imperial General Staff, Lieutenant-General Ronald Weeks, who reiterated that tank firms were responsible for perfecting the system.¹³⁸ In an attempt to improve both the production situation and arguably the reputations of all concerned, Thomas emphasised to the Crusader production group that 'the condition in which the vehicles are received at the Depot is the responsibility of the Erectors'. Furthermore, Thomas stressed that when a Crusader tank 'leaves any of our factories it should be capable of going straight into action so far as its mechanical condition is concerned'.¹³⁹

In addition to the necessary improvement to the level of inspection carried out by individual firms, there were shortcomings in relation to the method of official inspection at the factories. During July 1942, DCIGS Weeks confirmed to Thomas that 'I cannot see that the Ministry of Supply can ever do much more than a final inspection', with the result that faults on the production line would continue unnoticed without the possibility of being rectified.¹⁴⁰ Having received War Office consent, this official system of only inspecting the finished tank continued until at least 1944, which Thomas rightfully argued 'compared unfavourably' with the method to inspect aircraft which identified faults by reviewing the 'work in progress'.¹⁴¹

The limitations in the standard of Ministry of Supply inspection at the tank firms was partly due to shortages in the number of inspectors, as confirmed during a meeting of the fourth Tank Board in July 1942. The Director-General of Tank Supply, Sir George Usher, highlighted the difficulties of obtaining inspection staff, particularly since the Chief Inspector of Mechanization had lost a number of good inspectors to the Merchant Service as marine engineers.¹⁴² During the August meeting, the chairman of the Supply Council, Sir William Rootes, confirmed that he had secured Treasury authority for the appointment of 300 additional inspectors, together with the upgrading of 80 vehicle drivers.¹⁴³ The situation improved further with the reorganisation and formation of the new Armoured Fighting Vehicle Division under the chairmanship of Commander E. R. Micklem during September 1942 discussed in chapter 2. This created a Director of Fighting Vehicle Inspection, with

¹³⁸ HMC, 80/20/1/7 & 8/19, Weeks to Thomas, 20 July 1942.

¹³⁹ HMC, 80/20/1/1 & 2/1, Thomas to West; 80/20/1/5 & 6/7, Thomas to Foden; and 80/20/1/7 & 8/7, Thomas to Bone, all 10 August 1942.

¹⁴⁰ HMC, 80/20/1/7 & 8/19, Weeks to Thomas, 20 July 1942.

¹⁴¹ HMC, 80/20/1/7 & 8/15, Thomas to Gibb, 10 March 1944.

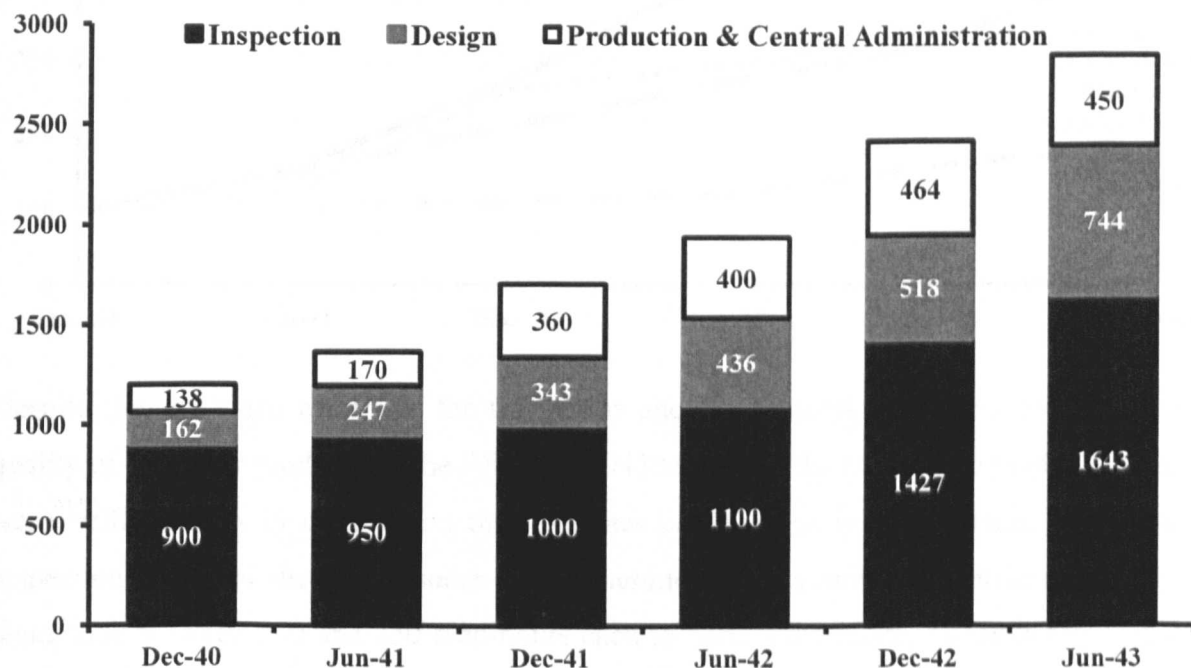
¹⁴² TNA, WO 185/8, '17th Meeting of the Tank Board', 9 July 1942.

¹⁴³ TNA, WO 185/8, '18th Meeting of the Tank Board', 4 August 1942.

responsibilities over both the departmental inspection of finished tanks and inspections within contracting firms to ensure that production was satisfactory.¹⁴⁴

To put the increase in the number of official inspectors into context, Figure 3.10 compares the growth of this section against the changes to the design and administration sections, from December 1940 until June 1943. Whilst inspection represented 75 per cent of all those employed in the Tank Department in December 1940, this proportion fell to 58 per cent by June 1943 as the number of employees in the design section had doubled from 13 to 26 per cent across the same period. The expansion of the administration section was more modest and during June 1943 became the only section to sustain a reduction over the two-and-a-half years.

Figure 3.10 Expanding strength of the Tank Department, by number of employees¹⁴⁵



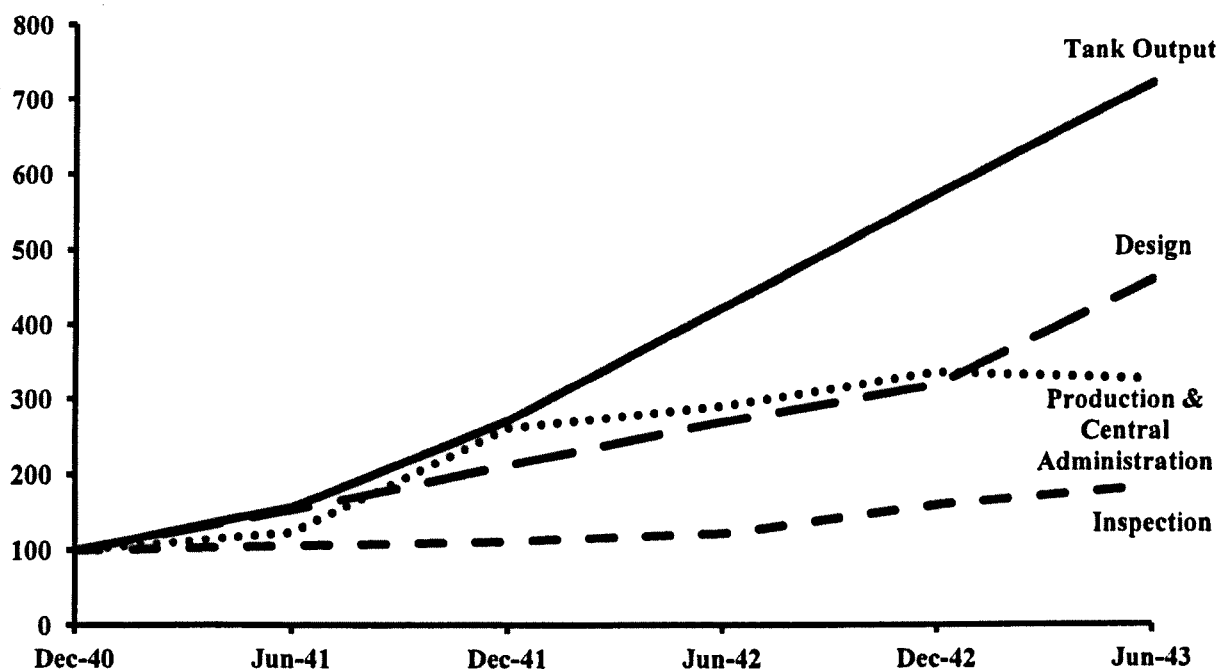
The index of these comparative changes is shown in Figure 3.11 below, which demonstrates how the Tank Department grew in strength relative to the steady expansion in tank output from the position in December 1940. The graph demonstrates that part of the reason why faulty tanks were released to armoured units, was because the gap between the number of tanks being produced and the number of official inspectors available to check for problems at

¹⁴⁴ TNA, AVIA 22/161, Ministry of Supply Memo No. 527, 'Organisation for the Provision of Armoured Fighting Vehicles', 9 October 1942; Cmd. 6865, *War-Time Tank Production* (London, H.M.S.O., July 1946), Appendix A, pp. 19-20.

¹⁴⁵ TNA, AVIA 46/188, 'Numerical Strength of Tank Department', p. 114.

the tank factories, considerably widened over the period. In contrast, the design section expanded by over four-and-a-half times, concluding with an extraordinary increase after December 1942. This final period quantifies the consensus amongst historians regarding the later strengthening of the design department, resulting in the successful A.41 Centurion tank being presented to the executive fifth Tank Board in November 1943.¹⁴⁶

Figure 3.11 Index of the expanding Tank Department and tank output¹⁴⁷



Despite the combined efforts of the tank firms and the Ministry of Supply to increase the quality of Crusader production, the February 1943 report for the Middle East noted that tanks were 'still arriving in a condition that indicates carelessness in manufacture and detailed inspection'. Out of the 41 Crusader tanks examined from a number of different firms, 12 tanks took between 200 and 250 man-hours each to correct the faults, 18 tanks required 250 to 300 hours, 9 tanks required 300 to 350 hours, with the last two tanks between 350 and 500 hours.¹⁴⁸ To put these workshop hours into context, Mechanization & Aero reported that 6,050 machining and assembly man-hours were needed to produce each Crusader tank during 1943.¹⁴⁹ Even allowing for probable variations in man-hours between the different tank firms, Mechanization & Aero would have incurred 248,050 hours to produce 41 Crusader

¹⁴⁶ Postan, et al., *Design and Development of Weapons*, p. 352; D. Edgerton, *Warfare State: Britain, 1920-1970* (Cambridge, Cambridge University Press, 2006), p. 81; TNA, WO 185/8, '36th Meeting of the Tank Board', 22 November 1943.

¹⁴⁷ TNA, AVIA 46/188, 'Numerical', p. 114; 'Monthly Deliveries', pp. 269-271.

¹⁴⁸ NCL, CHERWELL CSAC 80.4.81/G.368/4-14, 'Special', para. 18, 6 February 1943.

¹⁴⁹ HMC, 80/20/1/1 & 2/8, Luyks, Mechanization & Aero to Thomas, 'Assembly and Machining Time in Man Hours', 3 January 1944.

tanks. By taking an average of the time necessary to rectify the faults on all 41 tanks under repair, a total of 11,425 workshop hours would have been required thus representing 4.6 per cent of the total production man-hours identified with Mechanization & Aero.

The effect that the greater emphasis on inspection had upon Crusader production during 1942 was a shortfall in output of 125 tanks against the target of 2,465. This outcome was already expected by Duncan during November that year, who partly attributed this deficit 'to the increased inspection imposed in the interests of improved workmanship'. The other factors were the lack of armour plate above; the shortage of supplies from the United States; and that spare parts were taken from the production line to supply the tanks in the Middle East.¹⁵⁰

The importance of spare parts within any production programme should not be overlooked, as Lieutenant-General Weeks recalls after the war: 'I think I listened to more angry words about spare parts than almost any other subject.' Weeks used his General Staff experience as Director-General of Army Equipment from 1941 and as DCIGS from 1942, together with membership of the fourth and fifth Tank Boards, to provide a generally realistic assessment of the 'life history of a spare part'.¹⁵¹

It is conceived by intelligent R.E.M.E. guesswork, it is born in a factory when it is (frequently) regarded as a nuisance, and sometimes its life is prematurely cut short by utilisation in the production line; if it reaches an R.A.O.C depot like Chilwell, it becomes one amongst at least 500,000 other types of spares, subject to complicated paper-work and book-keeping; if it goes overseas, and it is a vital spare part, it may be sunk; if it goes by air, it may equally crash; if, however, it arrives at its destination, it may have a happy life reclining at Tel-el-Kebir or some such place until peace comes and it is scrapped, or it may find its way up the line into a forward R.E.M.E workshop where Pte Jones may use it for some purpose which was never intended or he may lose it in the mud.¹⁵²

The issuing of spare parts to the Middle East was discussed during May 1941 at the second meeting of the short-lived Tank Parliament discussed in chapter 2, as part of the discussion relating to the repair and maintenance of tanks. The Minister of Supply Duncan confirmed that the supply of spare parts had previously 'been governed by the needs of the strategical situation', which had provided available components for new tank production, rather than

¹⁵⁰ TNA, AVIA 46/188, 'Monthly Deliveries', p. 271; AVIA 11/24, Duncan to Churchill, 9 November 1942.

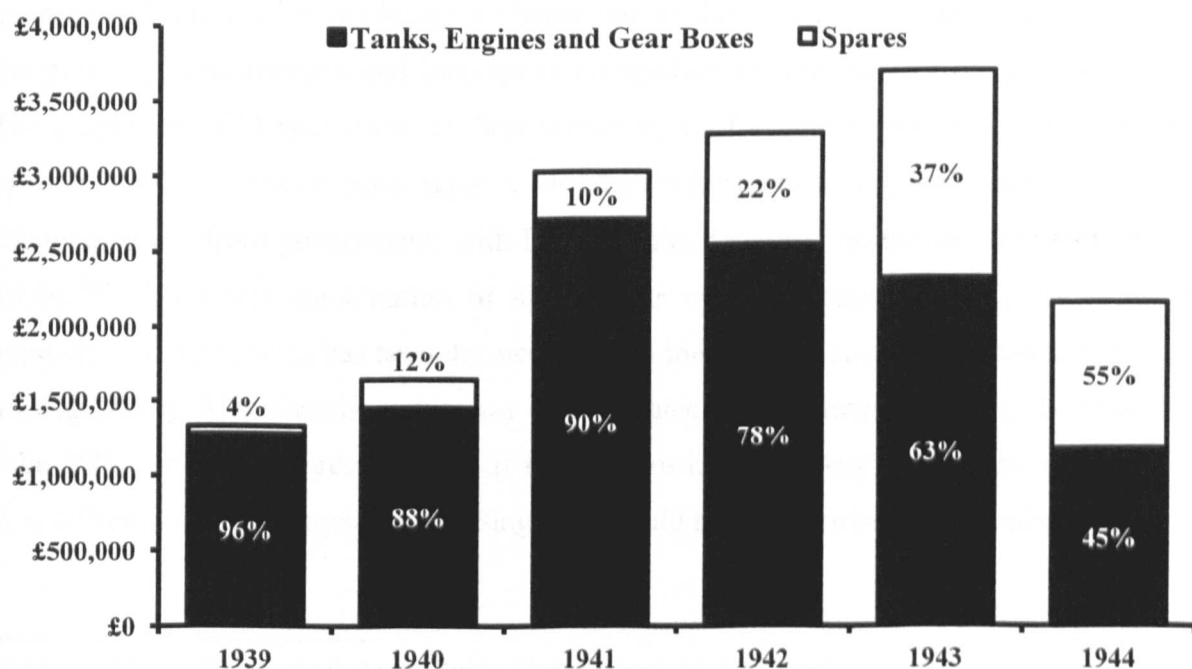
¹⁵¹ Lieut.-General Sir R. Weeks, *Organisation and Equipment for War* (Cambridge, Cambridge University Press, 1950), p. 90.

¹⁵² *Ibid.*

being issued as spares. Whilst the production of spares was now starting to expand, experience in the Middle East had shown that a greater number of spares was necessary than previously estimated.¹⁵³ This increased priority for the Middle East was confirmed at the July 1941 meeting of the second Tank Board, when DAFV Pope stated that the demand for Crusader tank spares was 'fully justified even if it meant reducing the output of Tanks for the month'.¹⁵⁴ This was however contrary to the existing policy of quantity production.

A long-term solution was highlighted by DGTS Usher during a meeting of the third Tank Board in January 1942, as the future tank programme was now 'aimed at greater standardization' thereby improving the supply of spares to the different theatres.¹⁵⁵ Without going into specifics, this standardised programme clearly referred to production of the Cromwell series of tanks from 1943, the details of which will be examined in the next chapter. Meanwhile with the shortages of spares continuing during 1942, the A.F.V Liaison Meeting during October confirmed that the current programme had been adjusted, so that firms were now required to supply spares simultaneously with new tank deliveries.¹⁵⁶

Figure 3.12 Mechanization & Aero Trading Accounts from 1939 to 1944 – Ministry of Supply sales, divided as a percentage of total cost¹⁵⁷



¹⁵³ TNA, CAB 98/20, 2nd Meeting of the Tank Parliament, 13 May 1941.

¹⁵⁴ TNA, WO 185/8, '18th Meeting of the Tank Board', 11 July 1941.

¹⁵⁵ TNA, WO 185/8, '9th Meeting of the Tank Board (Reconstituted)', 8 January 1942.

¹⁵⁶ TNA, WO 185/7, 2nd A.F.V. Liaison Meeting, 27 October 1942.

¹⁵⁷ MRC, MSS.226/NM/2/1/5-8, 'Trading Account', 1939-1944.

The transformation of the tank programme to meet the growing demand for spares, that were separate from engines and gear boxes, is displayed in Figure 3.12 above for Mechanization & Aero. This demonstrates that whilst Ministry of Supply 'sales' greatly expanded after 1940, the requirement for spares remained a low priority until 1943 with the planned simultaneous output alongside tank deliveries achieved during 1944. The reduction in the tank programme as indicated by the falling sales after 1943 will be examined in chapters 4 and 5, when the tank programme had transferred from quantity to quality production.

The shortage of spare parts specifically for home units came under top level scrutiny during July 1941, when the supply Defence Committee noted that nearly 26 per cent of all the tanks in static workshops or with units were recorded as 'unfit for action'.¹⁵⁸ When this number deteriorated to 27 per cent during the following week, Churchill understandably stated to Margesson and Lord Beaverbrook that this was 'far too high'. Churchill judged that the number of unfit tanks 'ought never to exceed 10 per cent' and instructed the Secretary of State for War to put forward proposals to remedy the situation.¹⁵⁹

Kevin Jefferys points out that Margesson was considered a 'Chamberlainite' in Churchill's government, and carried the legacy of being one of the 'Guilty Men' who were blamed for the policy of appeasement and inadequate preparation for the military campaigns in 1940. The promotion of Margesson to the War Office during December 1940 was in part designed to maintain Conservative party support for Churchill by off-setting the removal of another Chamberlainite from government, with Lord Halifax departing as ambassador to the United States.¹⁶⁰ With this combination of his pre-war reputation and ulterior motives for his appointment, Margesson has been deemed to be an ineffective Secretary of State for War. As highlighted by Alex Danchev, this was demonstrated when former CIGS Field-Marshal Sir John Dill, criticised Margesson in April 1942 for his lack of support when they worked at the War Office, with the suggestion that Singapore could have otherwise been reinforced.¹⁶¹

¹⁵⁸ TNA, PREM 3/426/16, 'Tank Return for the United Kingdom', 2 July 1941.

¹⁵⁹ TNA, PREM 3/426/4, Churchill to Margesson and Beaverbrook, 11 July 1941.

¹⁶⁰ K. Jefferys, *The Churchill coalition and wartime politics, 1940-1945* (Manchester and New York, Manchester University Press, 1991), pp. 37, 47, 55 & 93-94; the reputation of Margesson as a 'Chamberlainite' was noted by Soviet Ambassador Ivan Maisky: J. Beaumont, *British Aid to Russia, 1941-1945: Comrades in Arms* (London, Davis-Poynter, 1980), p. 75.

¹⁶¹ A. Danchev, 'Dilly-Dally', or Having the Last Word: Field Marshal Sir John Dill and Prime Minister Winston Churchill', *Journal of Contemporary History*, Vol. 22, No. 1 (Jan., 1987), p. 28; Jefferys, *Churchill coalition*, p. 108n.

Whilst this study does not dispute these opinions, in his reply to Churchill, Margesson did identify the departments or units responsible to account for such a high proportion of unfit tanks, and provided a series of common sense recommendations to approach the problem. Firstly, it was necessary for the Ministry of Supply to maintain a 'balanced production' to ensure that the tanks arrived to units complete with the necessary ancillary equipment. Secondly, in relation to tanks awaiting spare parts for more than 14 days, a joint arrangement with the Ministry of Supply meant that War Office store departments could now obtain the components direct from the manufacturers. Thirdly, the link between poor tank design and the number of unfit tanks did not escape attention with Margesson highlighting that the *Covenanter* and *Matilda* were 'mechanically unsound in certain particulars'. Fourthly, the unit workshops themselves were examined regarding the speed at which they could affect repairs and efforts to remedy the shortage of skilled technicians continued, including taking skilled labour from industry as a last resort. Finally, the inexperience of units in new armoured divisions meant that improvements in maintenance would not be seen until operators had acquired the necessary 'degree of skill and familiarity' with the equipment. Furthermore, Margesson suggested that a complete overhaul in static workshops should occur after a certain mileage and that on-going repairs be carried out in unit workshops, when the spares and skilled personnel position had improved.¹⁶²

The suggested transfer of additional skilled labour from industry to unit workshops would have been affected by the ban on the call-up of skilled mechanical and engineering workers from November 1941 until August 1942. This decision followed the report from a committee appointed by Bevin and headed by Sir William Beveridge, which was designed to investigate and ultimately corroborated the belief that the armed services, and in particular the army, were allocating skilled workers incorrectly. As highlighted by Frederick Perry, the War Office carried out a similar investigation and although they considered the number of inappropriate cases to be minimal, the system of allocating tradesmen was re-examined.¹⁶³

Despite Margesson's recommendations for improvement and before the stoppage of skilled workers being allocated to unit workshops from industry, by September 1941 the percentage of unfit tanks had increased by one point to 28 per cent. However, success was achieved by

¹⁶² TNA, PREM 3/426/4, Margesson to Churchill, 15 July 1941.

¹⁶³ Cmd. 6339, *Committee on Skilled Men in the Services* (London, H.M.S.O., 1942); F. W. Perry, 'Manpower and Organisational Problems in the Expansion of the British and other Commonwealth armies during the two World Wars' (PhD thesis, University of London, 1982), p. 122.

reducing the number of tanks awaiting spares after 14 days, from ten per cent in June to just three per cent.¹⁶⁴ The situation did improve by September 1942 when unfit tanks accounted for 21 per cent with a further reduction to 18 per cent by November. However by April 1943 this remained unchanged and was still greater than the ten per cent sought by Churchill.¹⁶⁵ This highlights the conflicting demands between the mass production of tanks on the one hand, many of which were taken straight from the 'drawing-board', and maintaining a sufficient quantity of battleworthy tanks within armoured units on the other.

The fifth and final stage of the production life span reviews the decisions to either place continuation orders for the tanks currently under assembly or cancel the contract altogether in preparation for a later tank design. The historiography highlights how the decisions to maintain instead of cancelling the production of obsolete British tanks during the first half of the war, affected the fighting capabilities of tank units during 1941 and 1942 and especially as late as 1944 in Normandy.¹⁶⁶ Whilst this is credible, these arguments do not fully appreciate the decision making at the time, which had to measure the effect upon tank output, labour resources and the supply of materials, when an obsolete tank was cancelled. Furthermore and as examined in chapter 6, continuation orders for the Valentine tank were necessary as part of the political decision to provide these tanks to the Russian war effort.

During December 1940 and March 1941, additional Covenanter tank orders were placed with English Electric, with Leyland receiving similar orders during January and April 1941.¹⁶⁷ Rather than being a misguided expression of confidence in an unreliable vehicle, the second Tank Board stated that continuation orders were necessary to ensure that firms incurred 'no gap in production', when transferring to new designs towards 1943.¹⁶⁸ This concern related to the uninterrupted expansion of production, supported by a manpower programme that had mobilised an additional 1.6 million men and women into the munitions industries, from June

¹⁶⁴ TNA, PREM 3/426/16, 'Tank Return for the United Kingdom', 24 September 1941.

¹⁶⁵ TNA, CAB 120/355, 'State of Readiness of Operational Tanks', 17 September 1942 and 26 November 1942; 'Summary of Tank State of Readiness', 7 April 1943.

¹⁶⁶ D. French, *Raising Churchill's Army: The British Army and the War against Germany 1919-1945* (Oxford, Oxford University Press, 2001), pp. 102 & 107; Buckley, *British Armour*, pp. 105-106.

¹⁶⁷ BLO, MS. Marconi 2724, 'War Diary of the English Electric Company Ltd. March 1938 - August 1945', entries for 10 December 1940 and 21 March 1941; BCVM, M632 143/5, 'Comparative Statement of Orders Received', April 1941.

¹⁶⁸ TNA, WO 185/8, '16th Meeting of the Tank Board', 23 May 1941.

1940 to June 1943.¹⁶⁹ From an industrial perspective, an important reason for avoiding inactive production was the retention of the existing labour force, rather than having workers mandatorily redirected to another firm that required such manpower. Sir Miles Thomas, on behalf of the Crusader Group, highlighted these concerns to the Ministry of Labour and National Service during August 1942, when discussing the upcoming transfer of production to the Cavalier or Centaur tank:

But I regard it as highly important that the machining firms, i.e. Mechanization & Aero Ltd., Morris Engines Ltd., Wolseley Motors Ltd., Morris Commercial Cars Ltd., and Ruston Hornsby do not have any of their skilled labour, either in the shops or in the executive offices taken away. As you know, a change-over in machining involving new tooling and jigging puts a very heavy demand on the technical executive and skilled labour, and it would be an appalling tragedy if we were to lose any such people during the forthcoming change-over.¹⁷⁰

In August 1941, the executive third Tank Board reaffirmed the decision not to cancel the Covenanter outright, although it 'should be eliminated as soon as possible' as it 'was the least satisfactory' tank under production.¹⁷¹ As a result, Leyland was requested to raise their deliveries to 40 per month, although the highest individual output was of 35 tanks during August 1942.¹⁷²

This continuation policy was applied to the Churchill tank during 1942, when DGTS Usher stated that a further 1,000 tanks were necessary to ensure that there 'was not to be a break in production', following completion of the original 3,000 vehicles.¹⁷³ Concern was expressed by Major-General Weeks towards this proposal, with particular details provided in a letter to the Tank Board chairman Geoffrey Burton the following day. The major areas of dissatisfaction in relation to this continuation order were:

- (1) The percentage of Churchills off the road at 15/1/42 was 42%.

This is an appalling number inasmuch as there are no tanks under-going routine overhaul and the majority of the tanks are new.

- (2) The casualties are due almost entirely to defects in design.

¹⁶⁹ M. Gowing, 'The Organisation of Manpower in Britain during the Second World War', *Journal of Contemporary History*, Vol. 7, No. 1/2 (Jan. - Apr., 1972), pp. 150 & 152.

¹⁷⁰ HMC, 80/20/6/38 & 39/16, Thomas to Egerton-Banks, 26 August 1942.

¹⁷¹ TNA, WO 185/8, 'First Meeting of the Tank Board (Reconstituted July 1941)', 1 August 1941.

¹⁷² BCVM, M632 143/5, 'Mark V', August 1941; TNA, AVIA 46/188, 'Monthly Deliveries', p. 271.

¹⁷³ TNA, WO 185/8, '10th Meeting of the Tank Board (Reconstituted)', 20 January 1942.

- (6) . . . We are not prepared to order more until or unless we can have assurances that battleworthy tanks are going to be produced.
- (8) The War Office Maintenance Department cannot be expected to (nor are they designed to) deal with a fleet of tanks which break down for design reasons almost as soon as we have received them.¹⁷⁴

Burton conveyed the same concerns to the Managing Director of Vauxhall Motors, C. J. Bartlett, as the Parent firm for the Churchill production group.¹⁷⁵ When a 'break in production' was discussed again during the next Tank Board meeting, Major-General Macready stated that the General Staff could not use more than 3,000 Churchill tanks in any event. The Tank Board therefore agreed that 'no further orders for Churchills should be placed' and that Vauxhall Motors should be approached to attend a special meeting with the board to discuss the situation.¹⁷⁶ During the meeting a compromise was reached for a continuation order of 500 Churchill tanks, instead of the 1,000 requested, in order to avoid a break in production and to facilitate the transfer of 'Churchill capacity for another tank'.¹⁷⁷

This change-over was expected to take place at the end of May 1943 following the completion of 3,500 tanks, at which point industrial capacity would convert to produce the Cromwell type powered by the Meteor engine.¹⁷⁸ Whilst the continuation order was meant to prevent a loss in output, a joint memorandum from the Secretary of State for War P. J. Grigg and Minister of Supply Duncan during August 1942, anticipated that the change-over would still sacrifice 400 production tanks.¹⁷⁹ This opinion was later confirmed by the operations Defence Committee, in full recognition of the detrimental impact upon overall tank output.¹⁸⁰ This remained the General Staff policy at the end of 1942, when DCIGS Weeks advised the AFV Liaison Meeting that Churchill production should cease at 3,500.¹⁸¹ When this is compared against production activity, the information used to compile Appendix 1 show that the order of 3,500 was not achieved until September 1943, instead of the May forecast above.

¹⁷⁴ TNA, WO 185/8, Weeks to Burton, 21 January 1942.

¹⁷⁵ TNA, WO 185/8, Burton to Bartlett, 22 January 1942.

¹⁷⁶ TNA, WO 185/8, '11th Meeting of the Tank Board (Reconstituted)', 11 February 1942.

¹⁷⁷ TNA, WO 185/8, '12th Meeting of the Tank Board (Reconstituted)', 17 February 1942.

¹⁷⁸ TNA, WO 185/8, '13th Meeting of the Tank Board', 7 May 1942.

¹⁷⁹ TNA, CAB 121/261, 'Tank Production by Vauxhall Group', by Grigg and Duncan, 7 August 1942.

¹⁸⁰ TNA, CAB 121/261, War Cabinet, Defence Committee (Operations), 11 August 1942.

¹⁸¹ TNA, WO 185/7, '8th A.F.V. Liaison Meeting', 8 December 1942.

The technical problems experienced during the development of the Cromwell prototype, discussed in the next chapter, meant that the date to commence production was delayed. In weighing up this deferment, Grigg and Duncan estimated during January 1943 that Vauxhall would not be able to commence Cromwell production until early 1944, and following a period of four to five months after completing Churchill deliveries. Similar to the concerns previously raised by Thomas, the effect that this break would have upon industry was measured in the 'risk that labour in this capacity would not be fully employed and that the labour forces would consequently be lost or reduced'. To alleviate this risk, a further order for 500 Churchill tanks 'embodying all recent improvements, which would be sufficient to bridge this gap', was jointly recommended by the War Office and the Ministry of Supply.¹⁸² The War Cabinet approved this decision therefore increasing the total Churchill order to 4,000 tanks.¹⁸³ Details of this decision was discussed at the next meeting of the fifth Tank Board, whereby the General Staff expressed the desire that these additional vehicles should be fitted with the new 75-mm medium velocity gun currently undergoing trials.¹⁸⁴

In addition to the risk of lost output and inactive or reduced labour resources, the consequences of cancelling a tank order in preparation for a later tank design could also affect how component suppliers provided the material to finish the contract. In February 1942, it was agreed that London Midland Scottish would cancel their remaining Covenanter order at Crewe and redistribute material requirements between Leyland and English Electric.¹⁸⁵ However, rather than receiving the remaining material by November 1942 as expected when Leyland was due to change-over to commence mass production of the new Centaur tank, the final material delivery did not arrive until January 1943. The reason for this delay was an understandable shift in focus by suppliers to produce materials for the new Centaur, but at the expense of residual Covenanter requirements. Therefore, the expansion of Centaur production was impeded for two months whilst Leyland had incomplete Covenanters taking up valuable floor space.¹⁸⁶ The monthly tank deliveries for January 1943 suggests that English Electric had a similar experience, with Centaur production commencing as the Covenanter order completed.¹⁸⁷

¹⁸² TNA, CAB 121/261, 'Tank Production by Vauxhall Group', by Grigg and Duncan, 20 January 1943.

¹⁸³ TNA, CAB 65/33/12, War Cabinet, '8. Tank Production', 20 January 1943.

¹⁸⁴ TNA, WO 185/8, '25th Meeting of the Tank Board', 25 January 1943.

¹⁸⁵ BCVM, M632 143/5, 'Covenanter Tank', February 1942.

¹⁸⁶ BCVM, M632 143/5, 'Covenanter Tank', August and November 1942.

¹⁸⁷ TNA, AVIA 46/188, 'Monthly Deliveries', p. 271.

In conclusion, when Prime Minister Churchill characterised the war in November 1942 as the 'end of the beginning' in light of recent successes in North Africa, the same term can also be applied to the state of the British tank programme as the war continued into 1943.¹⁸⁸ This was shown by the curtailment of Covenanter and Matilda production; the continuation of the Valentine, Churchill and Crusader contracts; and with the introduction of the new Cavalier, Centaur and Cromwell tanks. This chapter has reviewed the five stages of the tank production life span under a programme that responded to the deteriorating strategic situation in 1940, by demanding the mass production of tanks from an expanding industry.

With regards to the first stage, whilst the General Staff reacted to the change from static to mobile warfare from mid-1940 by requiring greater numbers of Cruiser than Infantry tanks, the production line could only change slowly. This was seen in the output for 1941 and 1942 that produced more Infantry than Cruiser tanks in proportions that were contrary to General Staff requirements over the same period. With regard to tank characteristics, the demand for reliability became paramount even at the expense of heavier armour, whereas greater firepower remained a high priority but incorporation into later tank designs was delayed by the need for quantity. The 1938 tank programme expanded during 1939 and 1940 to include 15 tank firms with 5,498 tanks under order for a contract value of over £81 million. Sixty-one per cent of these orders favoured the Infantry tank and in accordance with General Staff requirements prior to the defeat of France, although the higher basic cost price meant that Infantry tanks accounted for 66 per cent of the total cost. The demand for Infantry tanks extended to Canada with serious consideration given to the prospective Churchill tank before deciding upon the Valentine, as this tank had been accepted by the General Staff and could be mass produced following the loss of equipment in France. The introduction of the Churchill programme in Britain during 1941 and the expansion of Crusader production in 1942, increased the number of tank assembly firms to 27 with the majority concentrated in the northern Home Counties, the Midlands and the north of England. The number of separate component contractors varied for each tank programme, although the regional division was similar to tank assembly, with the exception of Scotland which had an increased involvement.

As for government action under this first stage, the 'Priority of Production Directive' from May 1940 co-ordinated industrial activity, but in keeping with Britain's strategic reality gave

¹⁸⁸ W. S. Churchill, speech at the Lord Mayor's Day luncheon, 10 November 1942, in C. Eade, *The War Speeches of Winston S. Churchill*, Vol. II (London, Purnell and Cassell, undated), pp. 341-345.

aircraft and anti-aircraft equipment dominance over the tank programme until late 1941. This hierarchy was fully endorsed by Churchill, who despite demanding a greater supply of tanks following the evacuations from France, was willing to sacrifice the tank programme in order to maintain the high production of aircraft.

In respect of air raid precautions, the government provided financial support towards the £1.3 million incurred by the 13 firms under review up to 1940, together with the on-going commitment towards maintaining camouflage and shelters during the war. The outbreak of war resulted in redundancies whilst civilian production was cut back, although some workers were retained through redeployment onto ARP work until war production expanded, with many workers volunteering in response to the emergency. Once the bombing had begun, the employment of a roof spotter system gave industry control over their production stoppages with a quantifiable reduction in lost time.

After considering the risk to output, the government supported the dispersal of factories and reimbursed the firm for the costs associated with crown plant and equipment, although disputed the relocation costs of the firm's own equipment. The method of government reimbursement for the expansion of industry went through a number of changes during the war, all of which were designed to meet the demands of increased production whilst not permitting the firm to unduly benefit. The success of this expansion scheme was seen with the Crusader programme, which had all but one of the firms reach or substantially exceeded the projected maximum monthly output.

The second stage of the production life span concerns the experience of industry in establishing or preparing new factory space after receiving an initial tank order. Delivery of the first tank could take between 13 and 18 months after the order date and whilst the original production forecast was too optimistic, delays were nonetheless caused by a combination of poor weather, a shortage of materials and labour, and enemy bombing.

The third stage relates to how the shortages of labour and materials affected the ability of industry to sustain the required level of output. Prior to the outbreak of war, some firms were able to compensate for the lack of labour by transferring more 'boys' to the production line, and transferring skilled workers from the night-shift to make up the shortfall during the day-shift. The process of dilution continued, albeit with understandable concerns regarding the

drop in efficiency following each transfer as the best semi-skilled workers were given priority. The introduction and expansion of women into industry made it possible for some factories to extend shift work to 24-hours per day for an entire week, although female conscription could affect the administrative efficiency of a tank Parent firm. The emergence of women also meant that large firms had to provide lavatories and shared canteens as part of an overall programme for greater welfare, albeit not without complaints in respect of the canteen operation. An increase in output was achieved by the temporary transfer of labour from the Air Ministry or other tank firms during the change-over of production to a new tank model. In the case of Churchill production with Leyland Motors, the shortage of 'free issue' items such as gear boxes or suspension systems, affected the monthly output of tanks by as much as one-third and delayed completion of the order by two months.

The fourth stage of the production life span highlighted that a consequence of not maintaining the number of official inspectors necessary to meet the demands of quantity production was an increase in the level of poor workmanship. The comparative trials of tanks in Britain revealed that many faults did originate during production, or from the existing design as highlighted by the different maintenance requirements to be carried out throughout the service life of the tanks. However, the overall level of quality of these tanks should be regarded as very impressive when considering that these tank mileages were markedly similar to the standard of British motor cars of the time. The result of an increased emphasis upon inspection was that fewer production tanks were delivered. Furthermore, whilst the numbers of official inspectors grew at a faster rate after June 1942 in response to the concerns of poor workmanship, the method of inspection omitted the production line so faulty tanks were still sent to armoured units.

A second problem under this fourth stage was that the demand for greater tank output meant a lack of spare parts for maintenance and repair, thus producing a higher percentage of 'unfit' tanks within armoured units, and contradicting the overall desire for more battleworthy tanks. The tank programme from 1943 was expected to avoid these problems with greater standardization, but the existing tank models still had a high proportion of 'unfit' tanks, although improvement was seen in respect of spares due after 14 days. This problem was resolved by 1944 when new production tanks and spares were delivered on an equal basis.

The fifth and final stage of the production life span dealt with the decisions to place continuation orders, even with unsatisfactory tanks, so that the firm would avoid a 'gap in production' with inactive or redirected labour before changing to a later tank design. Where a loss in tank output was accepted the contract was cancelled, although this could take a few months longer than expected with material suppliers prematurely focusing upon equipment for the incoming design, before production of the outgoing tank had been completed.

Ultimately the policy of sustained quantity war production during the first half of the war was incompatible with the intention to provide armoured units with reliable and battleworthy tanks. The main reasons for this antithesis were the decisions to forgo many of the necessary tank trials prior to mass production, inadequate inspection and by the general shortage of spare parts to keep the vehicles operational. However and despite the continued overriding priority of aircraft production, British industrial capacity expanded with new buildings, plant and equipment to produce more tanks during 1942 than during the combined output of rearmament until 1941. Furthermore this was achieved against the persistent delays caused by enemy bombing, a lack of workers, shortages in components and the inability to cancel orders prematurely for the risk of causing a break in production when quantity was stipulated. Finally and as highlighted further in the next chapter, from late 1942 overall tank policy represented the demands of the 'user' and 'supplier' concurrently by being formed on a joint basis between Grigg and Duncan, and then implemented by the executive fifth Tank Board.

Chapter 4

Tank Production, 1943 to 1945

This chapter will continue the examination of British tank production by reviewing the position from 1943 until the end of the war in 1945, under the single and executive direction of the fifth Tank Board examined in chapter 2. The previous chapter discussed how the tank programme from 1939 to 1942 demanded quantity production from British industry in response to the loss of equipment in France during 1940 and with the continued fighting in North Africa. By contrast, the required policy under discussion in this chapter stipulated that the new tank designs must represent quality production, even at the expense of output.

The insistence upon transforming the tank programme to produce tanks of quality was discussed amongst senior War Office and Ministry of Supply officials, during the final meeting of the fourth Tank Board in August 1942. In this instance, the non-executive chairman Lord Weir stated that the programme 'must be governed by the necessity for improved reliability and quality' as exemplified by the new Meteor powered Cromwell tank.¹ As briefly mentioned by John Buckley and examined in greater detail during chapter 2, this move from quantity to quality tank production was further strengthened by the organisational re-structuring that resulted in the executive fifth Tank Board in September 1942.²

Upon reviewing Appendix 1, quantity production appears to have continued with 17,239 deliveries from 1943 until April 1945, particularly when considering that this represented 51.4 per cent of all output during the entire war. However, a more detailed examination reveals that some industrial capacity was transferred during 1943 to the conversion of tanks to fulfil a supporting role, and therefore fewer standard gun tanks were delivered. To quantify this, the proportion of standard tanks delivered during 1943 accounted for 97 per cent of total output, with the amount dropping to just 49 per cent in 1944 and 57 per cent until April 1945. This resulted in the deliveries of standard gun tanks representing 71 per cent of total production activity across the 1943 to 1945 period, with a combined output of 12,181 tanks compared to the 16,300 all standard gun tanks delivered up to the end of 1942.

¹ The National Archives, Kew, WO 185/8, '18th Meeting of the Tank Board', 4 August 1942.

² J. Buckley, *British Armour in the Normandy Campaign 1944* (Frank Cass, London and New York, 2006), p. 165.

Although quality was desired from the new tank programme, problems were encountered with the new Cavalier and Centaur types. This resulted in the deliveries of battleworthy tanks being limited to the Churchill, Heavy Churchill, Cromwell, Challenger and Comet tanks, whilst Valentine production was still required by Russia to support their war effort. To summarise, of the 17,239 vehicles delivered from 1943 until April 1945, 8,211 or 48 per cent were of good quality and could be sent to the front line, with the remainder divided into 3,970 other gun tanks and 5,058 conversions.

In respect of the tanks converted to the different supporting roles required by the General Staff, these varied from: self-propelled artillery; 17-pounder gun tanks; anti-aircraft tanks; mine-clearing tanks; Duplex-Drive tanks; observation post tanks, and Royal Engineer and bulldozer tanks. Many of these conversions became known as 'Hobart's Funnies' and were first introduced during the Normandy campaign as part of the 79th Armoured Division.³ Despite many of these special vehicles being used successfully, Buckley highlights how the specialist tactical training required for some of these supporting roles, meant that tank crews had less time adequately to prepare for 'conventional armoured operations'.⁴

It is not necessary to revisit the experience of industry in relation to air raid precautions, the dispersal of production and the expansion of manufacturing capacity, as the previous chapter discussed these issues for the war as a whole. Therefore this chapter will examine five sections that either emerged during the second half of the war or had already existed during the earlier period but had the greatest impact upon tank output and the transfer to quality production. The first and largest section will identify the principal reasons for the various reductions in General Staff requirements between 1943 and 1945, resulting in some of the 27 tank assembly firms transferring to tank conversion and non-tank work. This will also highlight the organisational structure within Leyland Motors necessary to fulfil their requirements as a Parent firm, and demonstrate how the Nuffield Group retained their Parent responsibilities despite being subordinated to Leyland.

Whilst quality output was now required, this first section will highlight how the rate of production was greater than compared with the earlier tanks as the firms became more adept and that the later tank designs required fewer man-hours to assemble. This ability to produce

³ *Ibid.*, pp. 18-19 & 30.

⁴ *Ibid.*, p. 84.

quality Cromwell tanks in large numbers was seen during the Normandy campaign when industry responded to replace heavy combat losses, albeit at the expense of delaying the change-over to the Comet tank. A demonstration of the quality of British tanks produced during this period was confirmed by front line reports, thereby vindicating the efforts of all those involved in creating battleworthy tanks in large numbers on a sustainable basis.

The second section of this chapter will consider the decisions to choose the Meteor tank engine instead of the Ford V8, together with the placing of orders with Morris Engines and Rover to transfer control away from the Ministry of Aircraft Production. The third section will analyse the requirement and problems for incorporating greater armour protection and by using the production experience of Leyland Motors, how this became possible through the transfer to welded turret and hull construction. The fourth section will review the effect on output by workers taking holidays, which were important to avoid worker exhaustion and to slow the increase in industrial accidents, and by work stoppages through industrial action. Finally, there will be an examination of how industry changed towards the expectations of post-war civilian production and that part of the British peacetime tank programme was met by a newly formed and state owned Royal Tank Arsenal.

As highlighted during the previous chapter, the British tank programme was beginning to transfer some industrial capacity from the pre and early war tank designs to the new Cavalier, Centaur and Cromwell Cruiser designs at the end of 1942. The exceptions were the production of Churchill tanks that had received continuation orders, the Crusader tank that required further modification and as examined later in chapter 6, Valentine production was maintained because of Russian demand. A review of the changes to the anticipated 1943, 1944 and 1945 tank programmes reveals the initial limitations and later chief motivations that resulted in the successful large scale production of quality tanks.

When considering the three new Cruiser tanks, the executive third Tank Board identified during January 1942 that the Cavalier had the least potential and therefore production should terminate at 500 tanks. In the meantime, the tank firms that would have worked on the Cavalier were transferred to the Centaur and later Cromwell programmes after successful acceptance trials. The expectation that this decision would result in 500 fewer Cruiser tanks during 1942 was fully accepted by both the Ministry of Supply and War Office

representatives on the board, as this deficit was set to recover during 1943.⁵ Upon reviewing Appendix 1 the total number of Cruiser tanks delivered during 1943 was 543 more than in 1942, representing 52 per cent of total output and for the first time since 1939 Cruiser output exceeded the number of Infantry tanks. This shift in the tank programme was the result of the General Staff decision during 1940 discussed in the previous chapter, which insisted upon a greater proportion of Cruiser tanks in response to the tactical experience obtained in France.

The General Staff announced in February 1943 that they sought a reduction in Crusader and Valentine production, whilst requesting that the new tanks be introduced as quickly as possible.⁶ However, as indicated in the previous chapter, the speed at which the tank programme could change was still governed by existing contractual commitments and the avoidance of unused or misused labour resources during the change-over. To demonstrate, the forecast from November 1942 for the combined production of Crusader and Valentine tanks during 1943 was for 3,707, compared to the expectation of 3,900 Centaur and Cromwell tanks for the same year.⁷ However, Appendix 1 shows that Crusader and Valentine output during 1943 reached 3,482 which was nearly double the 1,784 Centaur and Cromwell tanks delivered, and less than half of their combined forecasts.

The experience in North Africa coupled with the availability of the British 75 mm gun from July 1943, changed War Office and Ministry of Supply requirements towards tank armament by emphasising greater high explosive rather than armour-piercing capability. The division of tank armament amongst the 1944 programme was quantified during April 1943, with ten per cent of vehicles expected to mount the 95 mm close support howitzer, 60 per cent with the 75 mm, and the remaining 30 per cent with the six-pounder. The last requirement was to fulfil the armour-piercing role under the expectation that the six-pounder would eventually be replaced with tanks capable of mounting either the dual-purpose and high velocity 77 mm or 17-pounder guns.⁸ The former related to the Comet tank from February 1945 with the latter mounted onto the Challenger and Sherman Firefly conversions as an interim measure, until the introduction of the Centurion tank at the end of the European war. Despite this continued separation of tactical ability, six-pounder armed tanks made a significant battlefield contribution during the 1944 and 1945 campaigns in Italy and north-west Europe, especially

⁵ TNA, WO 185/8, '10th Meeting of the Tank Board (Reconstituted)', 20 January 1942.

⁶ TNA, WO 185/7, '14th A.F.V. Liaison Meeting', 2 February 1943.

⁷ TNA, WO 32/10521, 'Home Production Programme', Ministry of Supply, 26 November 1942.

⁸ TNA, BT 87/137, 'Tank Policy', Grigg and Duncan, 30 April 1943; Buckley, *British Armour*, pp. 145-146.

when equipped with the new 'Sabot' ammunition.⁹ This APDS round was more than half the weight of the existing APCBC round and gave between 45 and 50 per cent greater armour penetration at short to medium range.¹⁰

The production of all types for the 1944 tank programme was estimated at the beginning of 1943 to be 7,600. By July 1943, Prime Minister Churchill approved a reduction in the current 1943 and expected 1944 programmes in order to accept an additional 3,000 tanks from the United States spread across both periods. This decision will be examined in the next chapter and was essentially designed to redirect some British industrial capacity towards the production of railway locomotives, rather than importing these from the United States and taking up valuable shipping space. As a result the number of vehicles to be produced in Britain during 1944 was reduced to 6,900, with the Centaur programme sustaining the biggest individual reduction.¹¹ In January 1944, Secretary of State for War P. J. Grigg and Minister of Supply Andrew Duncan, jointly recommended a further reduction to 5,280 vehicles during 1944 with the expectation of 8,500 tanks from the United States.¹²

In addition to receiving greater numbers of Lend-Lease tanks, there were a number of operational reasons behind these successive reductions in the British production programme. To begin with, by July 1943 the Liberty powered Centaur tank remained unfit as a gun tank and was therefore relegated to a training role in addition to some anti-aircraft and 95 mm armed close-support tanks for the Royal Marines Armoured Support Group. In an example of 'user' feedback, trials conducted with the standard Centaur tank by the 9th Armoured Division revealed that 23 out of 129 vehicles suffered from clutch failure, with improvement considered unlikely 'without radically redesigning' the clutch.¹³ This meant that the number of Centaur tanks deemed 'unfit for action' by this particular defect equated to 18 per cent, which was consistent with the findings from April 1943 examined in the previous chapter.

⁹ Cmd. 6865, 'Reply to the memorandum on tank production by the Select Committee on National Expenditure', 2 August 1944, in *War-Time Tank Production* (London, H.M.S.O., 1946), p. 49.

¹⁰ G. Macleod Ross, *The Business of Tanks, 1933 to 1945*, in collaboration with Major-General Sir Campbell Clarke (Ilfracombe, Arthur H. Stockwell, 1976), pp. 330-331; see Figure 12 in Buckley, *British Armour*, p. 175 for a cross-section of each projectile; APDS: Armour-Piercing, Discarding Sabot; APCBC: Armour-Piercing, Capped, Ballistic Capped.

¹¹ TNA, WO 185/6, 'Tank Programme 1944-45', 26 July 1943.

¹² TNA, BT 87/137, 'Tank Policy', 12 January 1944.

¹³ Nuffield College Library, Oxford, Lord Cherwell, CSAC 80.4.81/G369/12-15, 'British Tanks now in Production', 21 July 1943.

By 1944 the output of Valentine tanks had been curtailed with the final deliveries to Russia, whilst other production vehicles were converted to small numbers of self-propelled artillery and Duplex-Drive tanks. With regard to front line gun tanks, these consisted of the Meteor powered Cromwell, Challenger and Comet tanks, whilst the Churchill programme had now expanded to include the Heavy mark VII version.¹⁴ As shown in Appendix 1, this sustainable transition to quality production represented 41 per cent of the 1944 programme, with deliveries of 2,223 Meteor tanks and 1,062 Churchill based tanks. Now only eight per cent of deliveries were other gun tanks, whilst the majority 51 per cent related to the conversion programme, with adaptations to tanks from the United States receiving the most attention.

The same quality based rationale was applied to the 1945 British tank programme which was estimated during January 1944 at 5,500 together with 5,000 tanks from the United States. The production of individual British tanks had now eliminated the Centaur completely and whilst maintaining a strong Heavy Churchill contingent, the Meteor powered Cruiser tanks accounted for 73 per cent of total production.¹⁵ With the recent successes in north-west Europe following the Normandy campaign, and notwithstanding the setback at Arnhem, the 1945 tank programme was reduced during October 1944 with the expectation of the war ending by 31 March 1945. This new programme amounted to 2,850 British tanks split almost equally between the Heavy Churchill on the one hand and the Cromwell, Comet and Centurion on the other, and then 2,730 tanks from the United States.¹⁶ The consequences of this reduction will be discussed in the next chapter when reviewing the direct impact of a complete stoppage of Lend-Lease tanks from the United States during November and December 1944. To put these consecutive changes to the British tank programme into context, Table 4.1 below provides an overall summary of the position from 1943 to 1945.

¹⁴ TNA, BT 87/137, 'Tank Policy', 12 January 1944.

¹⁵ *Ibid.*

¹⁶ TNA, PREM 3/427/9, 'Tank Production Programme', Minister of Production, 4 October 1944.

Table 4.1 Summary of reductions in British tank requirements, 1943-1945

Tank Model	1943 (Note 7)	1944 (Note 11)	1944 (Note 11)	1944 (Note 12)	1945 (Note 15)	1945 (Note 17)
Valentine (incl. SP)	2059	900	900	500	300	
Valentine (incl. DD)				200		
Churchill (incl. Heavy)	1084	1000	1000	1200	1200	1430
Crusader (incl AA)	1648					
Cavalier (incl. OP)	495			80		
Centaur (incl. AA)	2935	2700	2000	800		
Meteor engined Tanks	965	3000	3000	2500	4000	1420
Total Requirements	9186	7600	6900	5280	5500	2850
Lend-Lease Expectations				8500	5000	2730

An important reason why quality production was achievable between 1943 and 1945 was that the tank programme did not introduce any new firms to tank assembly beyond the 27 identified in the previous chapter. Furthermore, as the General Staff requirement for British tanks reduced each year, this permitted some capacity to transfer to tank conversions or non-tank work, such as for the Admiralty, wheeled vehicles, engineering stores and civilian locomotives. The particular changes for each firm, as determined in October 1944, are provided in Appendix 6 which compares the production activity during 1942 against the position from 1943 to 1945. This demonstrates how the number of firms working on tank assembly fell from 27 to 19, with a further contraction to 11 firms when considering just the quality production of the Cromwell, Comet and Churchill tanks during 1944 and 1945.

The involvement of some of these firms has been duplicated as they were involved in more than one activity across the later period, albeit not always simultaneously. For example, Metropolitan-Cammell assembled the Cromwell and Comet tanks, whilst also working on Valentine and Sherman Duplex-Drive conversions during the 1943 to 1945 period. The large reduction in the Centaur programme for 1944 described above meant that Harland & Wolff could return to Admiralty work, whilst Ruston-Bucyrus transferred to engineering stores. In the case of Mechanization & Aero, they went from Centaur tank production to the conversion of the same base vehicle to anti-aircraft tanks highlighted above.

One of the problems associated with the substantial and sudden reductions in tank orders related to the storing of materials and completed tanks that were now surplus to requirements. The concern of Mechanization & Aero was that unless the excess material already received for the Centaur programme was taken away, they would 'refuse to accept or unload further

The administrative organisation required by Leyland following these changes is provided in Figure 4.1 above, displaying the division of full-time responsibility from April 1943. These included the separation of duties amongst engineering, production, plant and foundry capacity, material control and finally inspection. A number of Centaur tank firms, such as Fodens, Ruston-Bucyrus and West's Gas were already under the parentage of the Nuffield Organisation, which could have meant unnecessary confusion and duplication of effort with the parentage of Leyland. These changes were discussed at the General Policy Meeting at the Ministry of Supply during May 1943, which included the Tank Board chairman Commander Micklem and the Assistant Chief of the Imperial General Staff Major-General John Evetts. As a result, Sir Miles Thomas secured an agreement that the Nuffield Group "would retain their separate entity as a production parent" as part of the 'larger group under the general parentage of Leyland Motors'. This two-tier system of responsibilities was clarified by Thomas to each assembly firm, thereby confirming that individual dependent firms would continue to request and receive information and materials from the Nuffield Organisation as their Parent.¹⁹

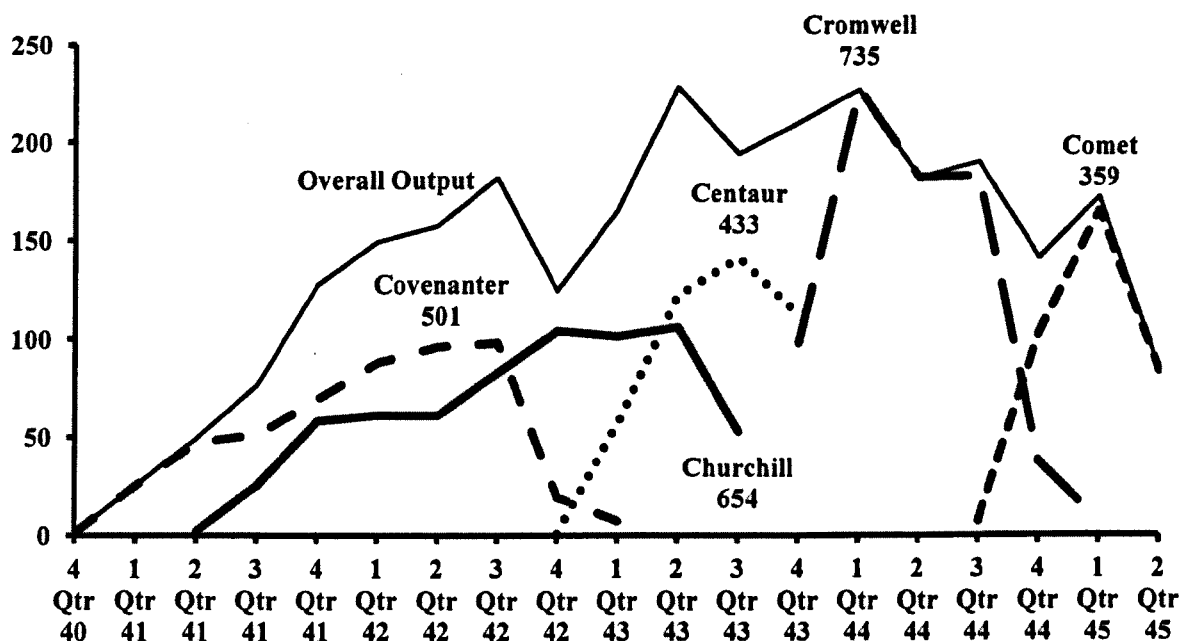
Although the reduction in British output for 1945 was premature with fewer tanks delivered to front line units, the tanks were of good quality and reliability with the latest Comet tank mounting greater firepower. This was a complete reversal of the theme of the previous chapter, which was dominated by the production of too many unreliable and inadequately armed tanks in direct response to the demand for quantity output. Whilst the overall number of tanks under the British programme reduced from 1943 until the end of the war, the production efficiency of tank firms had increased as displayed by Figure 4.2 below for the quarterly output from Leyland. The graph demonstrates that when compared to the earlier tank programmes, the deliveries of quality Cromwell and Comet tanks during 1944 and 1945 expanded at a faster rate and in greater numbers over a shorter period of time, whilst still being affected by material shortages.²⁰ In respect of total output for each quarter, Leyland delivered almost as many Cromwell tanks during the first quarter of 1944 as the combined output of Churchill and Centaur tanks during the second quarter of 1943. A similar comparison occurred in respect of Comet output during the first quarter of 1945 and the combined deliveries of the Covenanter and Churchill during the third quarter of 1942. The

¹⁹ HMC, 80/20/1/5 & 6/7, Thomas to W. Foden, Fodens Ltd; 80/20/1/7 & 8/7, Thomas to V. W. Bone, Ruston-Bucyrus; 80/20/1/1 & 2/1, Thomas to E. West, West's Gas, all 6 May 1943.

²⁰ Cromwell: BCVM, M631 143/5, 'Ministry of Supply Contracts', January to April, June, August, November and December 1944; Comet: M631 143/5, 'Ministry', September and October 1944 and April 1945.

significance of these examples was that the two later periods only produced front line tanks, whereas the earlier periods included the output of unbattleworthy Covenant and Centaur tanks.

Figure 4.2 Quarterly production figures for Leyland across five tank programmes totalling 2,682 deliveries, from Dec-40 to May-45²¹



The immediate transfer from the Centaur to the Cromwell tank was due to the design similarities between the two models, resulting in sustainably high numbers of Cromwell deliveries. The Comet tank had a number of design and production differences including a welded hull construction, that required specific jigs or 'manipulators' which will be examined below in relation to tank welding. Whilst this change in assembly organisation resulted in an initial loss of output, Leyland reported that labour resources had not been affected by the change-over and as seen above a high rate of production was quickly established.²² The reduction in Comet deliveries during the second quarter of 1945 related to the end of the war in Europe.

Greater output was also achieved with the later tank designs due to reductions in the number of man-hours necessary to complete each tank. With regard to the overall machining and assembly, each Centaur tank required approximately 5,600 man-hours compared to 6,900

²¹ TNA, AVIA 46/188, 'Monthly Deliveries', draft official history narrative by D. Hay, after 1950, pp. 269-271; BCVM, M632 143/5, meetings, 1941 to 1943; M631 143/5, General Manager's Meeting, 1944 to 1945.

²² BCVM, M631 143/5, 'General', October 1944.

hours for the Covenanter, and 6,050 hours for the Crusader by Mechanization & Aero. The reductions in man-hours to assemble the 28 ton Centaur is in contrast to the overall increase in weight when compared to the 18 ton Covenanter and 20 ton Crusader.²³ In respect of the 28 ton Cromwell tank, during November 1943 Leyland reported that an extra 40 hours assembly time was needed compared to the Centaur, due to the additional work relating to the preparation and installation of the Meteor engine.²⁴ Despite the additional work on the Cromwell, the total requirement of 5,640 man-hours was still less than the Covenanter and Crusader, and as shown in Figure 4.2 Leyland delivered more Cromwell tanks overall and in any one quarter. To sum up, the greater rate of output during 1943 and 1944 can be attributed to: the concentration of effort with fewer tank firms; improved production techniques through this increase in experience; the use of specialist jigs and equipment during tank assembly; and that the original designs of later tanks required fewer man-hours to complete overall.

To put these tank man-hours into context with aircraft, Sebastian Ritchie points out that in respect of airframe assembly, 51,000 'direct man-hours' were necessary for the Lancaster in 1941 and 20,000 man-hours by 1945 following organisational improvements.²⁵ The benefit of requiring fewer man-hours to assemble the heavier tanks above was also experienced within aircraft production, as the official history states that 'the heavier aircraft continued to require much less manpower per pound of weight than the lighter ones'.²⁶ This general improvement in the efficiency of British war production has been further emphasised by Ritchie, who argues that contrary to the 'pessimistic' opinion of Professor Postan and Correlli Barnett, 'the British aircraft industry was more efficient than its German counterpart'.²⁷

In respect of German tank production, Richard Overy highlights that industry was 'notoriously inefficient' until the programme had converted to 'flow production' in 1943, resulting in the number of man-hours for the Panzer Mark III falling from 4,000 to 2,000.²⁸ Despite this improvement in productivity, the Panzer III was no longer an effective front line tank when compared to the Cromwell, Sherman or Russian equivalents. Overall, the ability

²³ BCVM, M632 143/5, 'B/X Factory', July 1942; HMC, 80/20/1/1 & 2/8, Luyks, Mechanization & Aero to Thomas, 'Assembly and Machining Time in Man Hours', 3 January 1944.

²⁴ BCVM, M632 143/5, 'Cromwell Tank', November 1943.

²⁵ S. Ritchie, *Industry and Air Power: The Expansion of British Aircraft Production, 1935-1941* (London and New York, Routledge, 2007), pp. 243-244.

²⁶ M. M. Postan, *British War Production* (London, H.M.S.O. and Longmans, Green & Co., 1952), p. 171n.

²⁷ S. Ritchie, 'A New Audit of War: The Productivity of Britain's Wartime Aircraft Industry Reconsidered', *War & Society*, Volume 12, Number 1 (May, 1994), p. 141.

²⁸ R. Overy, *War and Economy in the Third Reich* (Oxford, Clarendon Press, 1995), p. 369.

of British industry to produce Cromwell tanks in large numbers raised the prospect of increasing the output of this operationally effective tank in response to the demands from the front line, such as following the invasion of north-west Europe in June 1944.

When considering the attritional nature of the Normandy campaign, John Buckley highlights that the loss of over 400 tanks during Operation Goodwood did not cause equipment shortages for front line units, although morale and confidence did suffer.²⁹ These losses consisted of British and American tanks from the 7th, 11th, and Guards Armoured divisions, with many of them being recovered and repaired in the field for future combat.³⁰ A number of extensively damaged Cromwell tanks were shipped back to Leyland during July and August in the hope that they could be rebuilt. This return was not prompted by faults with the vehicles but instead due to the close proximity of the Normandy battles discussed later, as illustrated when Leyland described the 'majority of the tanks appeared on examination to be too badly smashed up to be worth repairing'.³¹

In respect of replacement Cromwell tanks direct from the production line, Leyland received notice during July 1944 that 'losses in tanks were very high, and these can only be made good by new tanks built in this country'.³² The emphasis upon greater output following heavy combat losses is shown in Figure 4.3 below, which compares Cromwell and Comet production against their respective forecasts. Cromwell production followed the anticipated programme until July when output declined against expectations, after which there was a marked increase in deliveries during August in response to information being received from Normandy. With regards to July production, Leyland partly attributes the fall in output to the annual worker holiday, discussed later in this chapter, which can also account for the overall reduction in Cromwell deliveries for this month from the other firms.³³ The decrease in the Cromwell forecast after July was in accordance with the planned transfer to Comet production amongst the same assembly firms, with large scale deliveries due to commence in August. Whilst the first Comet tanks were released in September the rate of output was much smaller and slower than planned, as tank firms reacted to battlefield demands with Cromwell production continuing until April 1945.

²⁹ Buckley, *British Armour*, p. 36.

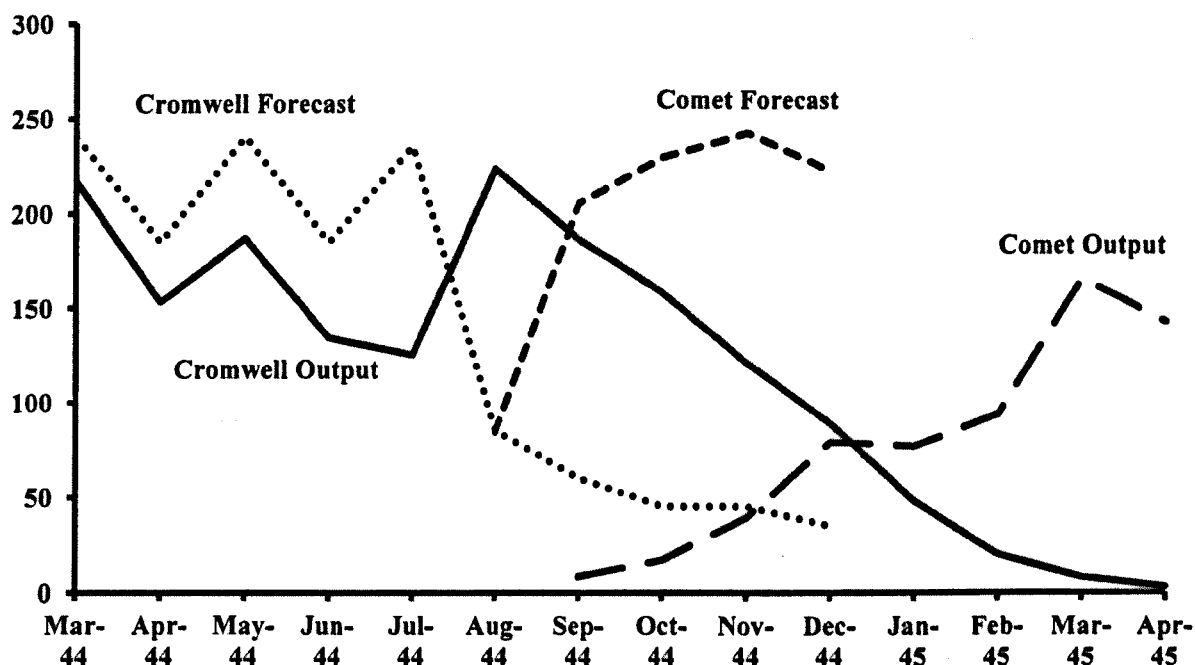
³⁰ E. Belfield and H. Essame, *The Battle for Normandy* (London, Batsford, 1965), p. 145.

³¹ BCVM, M631 143/5, 'General', August 1944.

³² BCVM, M631 143/5, 'General', July 1944.

³³ BCVM, M631 143/5, 'Cromwell Tank', July 1944.

Figure 4.3 Cromwell and Comet tank forecasts and output, Mar-44 to Apr-45³⁴



The poor reputation of British tanks reviewed in the previous chapter during the fourth stage of the production life span, was overturned between 1943 and 1945 when tank firms received operational feedback that demonstrated quality output of the latest tanks had been achieved. In March 1943, a technical report on the North African campaign reported that the reworked Churchill tanks of the 25th Army Tank Brigade completed '400 to 500 miles', without the number of mechanical problems experienced with the earlier models.³⁵ During June 1943 the Deputy Chief of the Imperial General Staff and Tank Board member, Lieutenant-General Ronald Weeks, wrote to Vauxhall Motors to emphasise how the Churchill tank contributed towards victory in North Africa. In addition to praising the ability to climb very steep slopes and that the Churchill had the prerequisite reliability necessary to give 'invaluable support to the infantry at a critical time', Weeks paid special tribute to those involved in production:

our thanks are due to the hard and painstaking work of all employed in Churchill production. You and your workers, whatever may be his or her task, may find in this their reward for the hard work done over many months, and also I hope a spur for the future, to maintain and indeed to improve upon the high standard of workmanship now expected.³⁶

³⁴ Forecast: TNA, AVIA 22/454, 'Centaur/Cromwell Planning', 9 November 1943; Production: CAB 120/356, 'A.F.V. Production', March 1944 to April 1945.

³⁵ Library and Archives Canada, Ottawa, RG 24, volume 2626 part 1, file HQS-3352-37-6-1, 'North African Theatre of Operations – A.F.V. Technical Report No. 1', 26 March 1943,

³⁶ HMC, 80/20/5/37/1, Weeks, DCIGS to C. J. Bartlett, Managing Director, Vauxhall Motors, 18 June 1943.

During the Italian campaign, Eighth Army Commander Lieutenant-General Oliver Leese confirmed to the War Office how the Churchill tank had 'stood up to a lot of punishment' during the attack and breaching of the Adolf Hitler Line in May 1944. Leese reported how this advantage together with the ability to cross 'some amazingly rough ground' and the effectiveness of the six-pounder gun, gave Churchill tank crews 'tremendous confidence' in the vehicle.³⁷ When particular mechanical or production defects were noted by tank crews which required the attention of the manufacturers, the tank was sent back to Britain for examination and correction. In an example during the Normandy campaign, the welding joints of the glacis plate on a Heavy Churchill tank failed upon being struck by a 150 mm high-explosive shell, resulting in the plate being forced into the hull and injuring the driver and gunner. The tank was returned to Britain for an investigation by the Department of Tank Design and the Parent firm Vauxhall Motors, whilst the field workshops modified all remaining Heavy Churchill tanks by welding a piece of armour plate to both sides of the glacis as a support.³⁸ By December 1944, permanent modifications were introduced to new production tanks by increasing the quantity of the weld metal on the internal and external joints of the glacis plate, which tank crews recognised by the tank letter 'K' instead of 'H'.³⁹

The combat performance of British tanks was questioned again during the Normandy battles forcing Field-Marshal Montgomery to prohibit the circulation of 'alarmist reports' issued outside of the 'accepted channels of command' in order to avoid undermining morale.⁴⁰ This fear originated from the differences of the Cromwell or Sherman tank when compared against the better armed and armoured German tanks. Montgomery's concern was that troops were 'developing a "Tiger" and "Panther" complex—when every tank becomes one of these types: compared to the old days when every gun was an 88mm', highlighted in the previous chapter.⁴¹ To put this 'complex' into perspective, Buckley argues that during the Normandy campaign about 30 per cent of German armour could be considered superior to standard Allied tanks, with the Tiger tank accounting for only five per cent.⁴² Given this numerical disparity, Montgomery was right to take action against 'alarmist reports' and believed that

³⁷ Quotation found in Cmd 6865, 'Reply', p. 49; The Adolf Hitler Line was also known as the Senger Line and formed part of the overall Winter Line to protect the route to Rome.

³⁸ LAC, RG 24, volume 9377, file 38/TECH LIA/2/2, '21 Army Group', No. 14, para. 14, 30 August 1944.

³⁹ LAC, RG 24, volume 9377, file 38/TECH LIA/2/3, '21 Army Group', No. 19, para. 26, 9 December 1944.

⁴⁰ Churchill College Archives, Cambridge, Sir Percy James Grigg, PJGG/9/8/11, Montgomery to Lieut-General Miles Dempsey, 25 June 1944.

⁴¹ Montgomery to de Guingand, 24 June 1944 found in D. French, *Raising Churchill's Army: The British Army and the War against Germany 1919-1945* (Oxford, Oxford University Press, 2001), p. 96.

⁴² Buckley, *British Armour*, p. 120.

better tactics was the key to defeating German armour through outflanking manoeuvres and wherever possible using the 17-pounder gun.⁴³ Improved tactics were even more important when the close proximity in Normandy made the armour protection of any tank inadequate against a better armed opponent. However, when reviewing the different operational requirements for Allied and German armour below, Montgomery correctly considered that the Allies had the superiority in the quality of their tanks and not just in the quantity.

The operational capabilities of British tanks was highlighted in July 1944 when Leyland received information that the Cromwell tank had 'proved very satisfactory in action' and notices to this effect were posted throughout the factories to inform the workers.⁴⁴ Following the breakout from Normandy, Major-General Gerald Verney commanding 7th Armoured Division, extended this praise for the ability of the Cromwell to travel long distances without needing serious maintenance or suffering from frequent breakdowns. In a note to the Director, Royal Armoured Corps Major-General Raymond Briggs, which was later forwarded to Birmingham Railway by the Director-General of Armoured Fighting Vehicles and fifth Tank Board member Claude Gibb, Verney highlighted:

how superb the Cromwell tank has been during our recent activities and I hope that you will pass on the gist of this letter to the various people responsible for the production of this magnificent machine.

For about three weeks the Armoured Regiments have been continuously in action and the opportunities for long maintenance have been non-existence. On most days the tanks have been moving and fighting all day, going into leaguer at dark in enemy-held territory and moving out again at dawn, which has meant that there has been no night maintenance at all'.

At dawn on 31st August we started our advance from South of the Seine, and it has carried us 250 miles into Ghent in six days. We have lost practically no tanks through mechanical failure (I should say at a guess four or five per Regiment).⁴⁵

The general reliability of the Cromwell tank with the ability for prolonged operations without lengthy maintenance did not reduce the importance for spare parts, as demonstrated by the

⁴³ Cmd 6865, 'Reply', p. 48.

⁴⁴ BCVM, M631 143/5, 'General', July 1944.

⁴⁵ Staffordshire Record Office, Stafford, Birmingham Railway Carriage and Wagon Company, BRCW, D831/1/6/2/M, Routine Correspondence and Letters, Verney to Briggs, 6 September 1944, copy forwarded by Gibb, 17 October 1944.

new orders with Birmingham Railway during April and August 1944, and January 1945.⁴⁶ Furthermore, in November 1944 the DTD stated that the overall increase in reliability over the previous three years was partly attributable to the improvements in 'crew maintenance', which had 'raised the standard of mechanical efficiency of all AFVs'. Essentially, in a reversal of the problems encountered with the Crusader tank and the Liberty engine discussed in the previous chapter, greater reliability had reduced the necessity for extensive repair and maintenance in the field, thereby avoiding these components being contaminated whenever they were removed or dismantled.⁴⁷ The effectiveness of British armour during the campaign in north-west Europe was summarised by Montgomery during February 1945. This commentary unfavourably compared the capabilities of German armour as demonstrated during the Ardennes offensive in December 1944, against the earlier performance of British tanks during September:

If Rundstedt had been equipped with British armour when he attacked in the Ardennes on 16 December, 1944, he would have reached the MEUSE in 36 hours: which would have placed the Allies in a very awkward situation.

If 21 Army Group had been equipped with German armour it could not have crossed the Seine on 28 August 1944 and reached Brussels on 3 September and Antwerp on 4 September, thus cutting off the whole Pas de Calais area in eight days: a very remarkable achievement, which had far reaching results.

The credit for all this must go to the War Office: the British armies were in June 1944 splendidly equipped for the job that had to be done.⁴⁸

In response, tank veteran Peter Beale criticises both Montgomery and the quality of British tanks, by stating that the statement was 'not only farcical in the eyes of the tank crews in the north-west Europe campaign, but criminal'.⁴⁹ This comment has merit when considering the direct combat comparisons between Allied and German tanks above, but otherwise fundamentally misses the central point of Montgomery's statement, which considers the different operational requirements for the two later campaigns.

To begin with, Lieutenant-General Giffard Martel argues that German heavy tanks were best suited for defence and 'did not possess the necessary mobility for operations' like the

⁴⁶ SRO, D831/4/2/20, Order book for new work, 1944-1945, 21 April and 12 August 1944; D831/4/2/21, Order book for new work, 1944-1946, 20 January 1945.

⁴⁷ LAC, 38/TECH LIA/2/3, '21 Army Group', No. 17, para. 24, 15 November 1944.

⁴⁸ TNA, WO 185/6, '21 Army Group, Memorandum on British Armour: No.2', Montgomery, 21 February 1945.

⁴⁹ P. Beale, *Death by Design: British Tank Development in the Second World War* (Stroud, Sutton Publishing, 1998), p. 203.

Ardennes offensive.⁵⁰ Furthermore, David French points out that during the pursuit of German forces from the Seine to Brussels, British armour averaged a greater mileage per day than the German Panzers of 1940 from the Meuse to the English Channel.⁵¹ As for American tanks, General George Patton criticised the slow speed and poor range of the Tiger and Panther, and claimed that Third Army would have sustained 100 per cent road losses had it used the Tiger on the route to the Moselle River during September 1944.⁵² Having examined General Staff requirements for a reduced tank programme together with the changes within industry to produce quality and quantity output, this chapter will now consider improvements to tank design starting with the engine.

This section will examine how the British tank programme demonstrated a tangible transfer to quality production with the emergence of mechanically reliable vehicles. The principal reason why this became possible was the adaptation of the existing Merlin aero-engine into the 600 horsepower (hp) Meteor tank engine, thereby replacing the older and problematic 300 to 395 hp Liberty engine. In respect of how the Meteor engine integrated with existing tank design, William Robotham from Rolls-Royce and occasional Tank Board contributor, highlighted the necessity of designing the Meteor to be interchangeable with the Liberty.⁵³

The Cromwell tank was the first production model to be designed and fitted with the Meteor engine with deliveries beginning in January 1943.⁵⁴ As the official history points out, this could not have occurred sooner as supplies of Meteor engines were insufficient to begin installing them until late 1942. This resulted in an opportunity cost of Cavalier and Centaur tanks having to be supplied with Liberty engines instead.⁵⁵ Much of this delay was due to the understandable reluctance by the Ministry of Aircraft Production to redirect their engine capacity towards the tank programme until mid-1942, with a commitment to produce 3,000 Meteor engines.⁵⁶ Whilst the original plan had Rolls-Royce delivering 500 tank engines by December 1942, this quickly reduced to just 37 under the condition contained in the

⁵⁰ Lieut-General Sir G. Martel, *An Outspoken Soldier: His Views and Memoirs* (London, Sifton Praed & Co., 1949), p. 283.

⁵¹ French, *Raising Churchill's Army*, p. 263.

⁵² Unreferenced quotation dated 19 March 1945 in Chrysler Corporation, *"Tanks are Mighty Fine Things"* (Detroit, Chrysler Corporation, 1946), pp. 82-86.

⁵³ W. A. Robotham, *Silver Ghosts & Silver Dawn* (London, Constable, 1970), pp. 123 & 147.

⁵⁴ TNA, CAB 120/355, 'A.F.V. Production', 6 January 1943.

⁵⁵ Postan, *British War Production*, p. 188.

⁵⁶ TNA, WO 185/8, '5th Meeting of the Tank Board (Reconstituted)', 24 October 1941; '14th Meeting of the Tank Board', 4 June 1942.

agreement that the supply of aero-engines always took precedence.⁵⁷ This decision was in accordance with British strategy during 1942, which sought to increase bomber production for the area bombing campaign against Germany alongside the growing contribution of American air power.⁵⁸ Therefore, with the delivery of Meteor engines currently outside the control of the Ministry of Supply, a production order for 2,000 engines was sent to Morris Engines in October 1942 to rectify the situation.⁵⁹

Following the British Tank Engine Mission to the United States at the end of 1942, the developmental 500 hp Ford V8 engine was suggested as an alternative to the Meteor for the latest Cruiser tanks under production or design. The mission 'emphatically' recommended that the Meteor order with Morris Engines be abandoned and replaced by the 'immediate tooling' towards production of the Ford V8, once this engine had been adopted by U.S. Ordnance.⁶⁰ The manufacturing benefits for the British tank programme of accepting the Ford V8 were that fewer machine tools and man-hours were required for assembly, with the result that three Ford engines could be produced for every two Meteor engines.⁶¹

The fifth Tank Board discussed the implications of cancelling the Meteor expansion in favour of the Ford V8 during December 1942 and 'unanimously' agreed to continue with the Meteor at Morris Engines. The main concerns were that the Meteor had a good record of reliability under trial; the Ford was not interchangeable with existing British tanks carrying either the Liberty or Meteor; and that the Meteor provided an extra 100 horsepower.⁶² Ultimately the Ford V8 did become an engine of good quality albeit after many additional and prolonged tests. When mission chairman Sir Miles Thomas learnt of this development during January 1944, he confirmed the same to the DCIGS Weeks who was present at the Tank Board meetings.⁶³ In his reply, Weeks stated that despite being a good engine 'it would have been most dangerous to have relied upon' the Ford V8.⁶⁴ Weeks elaborated on this comment after

⁵⁷ TNA, WO 185/8, '18th Meeting of the Tank Board', 4 August 1942.

⁵⁸ G. C. Peden, *Arms, Economics and British Strategy: From Dreadnoughts to Hydrogen Bombs* (Cambridge, Cambridge University Press, 2007), pp. 217-219.

⁵⁹ HMC, 80/20/1/1 & 2/6, Ministry of Supply, Director of Contracts to Morris Motors, 24 October 1942.

⁶⁰ TNA, WO 185/6, Report of the British Tank Engine Mission to the United States, November-December 1942, 'Conclusions Reached'.

⁶¹ *Ibid.*, 'Explanatory Comment on Work of and Decisions reached by Mission'.

⁶² TNA, WO 185/8, '22nd Meeting of the Tank Board', 22 December 1942; '24th Meeting of the Tank Board', 30 December 1942.

⁶³ HMC, 80/20/1/5 & 6/12, Major General G. M. Barnes, Ordnance Department Chief, Technical Division to Thomas, 27 January 1944; 80/20/1/7 & 8/19, Thomas to Weeks, 14 March 1944.

⁶⁴ HMC, 80/20/1/7 & 8/19, Weeks to Thomas, 17 March 1944.

the war, by highlighting that problems would have resulted from becoming dependent upon the Ford V8 and spares from 3,000 miles away.⁶⁵

Following the rejection of the Ford V8 engine, in March 1943 Rover Company received an order for 3,000 Meteor engines, thereby ensuring the future supply of reliable engines for the tank programme.⁶⁶ Further to the order for tank engines, later in March Rover purchased the "rights" of the Meteor engine from Rolls-Royce for £5,000 plus the transfer of three Rover Patents.⁶⁷ The production forecast for the different Meteor orders had Morris Engines commencing deliveries in April 1944 and with Rover in May. In respect of the order organised by the Ministry of Aircraft Production with Rolls-Royce and Henry Meadows, this was due to complete in September 1944 thereby placing all Meteor engine production under the control of the Ministry of Supply.⁶⁸

Whilst the engine requirement for the future tank programme was secured with sustained Meteor production, Thomas highlighted during July 1943 that Liberty output had to be maintained to 'hold together the labour force' during the transfer.⁶⁹ As a result, Morris Engines continued to build the Liberty until May 1944, when the strength of Meteor output permitted the final 94 Liberty engines to be cancelled, with any remaining material to be used as spare parts.⁷⁰ In respect of how these Liberty engines were used, despite the increase in production of Meteor powered tanks during 1944, Appendix 1 shows that 619 Cavalier and Centaur tanks were delivered or converted and thus required Liberty engines and spares.

Whilst tank losses sustained during the Normandy campaign compelled an increase in Cromwell deliveries discussed above, the military authorities considered that the existing Meteor orders were sufficient to meet the tank requirements in to 1945.⁷¹ With the end of the war in Europe in May 1945, cancellation orders were sent to Morris and Rover which cut

⁶⁵ Lieut.-General Sir R. Weeks, *Organisation and Equipment for War* (Cambridge, Cambridge University Press, 1950), p. 53.

⁶⁶ Modern Records Centre, Warwick, Rover Company, MSS.226/RO/1/1/6, Board Minutes, 1936-1943, '7225: (2) Meteor Engine Contract', 4 March 1943.

⁶⁷ MRC, MSS.226/RO/1/1/6, '7238: Rolls-Royce Limited', 8 April 1943.

⁶⁸ TNA, BT 87/137, 'Production Programme for Meteor Engines', 22 November 1943.

⁶⁹ HMC, 80/20/5/35 & 36/9, Thomas to H. Spurrier, Leyland Motors, 26 July 1943.

⁷⁰ HMC, 80/20/1/1 & 2/2, Thomas to Micklem, 15 May 1944.

⁷¹ MRC, MSS.226/RO/1/1/7, '7443: (a) Meteor Engine Contract', 22 June 1944; HMC, 80/20/1/1 & 2/5, Thomas to J. Shaw, Morris Motors, 30 June 1944.

each contract by 1,000 engines.⁷² To offset this loss of work, Thomas emphasised to DGAFV Gibb that Morris Engines now had sufficient capacity to accept more orders for wheeled vehicles.⁷³ With the Meteor programme providing an engine of increased power and reliability, the next section will now consider how this permitted British Cruiser tank design to incorporate greater armour protection whilst maintaining high mobility.

An example of when the senior civilian and military authorities discussed and understood the problems associated with adding heavier armour to existing tanks or new designs, occurred during the first Tank Parliament meeting in May 1941. As discussed in chapter 2, this forum was designed to permit an open discussion between the Ministry of Supply, the War Office and the different armoured divisional commanders, to identify specific issues and potential remedies relating to the tank programme. On this particular occasion, the meeting clarified that 'the addition of thicker armour meant greatly increased weight, which caused difficulties in tracks and suspensions, and called for higher engine power'.⁷⁴

To illustrate the last issue, the main Cruiser tanks under production during 1941 and 1942, had maximum armour protection of 40 mm on the Covenanter with the 280 hp Meadows engine and up to 66 mm on the Crusader III with the 340 hp Liberty engine. Whilst the Cavalier and Centaur tanks both had slightly enhanced Liberty engines, the armour thickness was limited to 76 mm and as such these tanks were ultimately unsuitable. The introduction of the 600 hp Meteor engine from 1943 permitted an increase in armour protection to 101 mm on the welded Cromwell and Comet tanks, and then later to 152 mm on the Centurion tank. A similar development occurred with Infantry tanks with armour protection increasing from 60 to 152 mm across the different types, whilst engine power doubled from the 165 hp GMC on the Valentine XI to the 325 hp Bedford on the Heavy Churchill.⁷⁵

To put this expansion in armour thickness into context, Figure 4.4 below demonstrates the relationship between the output of armour plate against the changes within the tank programme for quantity and then quality production from 1940 until 1944. The changes to these index values relative to 1940 show that the increase in tank armour thickness from

⁷² HMC, 80/20/1/3 & 4/21, Gibb to Thomas, 11 May 1945; MRC, MSS.226/RO/1/1/7, '7619: (a) Meteor Engine Contract', 17 May 1945.

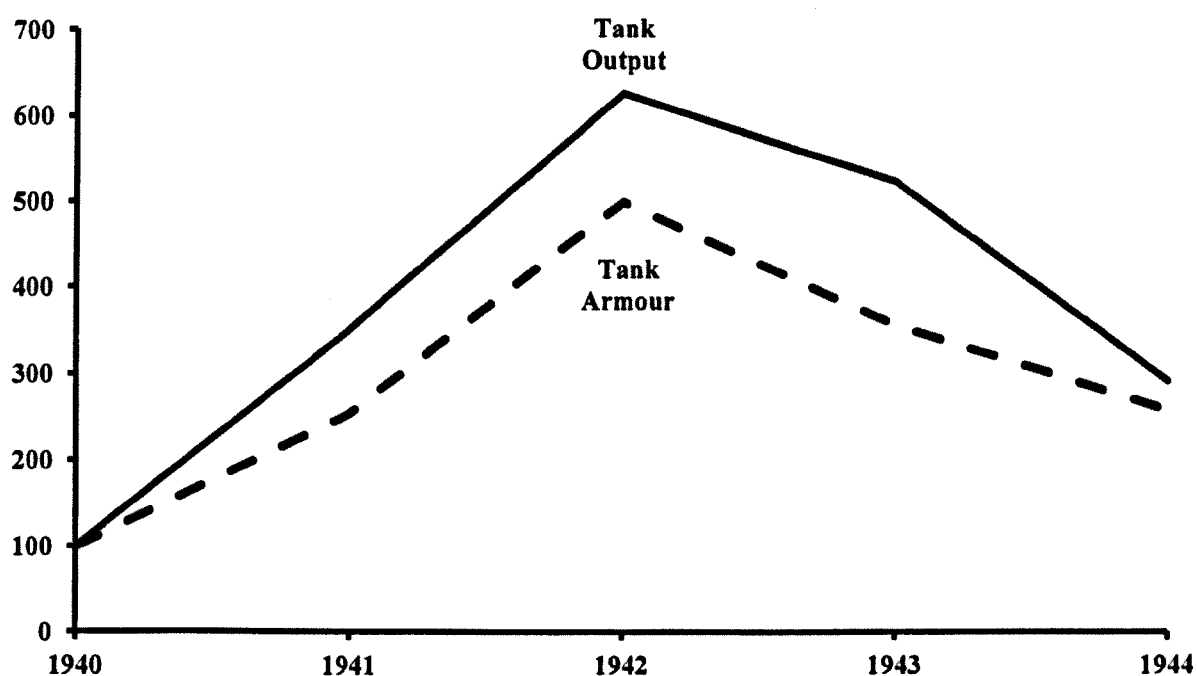
⁷³ HMC, 80/20/1/3 & 4/21, Thomas to Gibb, 10 May 1945.

⁷⁴ TNA, CAB 98/20, 'Tank Parliament', 1st Meeting, 5 May 1941.

⁷⁵ TNA, CAB 102/851, 'Brief Particulars of British, American, Russian and German Tanks', October 1944.

1943, was in contrast to the overall contraction of tank output and tank armour production over the same period. Whilst this does not compare tank armour output against actual orders to expose any shortfall, as highlighted in the previous chapter, armour plate was a 'free issue' item and supply shortages was one cause of delays in tank deliveries. Aware of such interruptions, during June 1943 the Ministry of Supply anticipated ordering more armour plate for the 1944 programme, to account for the greater protection provided by the welded hull construction on the later Cromwell tanks.⁷⁶

Figure 4.4 Index of total output of tank armour relative to total tank output⁷⁷



Notes:

- 1943 and 1944 have excluded tank conversions to demonstrate the falling volume of Light, Infantry and Cruiser gun tanks after 1942.
- 1944 armour values are estimated based upon the first quarterly figures continuing for the year.
- 1945 has been excluded due to different reporting times in each example.

At the end of 1942 the War Office received a summary of experiences from the General Headquarters of Middle East Forces, which included the ability of German tank and anti-tank guns to penetrate Allied armour at considerable distances. In his commentary, the Major-General, Armoured Fighting Vehicles Charles Norman, emphasised the necessity in desert or open country of engaging German gun positions at 2,500 to 2,000 yards to be 'much less likely' to be hit or penetrated. With regard to the much closer ranges of 1,000 yards or less,

⁷⁶ TNA, AVIA 11/30, A. J. Boyd, DGFVP to Duncan, 22 June 1943.

⁷⁷ Tank output: Appendix 1 for Light, Infantry and Cruiser tanks; Tank armour output: TNA, AVIA 46/188, 'Armour Plate Production for A.F.V.'s', p. 213.

Norman highlights that ‘NO armour can be expected to keep out the larger guns’, especially when they can be ‘easily concealed’.⁷⁸ Whether intended to or not this last comment identified the tactical difficulties that would confront the Allies as the war moved away from desert terrain, and into the environments of Italy and north-west Europe. In respect of tank policy, David French highlights that by February 1943 both the Ministry of Supply and General Staff had abandoned tank development that could withstand the German long 75 mm and 88 mm guns.⁷⁹

To demonstrate this, as shown in Appendix 1 the first of the new ‘Heavy Churchill’ tanks with maximum armour of 152 mm were delivered during late 1943, with a further 567 released during 1944 for the fighting in France and north-west Europe. Despite this increase in protection and as anticipated above, operational experience in Normandy revealed that the Heavy Churchill was still penetrated up to 1,640 yards by German heavy tanks and anti-tank guns.⁸⁰ The British authorities first identified the combat capabilities of the Tiger tank from the first intelligence reports and initial experiences in Tunisia during late 1942.⁸¹ Lieutenant-General Martel describes how a knocked out Tiger was later studied in the field during February 1943, resulting in detailed specifications from both the MI-10 Technical and MI-14 German branches of British Military Intelligence.⁸² Another Tiger was later captured intact during April and whilst the transfer to Britain for detailed examination was delayed until October 1943, this was still eight months prior to the Normandy campaign.⁸³

Whilst no longer developing tanks fully to withstand the heaviest German guns, during April 1943 the General Staff placed a requirement for a ‘small very heavily armoured special-purpose vehicle’ that resulted in the Tortoise.⁸⁴ The pilot for this assault tank weighed over 70-tons, mounted a limited traverse 32-pounder or 94 mm gun, and had nine-inches or 229 mm of frontal armour.⁸⁵ There are noticeable similarities between the Tortoise and German Jagdtiger deployed during the Normandy campaign, which was heavier in weight, had 250

⁷⁸ TNA, WO 185/6, Norman, MGAFV to Major-General A. W. C Richardson, DAFV, 19 December 1942.

⁷⁹ French, *Raising Churchill's Army*, p. 103.

⁸⁰ Commentary and Figure 10 in Buckley, *British Armour*, pp. 124-126.

⁸¹ *Ibid.*, pp. 148-149.

⁸² Martel, *An Outspoken Soldier*, pp. 207-208; NCL, Cherwell CSAC 80.4.81/G.371/7, ‘German Pz. Kw. VI’, by M.I.14, 5 February 1943; CSAC 80.4.81/G.371/8-10, M.I.10 to Lord Cherwell, 10 February 1943.

⁸³ Buckley, *British Armour*, p. 149.

⁸⁴ TNA, BT 87/137, ‘Tank Policy’, by P. J. Grigg and A. R. Duncan, 30 April 1943.

⁸⁵ TNA, BT 87/137, Duncan to Churchill, 21 December 1944.

mm of frontal armour and mounted a 128 mm gun.⁸⁶ When considering the operational value of these two vehicles, General Montgomery questioned the development of the Tortoise when he indicated to DCIGS Weeks in April 1944 that:

I doubt if it could be moved by rail; even if the width of any bridge would permit there are very few capable of taking the weight; the tank on a transporter would be a gigantic problem . . . It would be a major operation to assemble even a regiment of these tanks for an attack against a prepared position; in fact I doubt if you could do it in certain cases.⁸⁷

David Fletcher rightfully points out that the order of 25 Tortoise vehicles in February 1944 direct from the mock-up stage without trials of the pilot model, was reminiscent of the demands for quantity production discussed in the previous chapter.⁸⁸ In any event the project did not expand beyond the six pilot models, similar to the TOG tanks discussed in chapter 2. However, the ability to withstand a direct hit from the latest German 88 mm gun was proven during a firing trial upon the Tortoise superstructure in July 1945. In this case a new 88 mm gun with a recorded muzzle velocity of 3,380 feet per second, achieved a penetration of six-and-a-half inches or 165 mm with a capped ballistic shot against the nine-inches or 229 mm of hardened cast frontal armour.⁸⁹ This result was consistent with the L71 type gun mounted in the King or Royal Tiger at a range of approximately 1,000 yards, which together with the British 17-pounder gun firing the Sabot round, could penetrate about eight-inches or 208 mm at 500 yards.⁹⁰ Therefore, it was possible to defend against the best German tank and anti-tank guns in terms of armour protection, but the thickness required was so great that it became operationally impractical when considering the Tortoise pilot above.

In respect of cast armour, Brigadier Macleod Ross highlights that the production benefits were that the tank only required assembly and avoided the process of machining and riveting, saving time and labour resources. Furthermore, cast armour prevented the possibility of the rivets being forced into the tank interior 'like a bullet' and endangering the crew when the

⁸⁶ R. Ogorkiewicz, *Armour: The development of mechanised forces and their equipment* (London, Atlantic Books, 1960), pp. 310 & 322; Buckley, *British Armour*, p. 148.

⁸⁷ Montgomery to Weeks, 3 April 1944 found in S. Brooks (ed.), *Montgomery and the Battle of Normandy* (Stroud, The History Press, 2008), pp. 67-68.

⁸⁸ D. Fletcher, *The Universal Tank: British Armour in the Second World War, Part 2* (London, H.M.S.O., 1993), p. 89.

⁸⁹ HMC, 80/20/1/3 & 4/12, A. P. Wickens, Nuffield Mechanization to Thomas, 20 July 1945.

⁹⁰ Macleod Ross, *Business of Tanks*, pp. 330-331.

tank was hit.⁹¹ On the other hand, the official history identifies that the process was not without difficulties as casting involved complex designs and required highly skilled labour.⁹²

During January 1942, the executive third Tank Board reported that the technique for casting the armour had improved, as demonstrated by the successful firing trials against the six-pounder cast turret for the Churchill tank.⁹³ Despite this increase in quality, the use of cast turrets was still limited by the 'inability to obtain the necessary castings', with the fifth Tank Board reporting in August 1944, that only half of the reworked Churchill tanks would get the heavier turret.⁹⁴ The problem continued into the 1945 programme when production of the new Centurion tank was considered unlikely to exceed 160 by the end of the year due to 'a question of armour castings'.⁹⁵

The alternative was welded armour which had the advantages for tank construction of avoiding detailed machining, reduced weight and greater armour strength. The official history highlights that these advantages were understood by 1941, but it was not possible to make a 'drastic' and widespread adjustment to the manufacturing process until the reduction in the tank programme examined above from 1943 onwards.⁹⁶ The benefits of reduced weight was emphasised by the Department of Tank Design during May 1941, when considering that the 'welded hull project' for the Churchill tank could off-set the problems of mounting the heavier six-pounder gun turret.⁹⁷ In response, the third Tank Board discussed the Churchill weight problem in the following month and agreed that the majority of welding capacity be allocated to six-pounder turret construction, resulting in the Churchill III.⁹⁸

In respect of the latest tank designs, Leyland received a request from the DTD during June 1942 to produce a small number of experimental welded tank hulls of the Cromwell type. The objective was to assess the merits of this hull 'against the existing riveted construction, having regard to the ballistic properties, saving in man-hours, and problems connected with

⁹¹ *Ibid.*, p. 71.

⁹² W. Hornby, *Factories and Plant: A History of the Second World War* (London, H.M.S.O., 1958), pp. 282-283.

⁹³ TNA, WO 185/8, '10th Meeting of the Tank Board (Reconstituted)', 20 January 1942.

⁹⁴ TNA, WO 185/8, '42nd Meeting of the Tank Board', 16 August 1944.

⁹⁵ TNA, WO 185/8, '45th Meeting of the Tank Board', 3 January 1945.

⁹⁶ M. M. Postan, D. Hay and J. D. Scott, *Design and Development of Weapons: Studies in Government and Industrial Organisation* (London, H.M.S.O., 1964), p. 345.

⁹⁷ TNA, WO 185/5, 'Department of Tank Design – Monthly Report for May 1941'.

⁹⁸ TNA, WO 185/8, '17th Meeting of the Tank Board', 13 June 1941.

service in the field'.⁹⁹ By September Leyland recorded that 'good progress' had been made, but the limiting factors were the supply of armoured plate from outside sources and the transfer of internal workers to prepare the plates prior to welding.¹⁰⁰ The desire to increase the amount of welding in tank assembly was discussed during November 1942 at the Armoured Fighting Vehicle Liaison Meeting, when it was agreed that welded hulls and turrets should be applied to the Cromwell series as soon as possible.¹⁰¹ During the same month Leyland received an order from the Ministry of Supply for three welded hulls based upon the design prepared by the Leyland drawing office.¹⁰²

With regard to female labour in factories, the post war account by Vera Douie highlights how women workers proved to be 'excellent at welding' on aircraft and tank assembly, in addition to machining, riveting, lathe work and wiring.¹⁰³ However, as Penny Summerfield points out many tasks were deemed 'women's work' due to the particular process involved, and as such these women were paid less than those women on 'men's work'. This created a sub-division of inequality for the female workforce beyond the differences in pay between men and women generally.¹⁰⁴ In an example of gender equality, with the volume of welding being carried out by Leyland on Centaur production increasing during 1943, a 'welding school' was set up in April for male and female workers in order to keep pace with future expansion. The programme trained operatives to produce welded 'test pieces' for the Chief Metallurgist to examine, and if approved the candidate would commence work on tank production.¹⁰⁵

By July 1943, Leyland had obtained enough experience to provide a fully welded front section for the Centaur tank for firing trials, with results that gave 'vastly improved immunity under fire'. Furthermore, the welded construction did not require modifications to the armour plate, so when Leyland transferred production to the Cromwell tank during November 1943, the fully welded front section was incorporated on the first vehicles.¹⁰⁶ In addition to the gaining of welding experience and suitable skilled labour, the official history identifies how the lack of welding equipment also impeded the ability of industry to complete the various

⁹⁹ BCVM, M632 143/5, 'Experimental Welded Hull', June 1942.

¹⁰⁰ BCVM, M632 143/5, 'Experimental Welded Hull', September 1942.

¹⁰¹ TNA, WO 185/7, '3rd Liaison Meeting', 5 November 1942.

¹⁰² BCVM, M632 143/5, 'Experimental Welded Hull', November 1942.

¹⁰³ V. Douie, *Daughters of Britain* (Oxford, Vincent-Baxter Press, 1949), pp. 98-100.

¹⁰⁴ P. Summerfield, *Women Workers in the Second World War: Production and Patriarchy in Conflict* (London, Croom Helm Ltd, 1984), pp. 145, 168-170.

¹⁰⁵ BCVM, M632 143/5, 'Centaur Tank', April 1943.

¹⁰⁶ BCVM, M632 143/5, 'Centaur Tank', July 1943; 'Cromwell Tank', November 1943.

production programmes. With particular regard to ship building and the tank programme, equipment shortages were overcome by avoiding the 'wasteful use' of equipment larger than was necessary by eventually matching the demand against supply.¹⁰⁷

In the case of the Comet tank, specific welding equipment was designed by English Electric from November 1943 to meet the particular assembly demands of this all-welded vehicle. These "manipulators" were 'capable of holding the complete hull and turning it into the required position for each welding operation to be most efficiently performed'.¹⁰⁸ During January 1944, Leyland received a similar '6-ton welding manipulator' from Davy United for Comet turret assembly and immediately used it on turret welding for the current Cromwell production, whilst the training of welders for the Comet hull began.¹⁰⁹ By September and after Leyland had installed two hull welding manipulators and received the necessary materials, seven Comet tanks were delivered by using both manipulators day and night with six welders employed per hull per shift.¹¹⁰ During October four rotary manipulators were in use with an increased monthly output of 15 tanks, and by December the number of welders engaged on Comet production had increased to 115 with a rise in output to 53 tanks.¹¹¹

By September 1944 the increased use of welding was not without worker side-effects, as demonstrated by the 20 per cent of Leyland trainee welders who requested alternative employment for health reasons due to the intense heat. A second reported health concern from employed welders related to the presence of smoke fumes during welding which could not be easily or immediately extracted, especially from the hull interior.¹¹² The general problems of poor ventilation in industry increased during 1939 following the black-out, which the Chief Inspector of Factories described as having insufficient 'thought as to the interference that would result to ventilation and natural lighting'.¹¹³ The Chief Inspector reported for 1945 that ventilation issues had continued throughout the war and were exacerbated by 'instances of new factories or extensions being planned and built and put into

¹⁰⁷ Hornby, *Factories and Plant*, pp. 361-362.

¹⁰⁸ Bodleian Library, Department of Special Collections and Western Manuscripts, Oxford, English Electric Company, MS. Marconi 2724, 'War Diary of the English Electric Company Ltd. March 1938-August 1945', entry for 24 November 1943.

¹⁰⁹ BCVM, M631 143/5, 'Plant' and 'Comet Tank (A.34)', January 1944.

¹¹⁰ BCVM, M631 143/5, 'Comet Production', September 1944.

¹¹¹ BCVM, M631 143/5, 'Comet Production', October 1944; 'Comet Tanks', December 1944.

¹¹² BCVM, M631 143/5, 'General', September 1944.

¹¹³ Cmd. 6251, *Annual Report of the Chief Inspector of Factories for the year 1939* (London, H.M.S.O., 1941), p. 6.

production without any consideration of the question of ventilation'.¹¹⁴ For tank welding at Leyland, a partial solution was instigated in December 1944 with an 'air shute' to direct fumes towards the ventilators, and a curtain by the open outside door to allow fresh air to circulate without causing a draught.¹¹⁵ Despite these efforts the rate of welding absenteeism during January 1945 reached the highest figure to date at 33 per cent, resulting in additional work on one Saturday afternoon and later for a whole weekend to maintain the scheduled output.¹¹⁶ In addition to absenteeism, the next section examines the ability of industry to maintain a steady rate of output when affected by worker holidays and industrial action.

Following the evacuations from Dunkirk and with the continuing fighting in France during the remainder of June 1940, the government sought a 'general cancellation or postponement' of all holidays in both war and other industries. The main reasons for this decision were to avoid interrupting munitions output and to ensure that transport facilities supported the demands of the services, instead of people travelling to and from their holiday destination.¹¹⁷ By the end of July, Minister of Labour Ernest Bevin recognised that exhaustion would affect the employees and thus production levels, unless the policy was amended to permit a stoppage for a short period if rotation was not appropriate.¹¹⁸ In respect of Christmas 1940 and New Year, Bevin reached an agreement with the employers' and workers' associations that firms engaged on 'essential production', should only take a single day on Christmas Day, with Scotland taking New Year instead.¹¹⁹

A serious side-effect of working longer hours and the lack of holidays during 1940 has been argued by Richard Croucher as a 40 per cent increase in recorded accidents, with a 'disproportionate' amount experienced by new workers.¹²⁰ During the final years of war, Helen Jones states that the accident rate improved with the taking of holidays, with fewer hours being worked and more time available for new workers to become accustomed to the dangers of factory work.¹²¹ These arguments can be demonstrated by reviewing the figures

¹¹⁴ Cmd. 6992, *Annual Report of the Chief Inspector of Factories for the year 1945* (London, H.M.S.O., 1946), p. 21.

¹¹⁵ BCVM, M631 143/5, 'General', December 1944.

¹¹⁶ BCVM, M631 143/5, 'Comet Tanks', January 1945.

¹¹⁷ House of Commons, *Parliamentary Debates*, 'Workers' Holidays', vol. 361, cols. 1358-9, 13 June 1940.

¹¹⁸ TNA, CAB 67/8/7, Production Council, 'Holidays', by Bevin, 30 July 1940.

¹¹⁹ TNA, CAB 65/10/14, War Cabinet meeting, '9. Production', 22 November 1940.

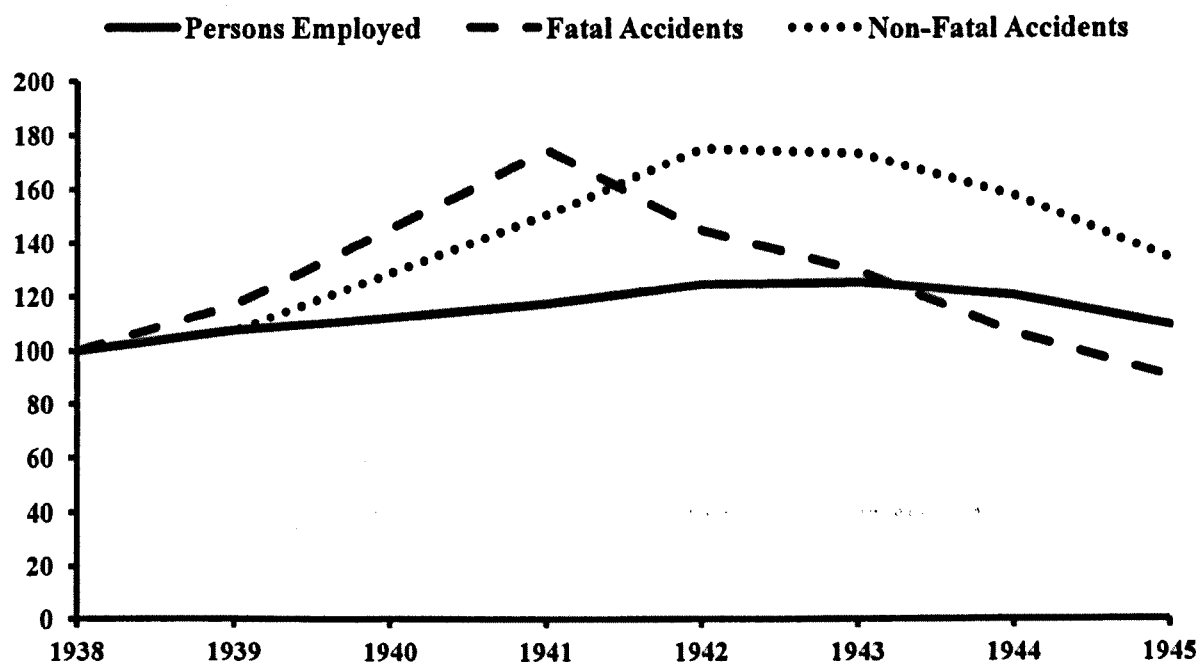
¹²⁰ R. Croucher, *Engineers at War, 1939-1945* (London, The Merlin Press, 1982), p. 15.

¹²¹ H. Jones, *British Civilians and the Front Line: Air Raids, productivity and wartime culture, 1939-45* (Manchester, Manchester University Press, 2006), p. 62.

reported by the Chief Inspector of Factories for fatal and non-fatal accidents, and to highlight the frequency of particular accidents against the examples recorded at Birmingham Railway.

To begin with the number of 'fatal accidents' fell from a peak of 1,646 during 1941 to 851 by 1945, which was still fewer than the 944 recorded for 1938. 'Non-Fatal Accidents' peaked in 1942 at 313,267 and likewise fell each subsequent year to 239,802 during 1945, although this was still 60,643 accidents higher than 1938.¹²² To put this into context against the number of workers employed within industry over the same period, Figure 4.5 compares the trend of these accidents since 1938 to demonstrate the greater chance of death or injury within factories in response to wartime demand.

Figure 4.5 Index of fatal and non-fatal accidents relative to the index of total number of industrial employees from 1938 to 1945¹²³



NB: Number employed excludes docks and building and civil engineering sites as defined under Sections 105-108 of the Factories Act 1937.

In respect of the circumstances of each accident, the report book of Birmingham Railway from November 1944 to July 1945 provides a small number of examples to compare against the Chief Inspector's report to highlight the overall frequency. In general terms, the proportion of accidents caused by the use of powered machinery fell from 17.1 per cent in 1942 to 14.9 by 1945, due to 'positive preventative measures' and enforcement 'through legal

¹²² Ibid.

¹²³ Cmd. 6992, *Annual Report*, 1945, Table I and II, p. 6.

enactments'. All the other causes were 'non-machinery' related, in which manual handling accidents became more common over the same period to increase from 25.7 to 27.5 per cent. As examples of such incidents, tank fitters Mr C46 (surname and age) and Mr S40 at Birmingham Railway strained themselves whilst lifting a steel plate, whilst tank fitter Mr J56 required hospital treatment after sustaining a hernia when lifting a tank door. The Chief Inspector reported that these types of injuries were preventable through increased mechanization and greater use of lifting machines. The recording of employees falling within the workplace represented about 13 per cent of all accidents from 1942 to 1945. At Birmingham Railway, tank fitters Mr S54 and Mr H62 both fell into the 'tank pit' when they lost their footing nearby, whilst tank electrician Mrs H43 fell down elsewhere due to poor lighting. Other types of accidents recorded by the Chief Inspector related to the use of hand tools, being hit by a falling item, and 'stepping on or striking' against an object.¹²⁴

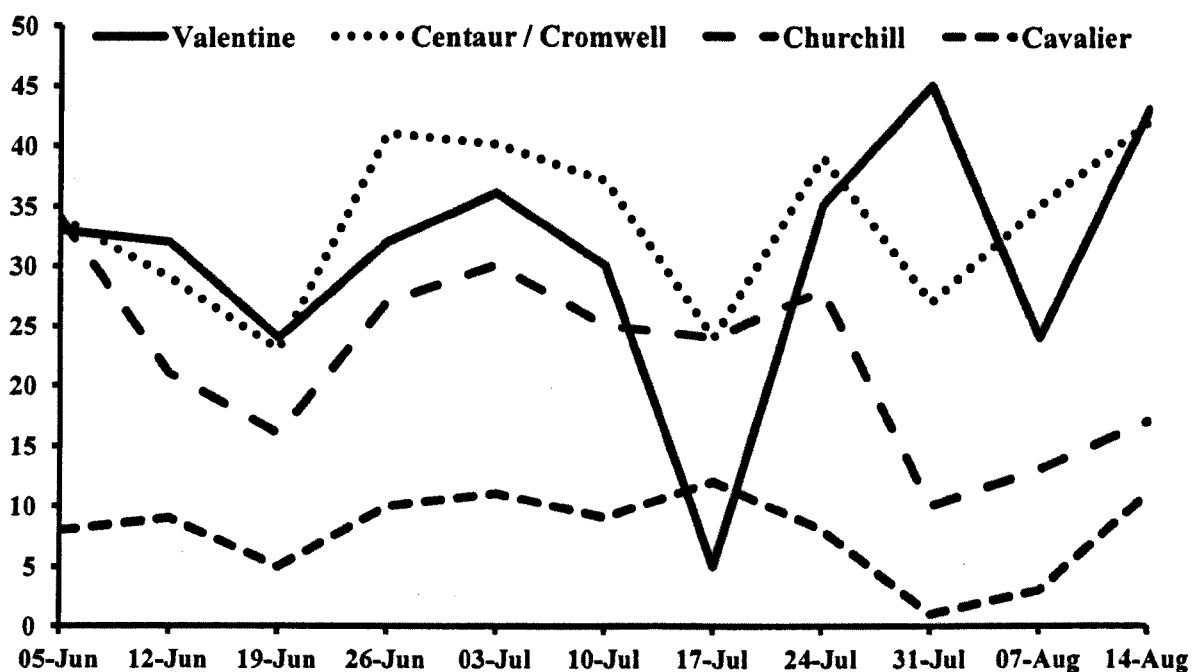
Therefore the taking of worker holidays was clearly necessary to reduce the accident rate within industry, in spite of the overall demand for greater and sustained war production. To demonstrate how holidays affected the tank programme, Figure 4.6 below uses the example of 1943 to highlight the fluctuations in the weekly output for five tank models, following the late Whitsun holiday in June and the summer holiday period during July. The importance of continually reporting the production figures by the Ministry of Supply on a weekly basis for individual tank models was reiterated by Churchill in December 1942.¹²⁵ This meant that individual tank programmes and manufacturers came under regular scrutiny, as any fall in output together with the causes could be immediately identified. This schedule of weekly tank output was maintained until January 1944 when Churchill agreed that this should now be provided on a monthly basis.¹²⁶ The different tank models displayed in the graph were in full production during 1943, thus excluding the Matilda programme which finished in August and combines Centaur and Cromwell output for consistency against the forecast later. In all five cases production fell in unison as a result of the 13 June Whitsun Bank Holiday as reported for the week ending 19 June, whilst the drop in output from the weeks ending 17 to 31 July was attributed to summer holidays at the tank firms.

¹²⁴ SRO, D831/6/1/2, 'Workmens Accident Book', 1944-1949, entries from November 1944 to July 1945; Cmd. 6698, *Annual Report of the Chief Inspector of Factories for the year 1944* (London, H.M.S.O., 1946), p. 7; Cmd. 6992, *Annual Report*, for 1945, pp. 11-12.

¹²⁵ TNA, CAB 120/355, E.I.C. Jacob, Offices of the War Cabinet to R.B. Tippetts, Ministry of Supply, 3 December 1942.

¹²⁶ TNA, CAB 120/356, M.R. Norman to Tippetts, 11 January 1944.

Figure 4.6 Interruptions to weekly tank output by the Whitsun Bank Holiday and summer holidays to five tank programmes during 1943¹²⁷



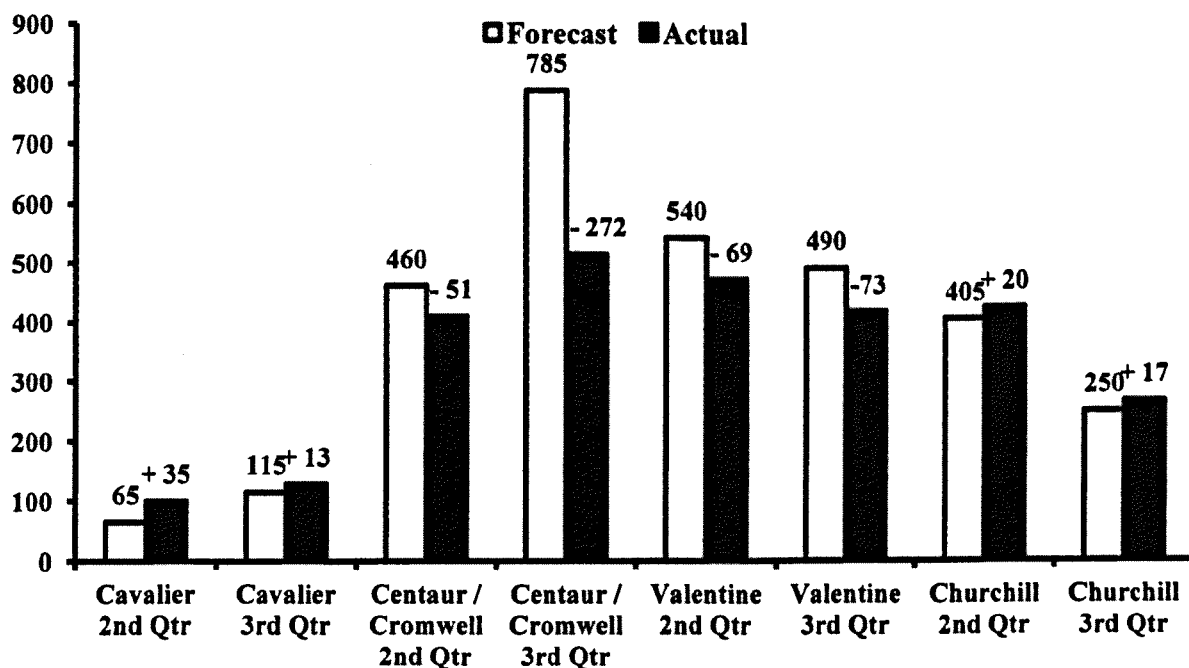
Valentine production had the most dramatic fluctuations across the ten weeks, whilst the overall downward nature of Churchill output was due to the introduction of the Heavy Churchill from December and thus the transfer of capacity during 1943. By the end of the period, Centaur and Cromwell output returned to exceed pre-holiday levels and the low output of the Cavalier was reflected by the small order of 500 tanks. Whilst Vulcan Foundry ceased tank production after May 1943, a review of their employment figures can reveal the type of worker reduction that occurred when a large percentage of factory personnel went on holiday simultaneously. To illustrate this, the number of workers employed at Vulcan Foundry fell from 3,640 in the week ending 17 July, to just 485 or by 87 per cent during the following holiday week, before returning to normal employment levels in the week after.¹²⁸

In respect of comparing these production figures against expectations, a joint report on 'Tank Policy' was presented in April 1943 to the supply Defence Committee by the Minister of Production, the Secretary of State for War, and the Minister of Supply. The forecast was presented as quarterly figures and as such have been compared against the actual output recorded for the second and third quarters of 1943 in Figure 4.7 below, resulting in an overall deficit of 65 and 315 tanks respectively.

¹²⁷ TNA, CAB 120/355, 'A.F.V. Production', for week ending 5 June to 14 August 1943.

¹²⁸ BLO, Vulcan Foundry, MS. Marconi 2740, Board Minutes 1940-1945, 19 August and 14 September 1943.

Figure 4.7 Comparison of tank production forecasts against actual output for five tank programmes from April to September 1943¹²⁹



The taking of holidays was not the only cause for the combined shortfall of 380 tanks across the two quarters, as the Cromwell programme expanded slower than expected. However, given the proximity of the forecast to the various holidays that followed, Buckley highlights how Churchill ‘fumed and berated’ Lyttelton for not taking holidays in to account.¹³⁰ The basis of this displeasure started when Churchill received the figures for 31 July which he described as ‘Dreadful. A shocking performance’, especially when Valentine production was excluded as part of the aid programme to Russia.¹³¹ Upon being ‘shocked at the appallingly low output’, Churchill later asked Lyttelton to provide a full report and expressed doubt that an explanation of summer holidays was sufficient.¹³² In response, Lyttelton stated that forecasts did not allow for holidays as they ‘vary in their incidence’, and calculated that lost output during this week amounted to about 31 tanks.¹³³ Churchill remained unsatisfied and as a final comment bluntly stated that:

I do not see why you should credit yourself with the losses due to annual holidays. These should have been foreseen in the forecasts that were made. Everyone knows

¹²⁹ Forecast: TNA, BT 87/137, ‘Tank Policy’, by O. Lyttelton, P. J. Grigg and A. R. Duncan, 16 April 1943, Appendix IV; Actual: CAB 120/355, ‘A.F.V Production’, 8 April to 29 September 1943.

¹³⁰ Buckley, *British Armour*, p. 167.

¹³¹ TNA, PREM 3/427/9, ‘A.F.V. Production’, week ending 31 July 1943, noted by Churchill, 6 August 1943.

¹³² TNA, PREM 3/427/9, ‘Prime Minister’s Personal Minute’ to Lyttelton and Duncan, 11 August 1943.

¹³³ TNA, PREM 3/427/9, Lyttelton to Churchill, 26 August 1943.

that there are annual holidays in July and August, and all estimates should take account of this fact.¹³⁴

To put this into context, during 1943 British industry was transforming to provide good quality tanks as shown above, whilst useful tanks from the United States were being received in increasing quantities as discussed in the next chapter. Despite this positive outlook, the tone of Churchill's remarks emphasises that sustained British tank output remained just as important as it did after the defeat of France, when equipment shortages were particularly severe. Given that the reduction in Cromwell output in Figure 4.3 above during July 1944 was contrary to expectations and partly as a result of annual holidays, the criticism raised by Churchill for calculating official forecasts appears not to have been followed.

A loss of output due to strike action was always a possibility throughout the munitions industries, which despite minor fluctuations experienced a continual increase in the number of strikes, the number of workers involved and number of working days lost from 1940 to 1944.¹³⁵ This was seen despite Communist Party influence within the factories that supported greater efforts to increase production, including an opposition towards strike action following the German invasion of Russia.¹³⁶ Regardless of this policy, Richard Croucher demonstrates that Communist shop stewards still applied the threat of strike action for reasons linked to earnings and a degree of 'male chauvinism'. For example, in July 1942 a demand was made for the removal of all women from the Tank Erecting Shop at the North British Locomotive Company, because the women were deemed unsuitable and would lower the bonus.¹³⁷

Another strike at North British Locomotive caused a complete stoppage in Matilda production over the three weeks ending 5 to 19 December 1942.¹³⁸ As a consequence, the number of Matilda tanks delivered from this firm fell from 22 in November, and following an average of 25 for the previous six months, to just nine during December. Following resolution of the strike the number of tanks delivered during January 1943 increased to 20,

¹³⁴ TNA, PREM 3/427/9, Churchill to Lyttelton, 2 September 1943.

¹³⁵ See Table 21 in P. Inman, *Labour in the Munitions Industries* (London, H.M.S.O., 1957), p. 393.

¹³⁶ R. Croucher, *Communist Politics and Shop Stewards in Engineering, 1935-46* (PhD thesis, University of Warwick, 1977), pp. 113, 211 & 231.

¹³⁷ *Ibid.*, p. 335.

¹³⁸ TNA, CAB 120/355, 'A.F.V. Production', 9, 16 and 24 December 1942.

which was consistent with the planned reduction in the Matilda programme with the contract finishing in August.¹³⁹

Birmingham Railway encountered a period of industrial action for one week during October 1943 that impacted upon the production of the Cromwell tank. Whilst Leyland Motors as the Parent firm had a Group Production Co-ordinator shown in Figure 4.1, it appears that the Parent could not influence the industrial relations of the firms within the group. In explaining the origins and effect of the strike, the Managing Director Harry Moyses reported:

that as a result of an unofficial strike throughout the works during the week ended 30 October 1943, 76,032 man hours production were lost. The grievance related to an increase rates of pay promised by the Association Chairman unknown to our Manager. Following the return of the employees to work on 30th October the matter was adjusted.¹⁴⁰

Based upon the 5,640 man-hours recorded at Leyland to produce each Cromwell tank above, the strike at Birmingham Railway resulted in the loss of approximately 13 tanks. The effect of this stoppage upon the Cromwell programme is examined in Figure 4.8 below which reviews the weekly output for the entire programme for the months either side of October for comparison. When considering just the monthly figures the strike and the loss of 13 tanks had no discernible effect upon the upward trend of Cromwell deliveries. However, a greater analysis of the results can reveal that the large increase during November was assisted by the introduction of Leyland to the assembly line with the delivery of 32 tanks for the month.¹⁴¹ As highlighted above with regards to Meteor engine output, the first Cromwell was delivered during January 1943, in which the rate of deliveries remained in single figures for all but one week until those ending 16 and 23 October.¹⁴² Therefore, whilst the strike at Leyland was significant enough to reduce the progress made during October, it should not be over-estimated when compared to the expansion of the Cromwell programme.

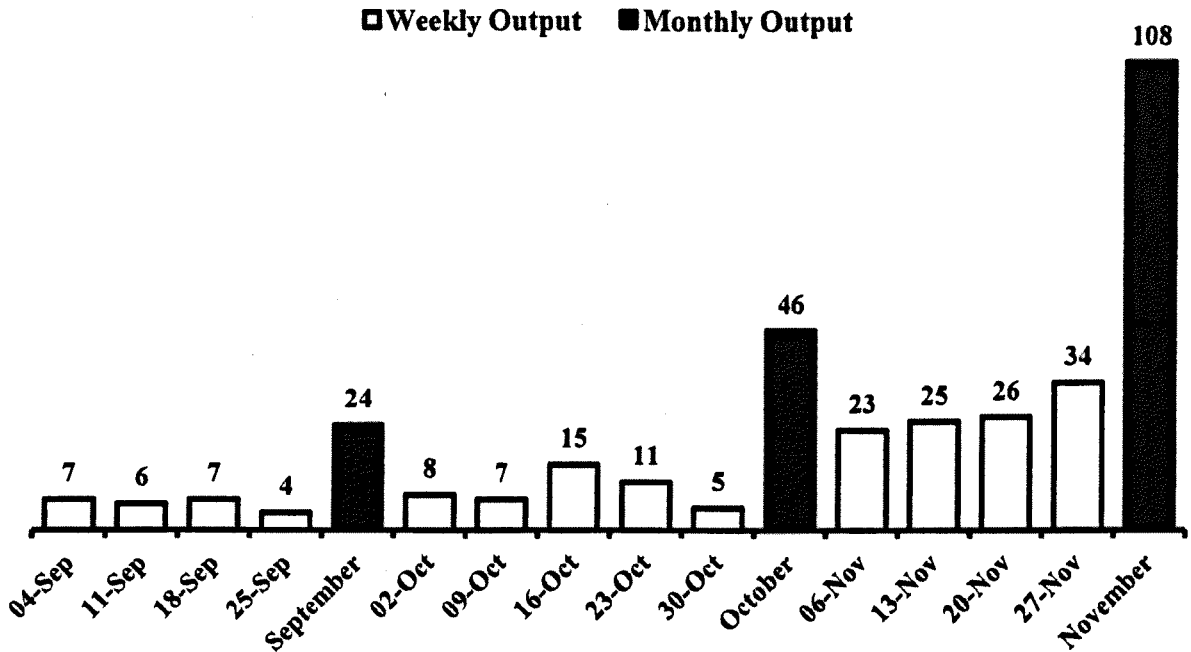
¹³⁹ TNA, AVIA 46/188, 'Monthly Deliveries', p. 271.

¹⁴⁰ SRO, D831/1/6/2/M, Minutes of directors' minutes, 1943-44, '6237: Unofficial Works Strike', 23 November 1943.

¹⁴¹ BCVM, M632 143/5, 'Cromwell Tank', November 1943.

¹⁴² TNA, CAB 120/355, 'A.F.V. Production', 6 January to 27 October 1943.

Figure 4.8 Total weekly and monthly Cromwell deliveries, Sep-Nov 1943¹⁴³



During the final 12 months of war, the overall effect of strike action upon industry diminished with the reduction in the number of lost working days from 1,048,000 in 1944 to 528,000 during 1945.¹⁴⁴ Croucher attributes this reduction to: the effect of Defence Regulation 1AA that strengthened the Trade Unions' ability to do deal with 'irresponsible elements'; in engineering the majority of significant disputes were carried out by women and apprentices, many of whom were not unionised; and concern by engineering workers regarding the eventual return to peacetime conditions and not wanting to lose work as a result.¹⁴⁵ The final section of this chapter will consider the planning within industry for post-war civilian production, together with how the government cancelled existing tank orders whilst preparing for peacetime tank production by using a Royal Tank Arsenal.

The post-war reverting of British industry from war to peacetime production was discussed amongst the War Cabinet in October 1943, with Churchill stating that 'detailed plans should be worked out as soon as possible'. At this stage of the war, it was understandably difficult for Service departments to state with accuracy when each factory would be released from war production, especially given the prospect of a 'two-stage ending' against Germany and Japan.¹⁴⁶ However, the instigation of post-war planning at this time was designed to avoid

¹⁴³ TNA, CAB 120/355, 'A.F.V. Production', 9 September to 1 December 1943.

¹⁴⁴ Table 21 in Inman, *Labour in the Munitions Industries*, p. 393.

¹⁴⁵ Croucher, *Engineers at War*, pp. 241 & 308-309.

¹⁴⁶ TNA, CAB 65/36/12, War Cabinet meeting, 'Reconstruction Plans', 21 October 1943.

the mistakes of the Lloyd George government during the Great War, which did not consider the matter of 'reconstruction' early enough and ultimately failed to provide the promised land 'fit for heroes'.¹⁴⁷ By December 1943, the Minister of Labour Ernest Bevin stated that demobilisation should be withheld until after the victory against Japan, whilst simultaneously maintaining the centralised controls on manpower by the Essential Work Orders.¹⁴⁸

As peacetime plans progressed during 1944, Harold Smith points out that government ministers identified that the labour problem after the war would not be a shortage of work, but instead a shortage of workers to meet requirements.¹⁴⁹ Kevin Jefferys highlights that the political speculation during 1943 regarding post-war reconstruction became more overt after the Normandy invasion, whereby party political differences replaced any prospect of continued co-operation in peace.¹⁵⁰ One example of this division in respect of manufacturing was the 1945 Distribution of Industry Bill brought by Labour member Hugh Dalton, which was designed to give government greater control over the post-war location of industry. Whilst Conservative capitalists, such as Cabinet members Oliver Lyttelton and Andrew Duncan opposed the bill as it threatened private enterprise, the coalition remained intact.¹⁵¹

Correlli Barnett argues that Britain's post-war industry declined because of the decision to create the 'social miracle of New Jerusalem' with the promise of improved welfare, instead of producing an 'economic miracle' by 'transforming Britain's obsolete industrial culture'.¹⁵² This 'polemic' has been disputed by historians for: ignoring the achievements of British industry during the war; for disregarding the extent of the housing problem due to German bombing; and that welfare expenditure and industrial regeneration were not exclusive options.¹⁵³ Furthermore, when comparing the post-war motor industry against the pre-war position, the addition of new buildings and equipment, similar to that discussed in the

¹⁴⁷ P. Adams, 'The Failure of Social Reform: 1918-1920', *Past & Present* (1963) 24(1), p. 50; K. O. Morgan, *Consensus and Disunity: The Lloyd George Coalition Government 1918-1922* (Oxford, Clarendon Press, 1979), pp. 22-24.

¹⁴⁸ CCA, Ernest Bevin, BEVIN 2/4, 'Demobilisation', by Bevin, 10 December 1943; TNA, CAB 66/44/14, 'Demobilisation', by Bevin, 14 December 1943.

¹⁴⁹ H. L. Smith, 'The Womanpower Problem in Britain during the Second World War', *The Historical Journal*, Vol. 27, No. 4 (Dec., 1984), p. 939.

¹⁵⁰ K. Jefferys, *The Churchill coalition and wartime politics, 1940-1945* (Manchester and New York, Manchester University Press, 1991), pp. 166-167.

¹⁵¹ *Ibid.*, pp. 180-181.

¹⁵² C. Barnett, *The Audit of War: The Illusion and Reality of Britain as a Great Nation* (London, Macmillan, 1986), p. 304.

¹⁵³ K. Jefferys, *War and reform: British politics during the Second World War* (Manchester, Manchester University Press, 1994), p. 9.

previous chapter, increased the productive capacity of commercial vehicles by 60 per cent and cars by 20 per cent.¹⁵⁴ As a result, Stephen Rosevear argues that this investment meant that the British motor industry was now better placed to meet the post-war opportunities.¹⁵⁵

To demonstrate how this preparedness went beyond mere physical capability, during December 1943 commercial vehicle firm Leyland and car firm Rover discussed the prospect of carrying out joint research and development after the war.¹⁵⁶ The benefits that this agreement gave to both firms were that they could share the results of investigations into the 'large percentage of engineering problems', whilst simultaneously not being in direct competition with each other in respect of sales.¹⁵⁷ Whilst this study has not reviewed how well this arrangement performed, this type of technological co-operation may have contributed towards the eventual acquisition of Rover by Leyland during 1966. Additionally, peacetime production was considered further within Leyland during June 1944, when a special Sales Conference was held to 'allow the salesmen to know that some thought was being given to the post-war programme'.¹⁵⁸

With the end of the war in Europe on 8 May 1945, Leyland was advised by the Ministry of Supply that a reduced rate of tank output and overall total would be shortly enacted by the Break Clause in the Comet contract. Leyland had planned for this occurrence by restructuring the remaining tank order, so that 'the maximum possible weight' could be put towards 'producing civil vehicles at the earliest convenient date, and in the greatest numbers'.¹⁵⁹ Later in May, the termination of the Churchill rework programme was scheduled to take effect during August, with Parent company Vauxhall Motors transferring capacity to work on the Heavy Churchill, whilst Broom & Wade lost 150 workers.¹⁶⁰ Similarly during June, Gloucester Railway received three months notice that the Break

¹⁵⁴ 617, *Fourteenth report from the Expenditure Committee: The motor vehicle industry* (London, H.M.S.O., 1975), p. 9.

¹⁵⁵ S. Rosevear, *Regional policy and the British motor vehicle industry 1945-64: a study in selective intervention and the economics of industrial location* (PhD thesis, University of Bristol, 1998), p. 61.

¹⁵⁶ BCVM, M632 143/5, 'General', December 1943.

¹⁵⁷ BCVM, M631 143/5, 'General', February 1944.

¹⁵⁸ BCVM, M631 143/5, 'General', June 1944.

¹⁵⁹ BCVM, M631 143/5, 'General', May 1945.

¹⁶⁰ TNA, AVIA 22/454, 'Curtailed of Production of Churchill Reworks', by DGAFV, 26 May 1945.

Clause had been applied to their Heavy Churchill contract, with cancellation taking place either in September or upon completion of the 185th welded tank if earlier.¹⁶¹

Whilst the Ministry of Supply had invoked the Break Clause, during September John Fowler sought to 'exercise fully its legal rights and complete the contract' of 150 Comet tanks for reasons of ensuring a 'smooth transition to peace time production'. Therefore the termination date was extended until 20 November or earlier if the firm had completed the remaining 27 Comet tanks.¹⁶² With these reductions in the Comet and Heavy Churchill programmes, future tank production was concentrated upon the new Centurion tank, under a required rate of 40 vehicles per month.¹⁶³ Given that industry was being converted back to civilian production, the government considered it necessary to place part of the peacetime Centurion tank programme under direct state control by means of creating a Royal Tank Arsenal.

The expansion of the design department during 1943, examined in the previous chapter, contributed towards the successful Centurion tank, with 20 prototypes built by Royal Ordnance Factories (ROF) during 1944 rather than by private firms.¹⁶⁴ The prospect of private involvement was discussed during May 1944, when Leyland was approached by the Tank Board chairman Commander Micklem to consider taking over the parentage of Centurion development from the government arsenal. Leyland declined for reasons of insufficient design capacity for at least six months, and that it would have given the 'wrong impression amongst the designing staff' who were currently working on preparing the Comet tank for production.¹⁶⁵ As a result Centurion design, development and production remained under government control with six prototypes sent after victory in Europe in May 1945, for use in one regiment albeit with crews from different units.¹⁶⁶ This selection was to ensure that the first Centurion tanks were operated by those crews with 'considerable battle experience' during the cross-country and firing trials north-east of Hamburg.¹⁶⁷

¹⁶¹ Gloucestershire Archives, Gloucester Railway Carriage and Wagon Company, D4791/6/20, Directors' Minute Books, 1944-1948, '1283: Managing Director's Reports', 13 June 1945.

¹⁶² TNA, AVIA 22/454, Deputy Director of Contracts to John Fowler & Co., 22 September 1945; R. G. E. Willison to Major-General Donald Fisher, DGAR, 1 October 1945.

¹⁶³ TNA, AVIA 22/454, letter to Henry Cooper-Thompson, Ministry of Supply, 25 July 1945.

¹⁶⁴ C. F. Foss and P. McKenzie, *The Vickers Tanks: From Landships to Challenger* (Wellingborough, Patrick Stephens, 1988), p. 150.

¹⁶⁵ BCVM, M631 143/5, 'General', May 1944.

¹⁶⁶ TNA, WO/185/8, '46th Meeting of the Tank Board', 24 April 1945.

¹⁶⁷ LAC, RG 24, volume 9377, file 38/TECH LIA/2/5, '21 Army Group', No. 26, para. 6, May 1945.

Following completion of the small order for Light tanks in 1936, tank production by ROFs had remained inactive until 1943 when production capacity was used to convert Sherman tanks into the Firefly by mounting the 17-pounder gun.¹⁶⁸ In February 1944, the Deputy Director-General of Ordnance Factories proposed that ROF Leeds be converted to a Royal Tank Arsenal to establish a government owned factory for peacetime tank production.¹⁶⁹ During August, Micklem agreed to the prospect of creating a government tank arsenal, with the potential of producing 20 Centurion tanks per month.¹⁷⁰ By October the War Office supported this plan, as they wanted to avoid some of the problems they had experienced when being entirely dependent upon private sources of tank supply.¹⁷¹ With regards to the location, ROF Leeds was chosen because it had good rail links and sidings for the transport of materials and finished tanks.¹⁷² Furthermore, the factory required little structural alteration beyond the strengthening of gantries and provision for cranes to handle heavy tank weights, although the cost and installation of this machinery was valued at a substantial £625,000.¹⁷³

This conversion gave the Ministry of Supply the post-war potential to increase monthly output to 50 tanks per month, or as much as 70 tanks with the assistance of private contractors if deemed necessary.¹⁷⁴ This plan created future capacity that was comparable to Comet production at Leyland Motors in Figure 4.2 above, and demonstrated how serious the government was in securing some control over peacetime tank production. The official history contends that the manufacture of tanks of 40 to 50 tons was not consistent with the post-war ambitions of heavy industry, and therefore lacked commercial viability.¹⁷⁵ Whilst this suggestion was certainly accurate when considering those firms which became tank manufacturers as a result of war and then reverted to their prior industry in peace, it omits the background and strength of Vickers-Armstrongs. In a sample from 1944 to 1957, Vickers received and completed orders for 310 Centurion Mark I or A tanks, and 726 Centurion Mark IIIs.¹⁷⁶ As a result, this brought the British tank programme to a full circle with production that was limited to factories that were either owned by the government or Vickers.

¹⁶⁸ Postan, *British War Production*, p. 426.

¹⁶⁹ TNA, WO 185/129, T. E. Harris, DDGOF (E) to Secretary, Building Executive, 22 September 1944

¹⁷⁰ TNA, WO 185/129, CAFV to CGMP, 22 August 1944.

¹⁷¹ TNA, WO 185/129, War Office to J. K. Eastham, 18 October 1944.

¹⁷² TNA, WO 185/129, letter to CGMP, 29 June 1944.

¹⁷³ TNA, WO 185/129, DDGOF to Building Executive, 22 September 1944

¹⁷⁴ TNA, WO 185/129, Ministry of Supply to Treasury Inter-Service Committee, 29 September 1944

¹⁷⁵ Postan, et al., *Design and Development of Weapons*, p. 352.

¹⁷⁶ Cambridge University Library, Manuscripts Department, Vickers-Armstrongs, VICKERS 744, 'Armoured Fighting Vehicles 1937 to 1959', 7 September 1959.

The expansion of state controlled munitions production to the tank programme could have been an extension of wartime policy and then subsequently continued by the Labour government with their post-war programme of nationalisation. However, an example from either period can demonstrate that the nationalisation of existing firms or industries was not always the preferred option. The wartime nationalisation of airframe manufacturers Shorts Group was a last resort measure designed to improve the poor production record of the firm, through direct state control to meet the demanding bomber programme.¹⁷⁷ In respect of post-war motor manufacturing, the Labour government decided during 1948 to keep the industry under private ownership to maintain the strong export position, with central control only relating to the allocation of raw materials.¹⁷⁸

In conclusion, for the Western Allies the period of 1943 until the end of the war was characterised by undertaking successful land campaigns against Germany, with victory in North Africa followed by the invasions of Sicily, Italy and north-west Europe. As examined by the different sections in this chapter, the British tank programme contributed towards this change in strategic outlook by providing good quality tanks in a sustainable quantity.

To begin with, the tank programme reduced each year in order to concentrate upon producing the maximum numbers of battleworthy tanks, whilst relying upon the United States to make up the balance of requirements. This brought an end to the production of the Crusader and Matilda tanks, whilst Valentine production was limited to small scale conversions and to meet the demand from Russia. The exception was the Churchill tank that developed to become tactically very useful and better armoured with the later Heavy version.

In respect of the replacement tanks, the Cavalier and Centaur were eventually dismissed due to continued design problems and because they were still powered by the Liberty engine. When production of battleworthy tanks commenced with the Meteor engine, the similarities between the Centaur and Cromwell meant that the change-over to the latter occurred immediately without unnecessary continuation orders or loss of labour resources. Tank armament also improved over this period with the introduction of greater high explosive firepower and armour-piercing capability, albeit with the shortcoming of each Churchill and

¹⁷⁷ P. Howlett, "The Thin End of the Wedge?": nationalisation and industrial structure during the Second World War', in R. Millward and J. Singleton, *The political economy of nationalisation in Britain 1920-1950* (Cambridge, Cambridge University Press, 1995).

¹⁷⁸ S. Bowden, 'The Motor Vehicle Industry', in *ibid.*

Cromwell tank mounting either one or the other. The Comet tank was the first production tank to mount an effective dual-purpose high-velocity gun and extended the qualities of the Cromwell even further with an all-welded hull construction. The benefits of reliable and battleworthy tank designs were complemented by a reduction in essential repair and maintenance by tank crews and unit workshops.

In addition to the development of battleworthy designs, the tank industry produced these vehicles at a greater rate of output than when compared to the period reviewed in the previous chapter. This was achieved by: not introducing any new firms to assembly; improvements in experience, techniques and equipment, especially in relation to welding; and a reduction in the man-hours needed for assembly despite a large increase in tank weight. Many tank firms transferred to tank conversions following the General Staff requirement for specialist tanks, whilst others changed to non-tank work or reverted to their pre-war industry of locomotive construction or Admiralty work. The Parent system was simplified under Leyland Motors for the Centaur, Cromwell and Comet tanks, whilst the Nuffield Group retained their Parent status in order to maintain consistency for the dependent firms.

The ability to produce quality tanks in large or suddenly increased numbers was seen during the Normandy campaign in response to heavy and irreparable tank losses, albeit at the expense of delaying and slowing down production of the Comet tank. The emergence of British tanks of good quality was seen by front line units, especially with the Churchill in North Africa and Italy and the Cromwell during and particularly following the Normandy campaign. Whilst British and American tanks can be criticised when drawing direct combat comparisons with the German Tiger and Panther tanks, they do not allow for the numerical inferiority or operational failings of the heavier German tanks.

A tangible demonstration of quality tank design was experienced by the introduction of the Meteor tank engine with the result of increased mechanical reliability and the incorporation of greater amounts of armour protection. To begin with, the fifth Tank Board was correct to insist upon the Meteor instead of the Ford V8 engine for reasons of supply, especially when production transferred from the control of the Ministry of Aircraft Production to the Ministry of Supply. Whilst armour thickness increased during the war, the level of protection required to withstand the heaviest guns, for example with the Tortoise or Jagdtiger, completely negated any attempt to maintain the initiative with operational mobility.

The transfer of British tank armour from riveted to cast and welded construction was consistently desired by the different Tank Boards, but the shortfall in industrial capacity and trained personnel meant this could not be fully realised until 1943. This was achieved by the internal training of male and female welders and specific welding equipment or 'manipulators', although a side-effect was an increase in absenteeism due to the wartime legacy of poor factory ventilation to minimise the increase in fumes.

The cancellation of holidays during the summer of 1940 could not be sustained for reasons of worker exhaustion and more importantly to reduce the number of industrial accidents. When factory holidays were taken in the example of July 1943, the effect upon tank output was a marked fall in deliveries, which was even more striking when the forecast that had not taken this foreseeable event into account. This lack of foresight was deemed unacceptable by Churchill and despite reiterating the importance of the tank programme, the output for July 1944 also experienced a reduction in deliveries against expectations. The growth of industrial action throughout the war affected the tank programme as demonstrated with North British Locomotive and Birmingham Railway, with both resulting in a decline in output. In the case of the latter the strike caused the loss of 13 tanks, although the growth of the Cromwell programme meant that this action did not materially affect output as a whole.

The expectation for post-war civilian production was discussed within government from late 1943 to avoid the problems after the Great War. Industry was ready to benefit from the large increase in productive capacity and detailed preparations that came into effect when war contracts were cancelled. With regard to the peacetime tank programme, a Royal Tank Arsenal was established in order to maintain a measure of state control over Centurion production, in addition to the pre-war tank firm of Vickers-Armstrongs.

During the second half of the war British industry successfully transferred to producing tanks of good quality that met the operational requirements of sustained reliability and mobility, which were essential to pursue an offensive strategy. This was achieved by the continued formation of tank policy on a joint basis between Grigg and Duncan. Advances in tank design and engine power increased the standard of armour protection, whilst improvements in production techniques delivered these vehicles in greater numbers. Finally, the supply of large numbers of Medium tanks from the United States meant that obsolete British tanks were eliminated whilst transferring some tank firms to other important war work.

Chapter 5

Tank Production in North America

This thesis has examined the military, political, strategic and industrial considerations of the British tank programme towards achieving the demands of the British war effort from the period of rearmament until the end of the war. This chapter will continue to review these different themes by highlighting the effects that the production capacity and tank programme of the United States had upon the British war effort from 1940 until 1945, together with comparative examples with the situation in Canada. With regards to production in the United States, the introductory chapter highlighted how the direction of labour was avoided, and that the motorised nature of pre-war society provided industry with skilled manpower and facilities. The United States also began producing 'offensive' munitions, whereas the initial demands upon British industry required a great deal of 'defensive' weapons, before changing emphasis in accordance with the strategic situation.

From 1940 until 1945 the United States produced a substantial 88,410 Light, Medium and Heavy tanks from the combined facilities of 17 manufacturers.¹ The output for each tank firm is provided in Appendix 7, displaying wide variations in potential monthly capacity, the number of tanks on order as at March 1942, and total output during the war. Upon reviewing the figures, 69,385 tanks or 78.5 per cent of the total were produced by five tank firms: Chrysler Corporation; American Car and Foundry; General Motors Corporation; the Cadillac Motor Company; and Pressed Steel Company. As highlighted in the introduction, this ability to concentrate the majority of production within a limited number of large factories was made possible by the strategic advantage of remaining immune to the threat of enemy attack. The remaining 21.5 per cent or 19,025 tanks were divided between 12 tank firms, with each one representing less than five per cent of the overall total, with four firms at one per cent or less.

The U.S. official history on procurement and supply highlights that the design and combat performance of American tanks during the war, received the same kind of criticism that was raised against British tanks discussed in the last two chapters.² In response to the complaints later in the war regarding the lack of American 'heavy tanks', defenders of the programme

¹ H. C. Thomson and L. Mayo, *United States Army in World War II, The Technical Services, The Ordnance Department: Procurement and Supply* (Washington, Department of the Army, 1960), reprinted 1968, p. 263.

² *Ibid.*, pp. 222-223.

emphasised that the new programme 'could not be translated into military hardware overnight', which was similar to the British programme discussed in chapter 3.³

This chapter will begin by examining the British contracts during 1940 for the supply of British tank components and American tanks from the United States, within the context of the legal and financial limitations that prevented further orders. This will demonstrate the similarities with British industry regarding the shortages of materials affecting the assembly line and how the productive practice of some tank firms advanced the ability to mass produce tanks. Lastly, this section will examine how Britain had to compete with the simultaneous demand from the U.S. War Department for the same vehicles, and that many of these orders were sold back to the United States at a cost that was discounted or *gratis*.

The second section will highlight the effects of Lend-Lease tanks upon British fighting units and the impact upon the British tank programme, including the increase in co-operation and co-ordination between Britain, Canada and the United States. The expansion of the American tank programme will be reviewed to identify the number and effect that the supply of Lend-Lease Medium tanks had upon Britain. The condition of Grant and Sherman tanks upon arrival in the Middle East and India will be examined to identify the faults sustained during production and shipping. The third section will analyse the decision to reduce the British tank programme in order to accept more Lend-Lease tanks during 1943 and 1944, as this would save valuable Lend-Lease shipping space by increasing locomotive production in Britain. The fourth and final section will review the consequences for both Britain and the United States of reducing their respective tank programmes, including the cancellation of Lend-Lease tank deliveries from November 1944.

To begin with, the British government decided to take advantage of the manufacturing potential of North America before the outbreak of war by setting up the British Supply Board in Ottawa, together with an office in New York under Arthur Purvis. When war was declared in September 1939, the Ministry of Supply formed the British Purchasing Commission (BPC) in Ottawa, whilst the continuing arms embargo in the United States prevented war production from this source. When this legal obstacle was removed in November 1939, Purvis was sent

³ *Ibid.*, p. 231.

to Washington DC to establish contact with the United States Government and became chairman of the BPC, now relocated more prominently to the business centre of New York.⁴

Even though arms could now be bought from the United States, this was done on a “Cash and Carry” basis which limited each nation to their ability to pay for the munitions in cash and then transport them in non-U.S. shipping. This arrangement favoured Britain over Germany given the differences in dollar reserves, and that German shipping across the Atlantic was extremely difficult and infrequent.⁵ Until June 1940 British purchases were selective to take into account the best price, although this changed following the defeat of France to a policy of “arms at any price”, as part of the demand for quantity munitions discussed in chapter 3.⁶

Table 5.1 Expenditure of foreign currencies approved by the Treasury for purchases made by the Ministry of Supply, Oct-39 to Apr-40⁷

Foreign Currency Commitments	American Dollars	Canadian Dollars	European	Other Worldwide	Total	% of Total
	£	£	£	£	£	
Equipment / Stores	463,183	199,646	448,766		1,111,595	0.8
Tanks / Transport	1,355,878	607,562	217,402		2,180,842	1.7
Machine Tools	3,331,231	1,057,680	259,588		4,648,499	3.6
Explosives	11,613,833	649,322	1,988		12,265,143	9.4
Others Munitions	3,881,285	10,234,182	258,505	250	14,374,222	11.0
Raw Materials	19,662,449	54,693,834	17,940,054	3,755,000	96,051,337	73.5
Total	£40,307,859	£67,442,226	£19,126,303	£3,755,250	£130,631,638	100

NB: European Currencies – French, Belgian, Swiss, Danish, Dutch, Swedish and Norwegian
Other Worldwide Currencies – Japanese, Dutch East Indies, Argentinean and West Indies

To highlight the level of buying power that the British authorities had before the end of April 1940, Table 5.1 provides the sterling value for foreign currency payments totalling £130 million for a number of Ministry of Supply commitments. These purchases were made before the increased pressure on obtaining war matériel with the start of the German offensive in the west during May 1940, and provide an indication of the priorities at this time.

⁴ W. K. Hancock and M. M. Gowing, *British War Economy* (London, H.M.S.O., 1949), pp. 105, 195n, 229 & 382; C. P. Stacey, *Arms, Men and Governments: The War Policies of Canada, 1939-1945* (Ottawa, Queen's Printer, 1970), pp. 490-491.

⁵ H. Rockoff, 'The United States: from ploughshares to swords', in M. Harrison (ed.), *The Economics of World War II: Six great powers in international comparison* (Cambridge, Cambridge University Press, 2000), p. 94.

⁶ Thomson and Mayo, *Procurement and Supply*, p. 10.

⁷ The National Archives, Kew, CAB 68/2/39, War Cabinet, Supply and Production, 'Third monthly report by the Minister of Supply', 13 November 1939; CAB 68/3/29, 'Fourth', 18 December 1939; CAB 68/4/27, 'Fifth' 17 January 1940; CAB 68/5/14, 'Sixth', 17 February 1940; CAB 68/5/51, 'Seventh', 23 March 1940; CAB 68/6/7, 'Eighth', 20 April 1940; CAB 68/6/34, 'Ninth', 23 May 1940.

To begin with there was a clear emphasis upon obtaining raw materials at 74 per cent of total expenditure, with over half of the payments being made to Canada. A large amount of explosives were purchased representing 10 per cent, with the majority of this provided by the United States. Finally, the demand for tanks and transport from overseas sources accounted for just over £2.1 million, which was less than half of the requirement for machine tools.

Before evaluating British tank requirements from American industry with the onset of fighting in France and Flanders, the U.S. War Department responded to the developments in Europe by instigating a programme for thousands of new tanks.⁸ This greater emphasis had followed a general expansion in matériel for the U.S. Army from \$25 million spent in 1938 to the approval of \$150 million for 1940.⁹ Central to this new priority was the creation of the \$21 million Chrysler Tank Arsenal on 100-acres of farmland on the outskirts of Detroit, with construction commencing early in September 1940.¹⁰

An example of selective purchasing with American firms was made by the BPC during May 1940, with orders totalling \$2.5 million for the supply of components to support the final assembly of 250 Valentine tanks in Britain. The individual contracts included suspension units from American Car and Foundry, gun mounts from York Safe and Lock, and transmissions from Buckeye Traction Ditcher.¹¹ With regard to the suspension order, during April 1941 British Colonel H. G. Hoare visited the American Car and Foundry works in Berwick, Pennsylvania, as part of a series of factory visits discussed in greater detail below. At this time the suspension contract was nearing completion although the firm was reluctant to undertake another order, as they considered the Valentine suspension unit too expensive to make and would have re-designed the arrangement.¹² In respect of tank engines from the General Motors Corporation for the Valentine tank, the executive second Tank Board discussed during May 1941 that increased Valentine output was now more likely, as these engines were being received from the United States.¹³

⁸ Thomson and Mayo, *Procurement and Supply*, p. 227.

⁹ *Ibid.*, p. 10.

¹⁰ *Ibid.*, pp. 228-230.

¹¹ TNA, AVIA 38/102, Memo from BPC, 1 June 1940.

¹² Churchill College Archives, Cambridge, 1st Viscount Weir, WEIR 20/9, 'Report on visit to American Car and Foundry' by Hoare, 29 April 1941.

¹³ TNA, WO 185/8, '15th Meeting of the Tank Board', 16 May 1941.

By the middle of 1942, North American industry provided the British war effort with many different components towards the production of British tanks, including the Valentine tank in Canada. A summary of the component contracts for each firm against each tank model is provided in Table 5.2, as recorded at the weekly British Tank Components Meeting during July and August 1942. To summarise, the Valentine programmes in Britain and Canada received components from the largest number of different firms towards the supply of tanks to Russia as reviewed in the next chapter. The seven firms that assisted the Crusader programme were much greater than the restrictions indicated during August 1940 below. The one firm supplying Matilda production probably reflected the plan to bring this programme to an end during 1943 as discussed in chapter 3. The Churchill and Centaur contracts demonstrated that Britain took advantage of North American industry to support tank production at home, whilst receiving Lend-Lease tanks in large numbers as examined later.

Table 5.2 American and Canadian firms identified during July to August 1942 for the supply of components towards the production of British tanks¹⁴

	Matilda	Valentine	Churchill	Crusader	Centaur	Firms
Transmissions		BT		BT, IH, LC	IH	3
Suspensions		BM, ML				2
Engines		GM				1
Tracks	CW	CW, HF, KS, TW	CW	CW		4
Armour Plate		RS		JS, NB		3
Castings		AM, KM, NT, RP		AM	AM, We	5
Total Firms						18
Total Contracts	1	13	1	7	3	25

Key:	AM	American Manganese	3	KS	Kensington Steel	1
	BM	Balch Morris	1	LC	L. C. Smith Company	1
	BT	Buckeye Traction Ditcher	2	ML	Montreal Locomotive Works	1
	CW	Campbell, Wyant & Cannon	4	NB	National Box Annealing Company	1
	GM	General Motors	1	NT	National Traffic Guard	1
	HF	Hull Foundries	1	RP	R & S Products	1
	IH	International Harvester	2	RS	Republic Steel Corporation	1
	JS	Jessop's Steel	1	TW	Taylor-Wharton and Hull	1
	KM	Kruckemeyer Machine Company	1	We	Westelectric	1

With the purchase of components for British tanks underway the next logical step during 1940 was to place orders within the United States for the complete assembly of British tanks, such as the Matilda and Crusader tanks. This was part of an overall policy of overseas tank production that included the prospective Infantry Mark IV in Canada before deciding upon

¹⁴ Library and Archives Canada, Ottawa, RG 24, volume 2615, file HQS-3352-25-1, 'Minutes of British Tank Components Meeting', weekly from 10 July to 14 August 1942.

the Valentine as discussed in chapter 3. Similarly, with the military situation in France deteriorating further during June 1940, a French Mission to the United States sought the assembly of 12,000 B1-Bis tanks from a production group headed by the Baldwin Locomotive Company, at an eventual rate of 50 vehicles per day. Whilst this rate of output was deemed impracticable due to the lack of capacity for moulded armour plate, the production of 10 tanks per day was considered viable from the end of 1940, assuming the U.S. authorities gave priority for the necessary machine tools. The seriousness of this proposal was reflected by the intention to ship a complete B1-Bis and a couple of specialists from France to the United States, so that the characteristics of the tank could be demonstrated. With regard to the British authorities in the United States, it was hoped that these tanks would be delivered on an equal basis with France, thereby demonstrating a clear British interest in the project.¹⁵

Given the availability of proven designs and vehicles to use as the basis of an overseas production programme, British tank units would have benefited from receiving the B1-Bis in large numbers during 1941 and even 1942. This would have achieved the overriding requirement for quantity output to replace the losses following the defeat of France, and provided the British with greater firepower when comparing the B1-Bis against British and German equivalents. With regard to French tank design and production, the visit to France by the Special Vehicle Development Committee during November 1939 discussed in chapter 2, identified that the qualities of the B1-Bis had taken ten years to develop.¹⁶ The French tank had slightly less armour protection than the British Matilda, although both were matched in terms of speed for the designed infantry support role. The B1-Bis had a larger and single 270 hp engine, together with greater firepower than current British tanks by incorporating a turret mounted 47 mm anti-tank and hull mounted 75 mm high explosive gun.¹⁷

In relation to German armour during 1940, Julian Jackson highlights the general agreement that the Somua S35 Medium tank gave the best overall performance in terms of speed, armour and firepower, when compared against the Panzer Mark III. Equally, the B1-Bis was superior to the Panzer Mark IV in respect of armour and overall firepower, although the German tank had greater speed and range of action. The B1-Bis was also at a disadvantage

¹⁵ TNA, BT 87/29, 'Tank Programme in the United States of America', 15 June 1940.

¹⁶ Liddell Hart Centre for Military Archives, King's College London, Sir Albert Stern, STERN 2/1/2, 'Visit to France', 27 November 1939.

¹⁷ LHCMA, Stern 2/16, 'Details of the French Tank (Char "B")', 2 November 1939.

tactically with the crew taking on multiple responsibilities and that the main 75 mm gun was hull and not turret mounted, thereby limiting the firepower to wherever the tank was facing.¹⁸ The question of how the B1-Bis would have performed under desert conditions from an operational standpoint will have to remain unanswered given the lack of opportunity. However, given the limitations of British armour during 1941 and 1942 in terms of numbers, reliability and high explosive firepower discussed in chapter 3, the potential of incorporating numerous B1-Bis and spares from the United States should not be ignored, especially before the large scale deliveries of Grant and Sherman tanks. When the advisory first Tank Board discussed the possibility of taking over the French arrangements later in June 1940, it was noted that the General Staff had rejected the production of the B1-Bis in the United States in favour of British tanks instead.¹⁹ However, with the defeat of France and the future of Britain still in the balance, the United States was unlikely to commit production capacity towards any tank design that did not equally fulfil the requirements of the U.S. Army.

Following the defeat of France, the British Mission to the United States under Major-General Ridley Pakenham-Walsh investigated the possibility of placing tank orders for the Matilda and Crusader. During the discussions in August 1940, it was noted that modifications would be needed to the Crusader power system, transmission and tracks, in order to harmonise the production model with standards in the United States.²⁰ Furthermore, American policy had limited the manufacturing of Matilda and Crusader components in the United States to just two firms, although as seen in Table 5.2 above this restriction was later relaxed.²¹ By mid-1940 the United States were understandably reluctant to start production of British equipment when this nation might “go under” at any day, thereby having factories that were not providing for the U.S. Army. In any event, the British Mission quickly identified that there was ‘little hope of getting parallel production’ of the Matilda or Crusader, so a limited order for the M3 Medium tank still under design was considered instead.²²

The inability to secure a foreign source of Crusader tank production likely contributed to the expansion programme discussed in chapter 3, with the introduction of a further six tank firms

¹⁸ J. Jackson, *The Fall of France: The Nazi Invasion of 1940* (Oxford, Oxford University Press, 2003), pp. 14-15.

¹⁹ TNA, WO 185/8, ‘2nd Meeting of the Tank Board’, 26 June 1940.

²⁰ TNA, AVIA 38/102, ‘Notes of meeting in New York: Tanks – Cruiser’, 18 August 1940.

²¹ LAC, RG 24, volume 2596, file HQS-3352-4, ‘Proceedings of the Second Meeting’, Joint Committee on Tank Development, 14 September 1940.

²² CCA, WEIR 20/42, Report on Mission to the United States by Pakenham-Walsh, October 1940.

to the existing three firm Crusader programme. As emphasised by David Edgerton, there were notable exceptions to the reluctance of the United States to produce British munitions in large quantities, with some equipment actually used by American forces towards their war effort. These included the Lee-Enfield Rifle, the Rolls-Royce Merlin aero-engine, the Mark XIV bombsight, the No.19 wireless set, the Universal carrier, the 6-pounder or 57 mm anti-tank gun and jet engines.²³

One problem in relation to the direct purchase of tanks designed in the United States was that official policy prohibited the release of information, unless a sizeable order was made beforehand. The difficulty for Britain was that they could not reasonably be expected to place a large cash order without first understanding the characteristics of the vehicles on offer. To overcome this obstacle, during May 1940 President Roosevelt's representative Henry Morgenthau agreed that this information could be obtained by an army officer, via an examination of the tank during manufacturing and testing.²⁴ This gave the British authorities the opportunity to scrutinise the equipment before making an outlay in dollars or gold.

Lieutenant-Colonel Blowey from the Royal Tank Regiment inspected the M2A1 Medium tank during June, raising concerns about the vulnerable 32 mm of armour and also that mass production would take time to achieve.²⁵ This time lag was demonstrated when Chrysler received an order for 1,000 M2A1 tanks during mid-August 1940 with the understanding that production at 100 per month would begin in September 1941 and complete in August 1942. In any event, this contract was cancelled and replaced by the speculative M3 Medium with Chrysler releasing the pilot after just seven months and first production tank in 11 months.²⁶

As the only option for the British General Staff was to purchase the M3 Medium, the Vice-Chief of the Imperial General Staff General Robert Haining confirmed to Mission leader Pakenham-Walsh during August 1940, that the War Office accepted an order for 1,500 tanks.²⁷ When the new M3 design was discussed with the Dewar Tank Mission later in 1940, it was noted the tank had greater firepower than the Crusader but concern was raised regarding the height of the vehicle, especially when including the turret cupola. The position

²³ D. Edgerton, *Britain's War Machine: Weapons, Resources and Experts in the Second World War* (London, Allen Lane, 2011), pp. 80-81.

²⁴ TNA, AVIA 38/102, Purvis to Greenly, 11 May 1940.

²⁵ TNA, AVIA 38/102, Purvis to Monnet, 13 June 1940.

²⁶ Chrysler Corporation, *"Tanks are Mighty Fine Things"* (Detroit, Chrysler Corporation, 1946), pp. 5-6 & 24.

²⁷ TNA, AVIA 38/42, VCIGS to Pakenham-Walsh, 21 August 1940.

of the wireless set in the main hull instead of the turret as per the British standard was also questioned.²⁸ As a result of these the comments the M3 Medium became the Grant tank by incorporating a 'British turret' that removed the cupola and moved the radio equipment.²⁹

Table 5.3 British cash orders for 1,686 Grant and 400 Sherman tanks from production facilities within the United States, Sep-Dec 1940³⁰

Contractor	Contract Order	Date of Contract	Materials and Charges
			\$
<i>Tanks</i>			
Pullman Standard Car Mfg. Co.	500 M3 Grant Tanks	18-Sep-40	18,363,875
Pressed Steel Car Co. Inc.	501 M3 Grant Tanks	25-Oct-40	19,435,562
Baldwin Locomotive Works	685 M3 Grant Tanks	04-Nov-40	27,621,886
Lima Locomotive Works Inc.	400 M4 Sherman Tanks	27-Nov-40	10,944,248
			\$ 76,365,571
<i>Components</i>			
Continental Motors Corp.	3500 Tank Engines	21-Sep-40	19,656,477
American Type Founders, Inc.	1500 37 mm Gun Mounts & Recoils	23-Oct-40	5,193,345
National Pneumatic Co. Inc.	1000 37 mm Guns	04-Nov-40	1,628,938
Empire Ordnance Corp.	Machining Armour Plate	08-Nov-40	1,549,101
Empire Ordnance Corp.	2500 75 mm Guns	08-Nov-40	8,350,615
Empire Ordnance Corp.	1550 75 mm Gun Mounts	08-Nov-40	5,536,180
Empire Ordnance Corp.	1550 75 mm Gun Recoils	08-Nov-40	2,557,541
Republic Steel Corp.	2086 Sets of Armour Plate	10-Dec-40	8,648,478
Mack Mfg. Co.	340 Transmission Sets	27-Dec-40	2,569,809
			\$ 55,690,484
Total Materials and Charges			\$ 132,056,055
Plus Capital Assistance			\$ 16,571,305
Grand Total			\$ 148,627,360

As displayed in Table 5.3, the first cash contracts for the Grant and new the M4 Sherman tank were made during the final quarter of 1940, together with additional orders for the necessary components in respect of armour plate, engines, guns and mounts. Each contract was presumably the maximum that could be placed with each firm for reasons of capacity and the minimum number to make the production cost effective. Additional British equipment such as sand shields, smoke generators and smoke bomb throwers were installed

²⁸ CCA, WEIR 20/42, Report by Pakenham-Walsh, October 1940.

²⁹ P. Chamberlain and C. Ellis, *British and American Tanks of World War Two: The complete illustrated history of British, American and Commonwealth tanks, 1939-1945* (Leicestershire, Silverdale Books, 2004), p. 112.

³⁰ TNA, AVIA 38/42, 'Launching of the Tank Programme', Appendix V (A): Principal tank contracts placed by BSM (BPC), after 1945.

separately at one of the Tank Depots in the United States, thereby avoiding any interruption to the production line at the tank firms.³¹

To put these amounts into context, the U.S. official history on planning munitions for war highlights that by the end of 1940 total munitions orders placed with American firms by the BPC had amounted to \$3.2 billion. Whilst these orders were 'invaluable in creating new plant capacity' and exposed American industry to the processes of ordnance production, they came into conflict with similar attempts by U.S. officials to equip their own armed forces.³² By 1942 the arrangements under Lend-Lease had superseded British contracts as the means of supplying the British war effort from the United States. In respect of the tank orders, Edward Stettinius highlights that out of the 951 tanks shipped to the British forces by the end of 1941, only 165 were sent under British contracts.³³

With Lend-Lease deliveries providing the greatest impact on the British war effort, the War Department purchased large quantities of munitions and capacity generated by British contracts. From the tank order in Table 5.3, the amount recovered from the U.S. government for 'materials' totalled \$66,019,686 or approximately half of the original total. This resulted in the transfer of 653 Grant and all but one of the 400 Sherman tanks from British contracts to the War Department.³⁴ This purchase did not include the new plant facilities paid for under 'capital assistance', which was instead leased to the War Department for the nominal rent of \$1 per year. During the course of the war some of the jigs, equipment and buildings were sold for about 30 per cent of the original value, whilst \$6.8 million of 'capital assistance' was deemed irrecoverable with the capacity directed to support the American war effort.³⁵

During the discussions to purchase Medium tanks during October 1940, the British authorities in the United States also considered the M2A4 Light tank from American Car and Foundry, with deliveries expected early in 1941.³⁶ Given that the contract would have to be a cash order, the possibility of Britain giving up 300 large aero-engines, presumably the Merlin

³¹ Thomson and Mayo, *Procurement and Supply*, p. 254.

³² C. M. Green, H. C. Thomson and P. C. Roots, *United States Army in World War II, The Technical Services, The Ordnance Department: Planning Munitions for War* (Washington, Department of the Army, 1955), reprinted 1970, pp. 75-76.

³³ E. R. Stettinius, Jr., *Lend-Lease: Weapon for Victory* (New York, Macmillan, 1944), p. 94.

³⁴ TNA, AVIA 38/42, 'Launching', Appendix V (B): Recoveries from United States Government on sale of material, after 1945.

³⁵ *Ibid.*, Appendix V (C): Recoveries from sale of capital facilities, after 1945.

³⁶ TNA, AVIA 38/102, 'Minutes of Meeting in Washington: Tanks - M2A4', 3 October 1940.

now under production in the United States, for the Light tanks was considered as an alternative.³⁷ The British War Cabinet was unlikely to agree to this exchange when considering the refusal to alter the Priority of Production Directive to raise British tank production at the expense of aircraft and air defence examined in chapter 3. In any event the purchase of 200 M2A4 Light tanks direct from American Car and Foundry was authorised by the U.S. authorities in November 1940.³⁸ However with the inability to finance tank orders by late January 1941, the British authorities became wholly dependent upon the anticipated introduction of Lend-Lease to continue benefitting from the large production capabilities of the United States.³⁹ A small number of M2A4 Light tanks possibly under Lend-Lease were delivered to Britain in 1941, however these were limited to training purposes only.⁴⁰

Whilst the lack of buying power prevented new tank orders from being placed during 1941, production of the existing cash orders was underway as indicated above by the visit of Colonel Hoare to three assembly firms during April 1941. The first factory visited by Hoare was to inspect the general production of the M3 Medium tank by the Montreal Locomotive Works, which was a subsidiary of the American Locomotive Company. Whilst the vehicles under assembly were not part of the cash order for Grant tanks above, the details relating to the first assembly models provided the British with greater understanding into the condition of North American industry to commence mass production. To begin with, by May the initial casting of the hull and turret was expected by the General Steel Castings Corporation, and the first delivery of engines was due from another unnamed firm. The supply of transmissions was thought to be the 'likely bottleneck' in connection with the assembly of this tank, thereby delaying the release of the first production vehicle from Montreal Locomotive until the end of August instead of from the anticipated June 1941.⁴¹ By comparison, Chrysler released their first M3 Medium during April 1941, partly as a result of producing their own transmissions in addition to supplying other contractors.⁴²

The second visit was to the Baldwin Locomotive Works which was one of the firms contracted to provide Grant tanks to Britain, although the tank under inspection on this

³⁷ TNA, AVIA 38/102, Purvis to Salter, 27 October 1940.

³⁸ TNA, AVIA 38/102, North American Supply Committee to BPC, 31 October 1940; Dewar to Burton, 9 November 1940.

³⁹ TNA, CAB 115/88, Cypher telegram from Consul General in New York, 31 January 1941.

⁴⁰ Chamberlain and Ellis, *British and American Tanks*, p. 87.

⁴¹ CCA, WEIR 20/9, 'Report on visit to Montreal Loco Works' by Hoare, 21 April 1941.

⁴² Thomson and Mayo, *Procurement and Supply*, pp. 230 & 246.

occasion was the first M3 Medium provided to the U.S. Army from this firm. Despite an impression of the firm being 'rather hurried on the final assembly', the tank performed well on the testing track and was considered to be 'rather quiet on the rubber tracks'.⁴³ The third and final visit during April was to American Car and Foundry during the production of the M3 Light or Stuart tank, following completion of the M2A4 Light tank reviewed above. The operational characteristics of the Stuart tank will be discussed later in this chapter when considering the reports received from the Middle East early in 1943. The inspection during April 1941 highlighted particular techniques that contributed towards mass production and differed from the British process of machining each tank separately during assembly. By means of a full description Hoare reported that:

There is no individual fitting of the armour plate, all the plates being machined to a standard size and fitted directly on to the tank. A certain number of gaps of approximately 1/64" [0.4 mm] to in some cases 1/32" [0.8 mm] were noted.⁴⁴

Whilst the width of these gaps appear miniscule, it was noted 'that it would be possible to get bullet splash through the side' of the driver's compartment. In relation to the change from a riveted to an all welded turret on the Stuart tank, the method adopted by American Car and Foundry was to apply a layer of welding to the edge of each plate before being placed into the welding assembly jig. This enabled any movement of the plate during assembly to be corrected by adjusting the layer of welding, rather than having to machine the plate separately to ensure a secure weld. With regard to how these time-saving assembly techniques were converted into output, the factory completed eight tanks on the day of the visit with the expectation of the rate increasing to 15 per day or approximately 450 tanks per month.⁴⁵ Based upon the information obtained during the March 1942 Tank Engine Mission to the United States, this forecast was entirely feasible as American Car and Foundry was already producing 420 tanks per month towards a planned maximum monthly capacity of 1,000.⁴⁶

To put these tank firm examples into context with the M3 Medium tank programme as a whole, Figure 5.1 below provides the scheduled monthly output of the first production tanks as determined during July 1941. These figures do not take into account the reduction in

⁴³ CCA, WEIR 20/9, 'Report on visit to Baldwin Locomotive Works' by Hoare, 24 April 1941.

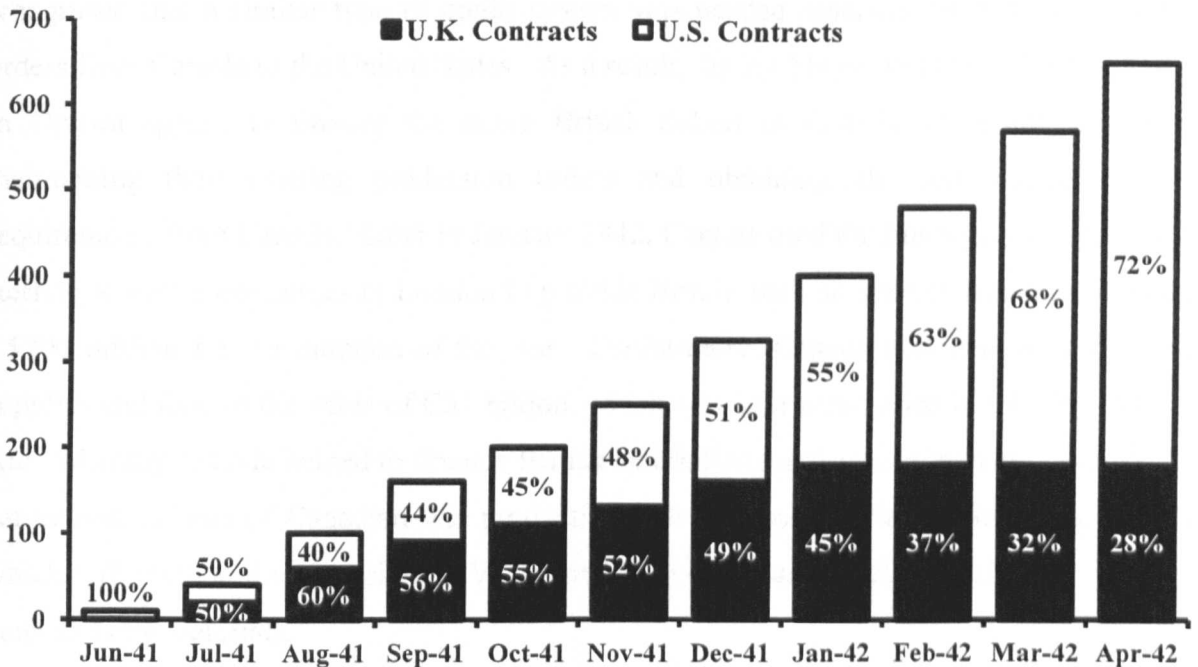
⁴⁴ CCA, WEIR 20/9, 'Report on visit to American Car and Foundry' by Hoare, 29 April 1941.

⁴⁵ Ibid.

⁴⁶ Heritage Motor Centre Motor Museum, Gaydon, Sir Miles Thomas, 80/20/1/5 & 6/4, Tank Engine Mission to USA, 'Appendix "A" to U.S. Tank Committee Plan', 30 March 1942.

British tank contracts following the later purchase and transfer of 653 Grant tanks to the War Department above. However the chart demonstrates the obstruction for Britain during this 1941 and early 1942 period was the expansion of the armed forces in the United States.

Figure 5.1 Forecasted monthly output for M3 Medium tank by the proportion of deliveries under UK and USA contracts, Jun-41 to Apr-42⁴⁷



Whilst Britain expected to receive an overall greater proportion of tanks until December 1941, from January 1942 onwards these deliveries were capped at 180 per month, whilst the U.S. Army received an increasing number each month. As indicated above, the necessity for British cash contracts to supply front line units with tanks became less important with the onset of Lend-Lease from 1941, the details of which will now be examined during the second section of this chapter.

The introductory chapter highlighted the different interpretations within the historiography regarding the introduction and effectiveness of the Lend-Lease Act for Britain. To begin with, the benefits of Lend-Lease were clearly the supply of much needed raw materials, equipment and munitions which the British could not otherwise produce or finance from their own resources. On the other hand, this was balanced against the United States gaining a controlling interest over Britain's own production efforts and rather than being an 'unsordid act', it was primarily designed to keep the war away from mainland United States. As

⁴⁷ TNA, AVIA 38/137, British Purchasing Commission, G. S. Murray to Sir C. Baillieu, 1 July 1941.

examined in the previous chapter, the effect of Lend-Lease upon the British tank programme was the expectation of receiving large numbers of battleworthy tanks, thereby supporting the change in Britain from quantity to quality tank production.

Further to the alternative effects of Lend-Lease upon Britain, the Canadian government recognised that a similar type of credit system was needed otherwise Britain would divert orders from Canada to the United States. As a result, during March 1941 the War Committee in Ottawa agreed to finance the entire British deficit in Canada, in return for Britain maintaining their existing production orders and obtaining all their Canadian dollar requirements from Canada. Later in January 1942, Canada used the funds generated from the sterling to dollar exchanges in London to provide Britain with an interest-free loan valued at C\$700 million for the duration of the war. Furthermore, Canada provided the gift of war supplies and food to the value of C\$1 billion, which was later superseded in 1943 by "Mutual Aid" whereby Canada helped to finance British and Allied purchases in the Dominion.⁴⁸ The nature and volume of Canadian war production will be examined in the following chapter, which will include the provision of Valentine tanks to Russia, together with other vehicles, guns and raw materials.

The combined benefits to the British war effort of receiving financial and material aid from the North American Continent were supported by the continued and mutual exchange of information and equipment between the Western Allies. An early example of co-operation in relation to tank production was seen during September 1940 when representatives of the British Mission to the United States attended the Canadian Joint Committee on Tank Development reviewed in chapter 2. Part of this meeting reviewed the unsuccessful British attempt to manufacture Matilda and Crusader tanks in the United States examined above. The meeting also covered the current status of Valentine production in Canada, together with the possibility of using Canadian industry to produce the modified M3 Medium tank, the British six-pounder gun and various armoured cars.⁴⁹

During February 1941 the Canadian Chief of the General Staff, Major-General Henry [Harry] Crerar, suggested an informal meeting in Montreal for the 'exchange of information and ideas between U.S.A., British and Canadian officers interested in tank design'. Whilst this brought

⁴⁸ Stacey, *Arms, Men and Governments*, pp. 49 & 172.

⁴⁹ LAC, HQS-3352-4, 'Second Meeting', 14 September 1940.

the latest tank developments to the military authorities from each nation, the casual nature of the occasion was emphasised when the meeting had 'no formal recognition on part of any government concerned'.⁵⁰ Despite being a short-term and ad hoc arrangement, the variety of issues under discussion included: the benefits of cast armour in respect of production and protective quality by taking into account British combat experience to date; tank armament, power traverse and gyro stabilising; steel and rubber tracks; and tank radio equipment.⁵¹

By August 1941, the Canadian Military Headquarters in London contacted the Ministry of Supply to propose the formation of an Armoured Fighting Vehicle User Committee in Britain. The purpose of this committee was to initiate the testing of vehicles shipped to the Canadian Corps in Britain from Canadian production, under the terms of reference to:

specify the trials of Canadian army A.F.V's which are to be carried out; to arrange therefor[e]; to supervise the conduct of trials and of any related tests of components; to report thereon to the Commander, Canadian Corps.⁵²

To achieve this, the Military Headquarters secured the agreement of the Tank Design Department in Britain for the Canadian vehicles to be included into the existing and 'heavy' programme of trials to be undertaken at the Experimental Wing at Farnborough. In a further example of co-operation between Britain and Canada, the secretary of the user committee was attached to Farnborough to witness the trials taking place, whilst a British Royal Engineers officer became a permanent member on the committee for the Ministry of Supply.⁵³ The first committee meeting occurred on 30 September 1941 and continued until the 41st meeting on 4 December 1943. The range of tank related issues under discussion during these 26 months included the trials of tank guns, engineer tank adaptations, tank transporters, the arrangement of the tank fighting compartment, and crew clothing.⁵⁴

Prior to the entry of the United States into the war in December 1941, the benefits brought about by the introduction of Lend-Lease were complemented by increased co-ordination on tank policy between the British and American authorities. As demonstrated in chapter 2,

⁵⁰ LAC, RG 24, volume 2615, file HQS-3352-25, telegram to Military Attaché, Washington, 19 February 1941.

⁵¹ LAC, HQS-3352-25, 'Points for Discussion at Tank Meeting' and 'Minutes of Meeting', 28 February 1941.

⁵² LAC, RG 24, volume 9370, file 38/COMM AFV/1, Brigadier J. H. MacQueen, Canadian Military Headquarters to Deputy Director-General for Mechanization, 26 August 1941.

⁵³ LAC, 38/COMM AFV/1, G. Burton, Chairman, Tank Board to MacQueen, 9 September 1941.

⁵⁴ For meetings 1 to 26: LAC, RG 24, volume 9370, file 38/COM AFV/2, 30 September 1941 to 3 April 1943; for meetings 27 to 41: LAC, RG 24, volume 9370, file 38/COM AFV/2/2, 17 April 1943 to 4 December 1943.

from August 1941 the membership of the third, fourth and fifth Tank Boards included the part-time involvement of U.S. Army Colonel G. A. Green from the Harriman mission, in both an advisory and liaison capacity for the United States. To emphasise how this co-operation was not an isolated arrangement, the U.S. official history highlights that 'on no other type of matériel was collaboration with the British so extensive and carefully organized as on tanks, tank guns and tank accessories'. For example, during September 1941 the U.S. Chief of Ordnance, General Charles Wesson, visited London to receive British opinion on tank and artillery design based upon combat experience over the previous two years.⁵⁵ Following the attack on Pearl Harbor, the military relationship between Britain and the United States was strengthened when Field-Marshal Sir John Dill was appointed to Washington and became instrumental in removing 'suspicion and foster mutual understanding'.⁵⁶ Specific co-operation was formalised in March 1942 when the British Tank Mission to Washington secured a joint agreement with the United States Tank Committee on future collaboration to maintain "the fullest of mutual exchange of information and of coordination of plans".⁵⁷ A similar agreement was signed in September 1942 between Britain and Russia, but as discussed in the next chapter, this was one-sided with Britain providing technical detail and equipment with little reciprocation from Moscow.

A demonstration of how the Anglo-American agreement worked in the practice was seen in respect of the British tank adaptations that the U.S. authorities were prepared to incorporate into the U.S. Army. To begin with, between June 1942 and December 1943 the Research and Development Service in the United States received regular reports on work relating to the Sherman Duplex-Drive (DD) tank.⁵⁸ In another example, Britain supplied full details of the Canal Defence Light (CDL) adaption to the Grant turret which assisted night river crossings with a powerful and dazzling searchlight. This information permitted the U.S. Ordnance to build 500 of these turrets over 18 months, thereby saving two years of preliminary work. Whilst the CDL device was not extensively used during the war, the U.S official history is keen to emphasise that this should not 'diminish the value of the collaboration'.⁵⁹

⁵⁵ Green, et al., *Planning Munitions for War*, pp. 268-269.

⁵⁶ A. Danchev, 'Dill', in J. Keegan (ed.), *Churchill's Generals* (New York, Grove Weidenfeld, 1991), pp. 60-68.

⁵⁷ Green, et al., *Planning Munitions for War*, p. 269.

⁵⁸ *Ibid.*, p. 270; for the deployment and limitations of the Sherman DD tank during the Normandy invasion see: A. R. Lewis, 'The Failure of Allied Planning and Doctrine for Operation Overlord: The Case of Minefield and Obstacle Clearance', *The Journal of Military History*, Vol. 62, No. 4 (Oct., 1998), pp. 787-807.

⁵⁹ Green, et al., *Planning Munitions for War*, p. 272; for an assessment of the CDL device see: B. H. Reid, 'The attack by illumination: The strange case of Canal Defence Lights', *RUSI Journal*, 128, 4 (1983), pp. 44-49.

Overall, American Ordnance officers were never denied access to British research and development information whilst attached to the various experimental stations or proving grounds in Britain.⁶⁰ One area of limitation was identified during September 1943 when the Department of Tank Design (DTD) chose not to supply the Canadian Military Headquarters in London with the latest 'data books' relating to British tanks. This inflexible approach was not due to security restrictions, but instead aimed at 'keeping the circulation to an absolute minimum' because the 'frequent changes in data' resulted in a considerable amount of work to compile and distribute the new books. As a consequence, the DTD confined the tank data to 'actively interested Branches and Departments' within Britain, so that 'the limited number of recognized holders' received the updated information in a timely fashion.⁶¹ As for the United States, from mid-1943 the U.S. Ordnance provided the British with thousands of technical and industrial reports every month, detailing important and mutually beneficial information on manufacturing processes.⁶²

The ability of the United States to supply the various requirements of the different allied nations via Lend-Lease, demonstrated the extent of American industrial strength. As highlighted above for the tank industry, much of this production capacity was generated after September 1940 by the combination of British cash contracts and War Department orders and facilities like the Chrysler Tank Arsenal. This expansion was important when considering that the U.S. Chief of War Plans, Major-General George Strong, revealed to Mission leader Pakenham-Walsh during August 1940 that the U.S. army programme was currently 60 per cent of the British army programme.⁶³ The accuracy of this claim was later demonstrated when the United States produced 4,383 tanks during 1940 and 1941, which represented 71 per cent of total British tank output of 6,216 over the same period.⁶⁴

Following the German invasion of Russia during June 1941, President Roosevelt demanded an increase in tank production to 2,800 tanks per month, although by December American industry was still limited to 900 vehicles by comparison. Despite this shortfall in planned output, developments to increase production had taken place during 1941 which would take effect from 1942 onwards. These included raising the priority status for tanks from A-1-g to

⁶⁰ Green, et al., *Planning Munitions for War*, p. 270.

⁶¹ LAC, RG 24, volume 9363, file 38/ARM VEH/10, Director of Design of Equipment & Mechanization, London to Director of Mechanization, Ottawa, 2 September 1943.

⁶² Green, et al., *Planning Munitions for War*, p. 271.

⁶³ CCA, WEIR 20/42, Report by Pakenham-Walsh, October 1940.

⁶⁴ British: Appendix 1; United States: Thomson and Mayo, *Procurement and Supply*, p. 263.

A-1-a, and with the decision to construct the General Motors Fisher Tank Arsenal with the potential capacity to assemble 1,000 Sherman tanks per month.⁶⁵ Furthermore, organisational improvements occurred from 1942 with the creation of industry integration committees that brought manufacturers together to eliminate bottlenecks and increase the rate of production. By April 1943 a total of 27 committees had been formed with some continuing throughout the war as required, whereas others were disbanded following the successful outcome of the problems that they were set up to resolve.⁶⁶

Whilst Roosevelt raised the tank programme in January 1942 from 33,600 to 45,000 deliveries for the year or an average of 3,750 tanks per month, total output for 1942 was still 20,000 vehicles fewer than expected. The U.S. official history highlights that in addition to a reduction in overall requirements, the main reasons for this deficit was shortages of material, irregular deliveries of material, and an increased demand upon the provision of spare parts.⁶⁷ When comparing this situation against British tank production discussed in chapter 3, whilst there were differences in the size of industrial capacity and total output, it is clear that both programmes were susceptible to the same pressures. Despite this shortfall in the 1942 American programme, the tank industry had greatly expanded over the twelve months as demonstrated by the output of 954 tanks in January to an exceptional 4,853 during December.⁶⁸ To conclude this period of growth, by spring 1943 the tank programme in the United States was producing nearly 4,000 vehicles each month from 16 factories at an overall cost for tools, equipment and buildings of \$250 million.⁶⁹

To demonstrate the differences between the British and American production efforts, Table 5.4 below compares the output of standard tanks from the United States and Britain, together with the number of Medium tanks provided under Lend-Lease. This table excludes production during 1941 and 1945 together with the output of Self-Propelled and tank conversions across the whole period, due to differences in the available source material. Furthermore, the Lend-Lease deliveries are limited to Medium tanks of the Grant and Sherman range as these vehicles had the greatest impact upon the British tank programme and war effort generally. Finally, in order to demonstrate how dependent Britain was upon

⁶⁵ *Ibid.*, pp. 231-233.

⁶⁶ *Ibid.*, p. 244.

⁶⁷ *Ibid.*, p. 238.

⁶⁸ *Ibid.*

⁶⁹ *Ibid.*, p. 255.

the supply of Lend-Lease tanks to continue pursuing an offensive strategy across the different theatres, the Medium tanks are compared against the production of British front line tanks.

Table 5.4 Production of tanks from the United States and Britain, compared against the supply of Lend-Lease Medium tanks and British front line tanks

	1942	1943	1944	Total
Total USA tank output ⁷⁰	24997	29497	17565	72059
Total Lend-Lease Medium tanks sent to Britain ⁷¹	4388	10110	5492	19990
Total British tank output ⁷²	8622	7217	4000	19839
Total British front line tanks ⁷³	7616	5531	3565	16712
Percentage of Medium tanks to USA output	18	34	31	28
Percentage of British output to USA output	34	24	23	28
Percentage of Medium tanks to British output	51	140	137	101
Percentage of Medium tanks to British front line tanks	58	183	154	120

The table demonstrates that whilst tank production in the United States did not reach the targets set by Roosevelt, the programme from 1942 to 1944 delivered three-and-a-half times more tanks than were produced in Britain during that time. The supply of Lend-Lease Medium tanks from the United States to Britain represented 28 per cent of the American tank programme over the period and by as much as one-third over the last two full years of the war. As identified in the previous chapter and in greater detail below, increased numbers of Lend-Lease Sherman tanks permitted the British tank programme to concentrate upon quality output and redirect industrial capacity to tank conversions or non-tank work. The table quantifies this dependency upon Lend-Lease with the supply of good quality Medium tanks to support reductions in the British tank programme by the rise from 51 per cent of British output in 1942 to 139 per cent across both 1943 and 1944. This reliance was even greater when considering that these Medium tanks represented 183 and 154 per cent of British front line tank output over the last two years under review.

As discussed during the last two chapters, a large number of British production tanks were unsuitable for operational duty and restricted to training or were otherwise mechanically

⁷⁰ Total USA output for Light, Medium and Heavy tanks: *Ibid.*, p. 263.

⁷¹ Lend-Lease Medium tanks Britain 1942-43: TNA, AVIA 22/454, 'Medium Tanks', 5 February 1944; 1944: Figure 5.3 below.

⁷² Total British output for Light, Cruiser and Infantry tanks: Appendix 1.

⁷³ Total British front line tanks: extrapolated from Appendix 1 by incorporating those tanks which were produced for front line service including shipments to the Soviet Union, thereby excluding Light tanks, the Covenanter, Cavalier and Centaur tanks, plus all tank conversions.

unreliable once received by armoured units. Generally speaking, this was not repeated amongst the majority of tanks provided under Lend-Lease, as highlighted by the testimony of British tank crews who operated the first vehicles under combat conditions in the Middle East. Particular endorsements of the Grant tank included greater firepower with the 75 mm gun, good manoeuvrability and quality armour, compared against the common concerns of the high silhouette and that the main gun was not turret mounted.⁷⁴ Overall, Jonathan Fennell highlights how the Grant had contributed to the “enhanced” fighting spirit of the troops.⁷⁵

However, this front line opinion cannot account for the condition of American tanks upon arrival in the Middle East, and the level of maintenance required in the workshops before being sent forward and used by tank crews for the first time. To begin with, the U.S. official history highlights how the Grant tank was ‘hurriedly designed’ following German armoured successes in Europe during 1940, and went into production without adequate tests.⁷⁶ During July 1942 the fourth Tank Board considered how these Grant tanks were received and first used by British forces in the Middle East, based upon the report of Colonel William Blagden following his six month visit to this theatre. In addition to Blagden, the meeting was also attended by Averill Harriman from the U.S. Embassy, who later confirmed the same information together with some additional detail to the U.S. Under-Secretary of War.

In respect of the Tank Board discussion, the quality of the 50 mm cast armour on the Grant was considered to be ‘excellent’ and superior to the riveted armour on the British Crusader tank of equal thickness. There was some doubt regarding the ‘excessive oil consumption’ noted during the training period on the Grant, although this had not affected the vehicles during subsequent combat operations. The Grant engine ‘could be replaced in a fraction of the time taken to replace a Crusader engine’, giving rise to the complaint that ‘insufficient attention had been given to accessibility and ease of replacement of assemblies in British tanks’. Whilst the tracks on the front of the Grant were exposed and provided the enemy gunners with ‘rather a large target’, the manoeuvrability of the tank was not affected when the rubber sections had either worn or fallen away. The main area of concern was the

⁷⁴ Major B. Close, *A View from the Turret: A History of the 3rd Royal Tank Regiment in the Second World War* (Tewkesbury, Dell & Bredon, 1998), pp. 74-75; G. Forty (ed.), *Tanks Across the Desert: The war diary of Jake Wardrop* (Gloucestershire, Sutton Publishing, 2003), pp. 50-52; R. Leakey, *Leakey's Luck: A tank commander with nine lives*, with G. Forty (Gloucestershire, Sutton Publishing, 1999), pp. 94-96.

⁷⁵ J. Fennell, *Combat and Morale in the North African Campaign: The Eighth Army and the Path to El Alamein* (Cambridge, Cambridge University Press, 2011), pp. 67-68.

⁷⁶ Thomson and Mayo, *Procurement and Supply*, p. 252.

shortage of spares for the Grant, which although they slightly increased with the delivery of engines and volute springs during combat operations, the report stressed that this needed significant improvement. As for maintenance, there was a lack of handbooks for the Grant tank which limited the ability of crews to learn the required tank servicing.⁷⁷

The cable sent by Harriman to the United States confirmed what was said at the Tank Board meeting, together with some elaboration in respect of the operational problems faced by British tank crews such as the lack of spare parts. This was demonstrated by the need to dismantle newly received Grant tanks in order to distribute the parts as spares and keep the remaining vehicles operational, such as prior to the Battle of Gazala in May 1942. In this instance, 65 Grant tanks were cannibalised upon receipt in preparation for the battle, thereby weakening the overall strength of British armoured units, particularly when this was the first combat deployment of the Grant from the United States. Later, the 'engines from 15 good tanks' were removed and sent forward from the rear areas, so that the tanks disabled on the front during the June battles could be repaired.⁷⁸

To quantify this effect, the British official history identifies that the British 1st and 7th Armoured Divisions and reserves had 167 Grant tanks at the start of Gazala, out of total strength of 573 that included 257 Crusaders and 149 Stuarts.⁷⁹ Given the particular benefits that the Grant tank gave British crews against German armour and soft targets, the loss of 65 tanks or 28 per cent from the original 232 vehicles was extremely serious, especially when these were needed just to make up the shortages in spare parts. Finally in relation to tank maintenance, it was recorded that Grant tool kits were lacking track adjusting tools and special wrenches, and that the shortage of hand books was quantified as only enough for three tanks per regiment of 36 tanks.⁸⁰

Colonel Blagden provided another statement later during February 1943, as a supplement to the twelfth Armoured Fighting Vehicle Technical Report. As discussed in chapter 3, the unreliable nature of the Crusader tank in the Middle East was attributable to both poor workmanship and inspection at the factory and the inappropriate preparations at the dockside

⁷⁷ TNA, WO 185/8, 'Minutes of the 17th Meeting of the Tank Board', 9 July 1942.

⁷⁸ Nuffield College Library, Oxford, Lord Cherwell, Cherwell G367/19-22, message to Under Secretary of War, Patterson from Harriman, 13 July 1942.

⁷⁹ I. S. O. Playfair, et al., *The Mediterranean and Middle East, Volume III: British Fortunes Reach Their Lowest Ebb* (London, H.M.S.O., 1960), p. 234.

⁸⁰ NCL, Cherwell G367/19-22, message, 13 July 1942.

and during the voyage to North Africa. The U.S. official history highlights that measures were undertaken after mid-1942, to avoid this type and level of damage being sustained to American tanks sent on the long sea voyage. These included protecting the engines with an internal coating of preservative oil and an external spraying with a rust-preventative, and then sealing both the engine and crew compartments with waterproof tape.⁸¹

The 1943 report from Blagden highlights that these preventative practices were either not completely or at least immediately successful, as defects were still found with the sample of 38 Grant and Sherman tanks received from the United States. The problems encountered were a combination of haste in production and inadequate inspection at the factory, and corrosion and damage caused during shipping. The effect of these defects was to delay the supply of Grant and Sherman tanks to British armoured units by about three weeks, whilst corrections were carried out at the base workshops.⁸² With regard to specific defects, Table 5.5 provides a summary of the different types of problems that required attention, and whether they were caused during assembly or during transit by either moisture or collision. Each problem has been divided by the number of different types of fault and then the total number of individual faults requiring attention, demonstrating that many tanks had multiple problems to overcome.

Table 5.5 Summary of defects found with 38 Grant and Sherman tanks upon arrival in the Middle East early 1943⁸³

Problems on 22 Sherman and 16 Grant tanks	Defects during factory assembly		Defects from moisture during transit		Defects from collision during transit	
	Different faults	Total faults	Different faults	Total faults	Different faults	Total faults
Electrical	10	39	1	8		
Engine	6	36	2	2		
Final Drive / Transmission	2	3	4	12		
Suspension	2	4	2	3		
Tracks	2	5				
Fighting Compartment	20	37	4	10		
Other Assembly	12	22				
External Damage					5	11
Internal Damage					3	4
Total	54	146	13	35	8	15

⁸¹ Thomson and Mayo, *Procurement and Supply*, p. 255.

⁸² NCL, Cherwell G.368/5, Special Supplement to A.F.V. Technical Report No.12, by Blagden, 'Grant and Sherman', paras. 22-24, 6 February 1943.

⁸³ NCL, Cherwell G.368/8, Appendix A, 'American Tanks: Defects on Arrival', in Special, 6 February 1943.

Whilst the report does not distinguish between the Grant and Sherman nor which tanks had the most or least defects, the table demonstrates that the majority of individual and accumulative defects occurred on the production line. A similar outcome was reached by the General Motors engine technician stationed in Cairo during February 1943. In terms of workmanship or construction, the technician informed the Detroit facility that some bolts were recorded as loose whilst some bolt holes in engine doors were not lining up with holes in the hull. There were examples that the turret had not been fitted correctly and that some vehicles did not 'track a perfectly straight line'. As a conclusion the technician highlighted that 'many of these defects can be eliminated at the assembly plant through more rigid inspection; others could be prevented by the liberal use of anti-corrosive elements prior to storing or shipping'. To demonstrate the type of 'rigid inspection' that each vehicle had to 'undergo at the base workshop before being put into service' in the Middle East, the technician provided the inspection report of tank T-24111 which listed 84 separate defects.⁸⁴

When production changed to the Sherman tank from mid-1942, by 1943 there were nearly 5,000 Grant tanks still in U.S. service and surplus to requirements. Some were adapted as CDL tanks above or deployed as recovery or training vehicles, whereas the remainder were dismantled for spare parts or otherwise scrapped.⁸⁵ In respect of British requirements, whilst the North African and European theatre armies received the latest Sherman tanks, the British Army in Burma under Lieutenant-General William Slim, continued to fight with older Stuart and Grant tanks. This lack of up-to-date equipment was exacerbated by the same problems that affected the supply of tanks to the Middle East discussed above when Grant tanks were received in India during July 1942 with rusted oil coolers. Whilst initial investigations did not determine the cause of the problem and that the age and prior usage was likely a contributory factor, the inspectors highlighted the possibility that the defects were because of 'rusting during the sea voyage'.⁸⁶ Despite these problems, Slim highlights that the Grant was still capable of combating Japanese Medium tanks and together with the later supply of older Sherman tanks were very useful in overcoming Japanese bunkers:

It was solved in Arakan – and copied throughout the Fourteenth Army – by the tanks firing, first, surface-burst high explosive to clear the jungle, then delay-action high explosive to break up the faces of the bunkers thus exposed, and lastly solid armour-piercing shot as the infantry closed in. With no explosion, the last few yards were

⁸⁴ NCL, Cherwell G.368/9-10, Appendix B, Diesel Technician to GMC, 20 January 1943 in *ibid.*

⁸⁵ Thomson and Mayo, *Procurement and Supply*, p. 253.

⁸⁶ LAC, 38/ARM VEH/10, Ordnance Consulting Officer for India to MGO in India, 28 July 1942.

safe, if you had first-class tank gunners and infantrymen with steady nerves, who let the shot whistle past their heads and strike a few feet beyond or to one side of them.⁸⁷

With regard to the Light M3 Stuart tank, British tank crews have expressed considerable praise for the reliability and top speed of this vehicle, which they accordingly nicknamed the 'Honey'. The extent of this admiration still recognised that as a reconnaissance tank the Stuart had limitations in armour protection and firepower with the 37 mm main gun, together with a short operational range between re-fuelling.⁸⁸ The inspection of the latest type of Stuart tank received in the Middle East from the United States early in 1943 revealed problems of ergonomic design with the fighting compartment rather than mechanical defects following poor assembly or inspection.

The report by Blagden highlighted above identified that despite a 'heroic attempt' to provide 'this hitherto admirable vehicle with every modern convenience', the result was 'decidedly unfortunate'. Based upon the trials carried out by an experienced Stuart tank crew, the fighting compartment was cramped for the commander and gunner with insufficient head, leg or elbow room. The prospect of rapid evacuation was hampered by the shape and size of the turret escape hatches and that due to the short distance from the tank floor to the turret roof, the Commander was exposed from the waist upwards. Finally, whilst the driving position was reasonably good, there was no communication between driver and commander. The remedies for some of these problems included enlarging the turret hatches and moving the wireless set forward.⁸⁹ Blagden pointed out that despite a general feeling against these types of workshop adjustments, they were ultimately necessary:

We are extremely reluctant to cut brand new vehicles about in this way, and to take out fittings which other people have been at great pains to put in. But there is no doubt that units will not accept the tank in its present condition; if we can improve it in anyway, we must.⁹⁰

Grant, Lee and Stuart tanks were also provided to Australia under Lend-Lease from 1942 as part of the general strengthening of Australian defences by the United States, who wanted to 'utilise Australian facilities' as a base of operations following Japanese attacks in the

⁸⁷ Sir Field-Marshal W. Slim, *Defeat into Victory* (London, Cassell, 1956), 2nd edition, p. 230; for further commentary on American tanks see, pp. 288 & 479-80.

⁸⁸ Close, *A View from the Turret*, pp. 46 & 57; S. Hills, *By Tank into Normandy: A memoir of the campaign in north-west Europe from D-Day to VE Day* (London, Cassell, 2003), p. 214.

⁸⁹ NCL, Cherwell G.368/6, Special, 'General Stuart', paras. 32-38, 6 February 1943.

⁹⁰ *Ibid.*, para. 39.

Pacific.⁹¹ Together with Matilda tanks from Britain over the same period as discussed in the next chapter, these vehicles provided a supply of armour which Australia's own tank production could not match with the first pilot only delivered in January 1942.⁹² Whilst these vehicles relieved some of the fears of quantitative deficiency in Australia that had similarly existed in Britain in 1940, the increasingly obsolete nature of these Allied tanks was noted by the Australian authorities during April 1942. The Grant and Lee tanks were reported as having 'serious disabilities', whilst the Stuart required 'considerable modification to make them "battle-worthy"', and the Matilda was too slow and could not operate over long distances.⁹³ By March 1943 it was noted that 255 Lee tanks had required numerous modifications and limited for "training" purposes rather than combat deployment.⁹⁴ Overall the Australian Army received 1,624 tanks from overseas sources, including 487 M3 Light and 757 M3 Medium tanks from the United States and 380 Matilda tanks from Britain.⁹⁵

The third section of this chapter will examine the advantages of Lend-Lease upon British industry during 1943 and 1944, as the British tank programme was reduced in order to accept greater numbers of Medium from the United States, as identified in the previous chapter. One advantage for the British tank programme following the large increase in Lend-Lease tanks during 1943 as displayed in Table 5.4 above, was that the Cromwell tank was not forced into mass production similar to the Crusader or Churchill tank beforehand. The War Cabinet emphasised this particular benefit of Lend-Lease during the August 1944 reply to the Select Committee on National Expenditure, following their report on British tank production:

The Cromwell would have been used, if it had been required in 1943; but since there was little tank fighting and Shermans were available, opportunity was taken to submit it to prolonged tests and modification in order to bring it up to the present high standard. Units equipped with tanks are now in action in Normandy, and General Montgomery reports that they are proving reliable and with other British armour are playing a notable part in the battle.⁹⁶

⁹¹ National Archives of Australia, A816, 45/302/161, Minister for the Army, F. M. Forde to Prime Minister, J Curtin, 7 January 1942.

⁹² For Australian tank programme see: D. P. Mellor, *Australia in the war of 1939-1945: The role of science and industry* (Canberra, Australian War Memorial, 1958), pp. 301-322.

⁹³ NAA, A816, 45/302/161, 'Notes on tanks being supplied from overseas', April 1942.

⁹⁴ NAA, A816, 45/302/161, Director Armoured Fighting Vehicle Production, A. R. Code to Ministry of Munitions, 25 February 1943.

⁹⁵ NAA, A816, 45/302/184, Australian Tank Production, report by Colonel G. A. Green, 17 May 1943, 'Survey of tanks received from overseas and tanks on issue'.

⁹⁶ Cmd. 6865, 'Reply to the memorandum on tank production by the Select Committee on National Expenditure', 2 August 1944, in *War-Time Tank Production* (London, H.M.S.O., 1946), p. 50.

Whilst the decision to accept more Lend-Lease tanks was complemented by necessary reductions of the unsatisfactory Centaur tank, the underlying reason was linked to the build up of American forces in Britain under operation “Bolero”. Together with the initial D-Day preparations under operation “Roundup”, the Minister of Production Oliver Lyttelton emphasised to Prime Minister Churchill in August 1942 that these operations required large numbers of locomotives. The problem for Britain was that industry was directed towards war production so the locomotives would have to be supplied fully constructed from the United States, thereby consuming valuable Lend-Lease shipping space.⁹⁷

A solution to this predicament was offered by Lieutenant-General Brehon Somervell from the U.S. War Department earlier in June 1942, who recommended that locomotives be built in Britain from materials supplied by the United States. The Ministry of Supply had already reviewed this possibility and concluded that it was not possible to increase locomotive production without interfering with tank output, as both programmes required much of the same heavy machinery. However, tank deliveries from the United States were expected and ultimately did significantly increase during 1943, thereby supporting a reduction of 918 Centaur tanks whilst transferring some British industrial capacity to locomotives.⁹⁸

In quantifying these proposed changes, Lyttelton stated to Churchill that 485 locomotives would be constructed by the capacity released from tank production. With regards to shipping space, Lyttelton estimated that the saving could be as much as 70,000 measurement tons below deck or the full carrying capacity of eight to ten cargo ships, plus part of the deck space equivalent to the total supply of 300 tanks. The necessity of accepting more tanks from the United States with the construction of locomotives in Britain was reiterated by Lyttelton, as locomotives were ‘one of the most difficult of all cargoes to handle’, hence the substantial gain in shipping space.⁹⁹ In a comparative example, George Peden highlights that steel production in Britain was reduced during 1944 as a means to increase shipping space by accepting finished steel from the United States, rather than importing the bulky iron ore.¹⁰⁰ Churchill was understandably concerned by the ‘very serious’ loss of 918 tanks from the

⁹⁷ TNA, PREM 3/426/15, Lyttelton to Churchill, 28 August 1942.

⁹⁸ Ibid.

⁹⁹ TNA, PREM 3/426/15, Lyttelton to Churchill, 8 September 1942.

¹⁰⁰ G. C. Peden, *Arms, Economics and British Strategy: From Dreadnoughts to Hydrogen Bombs* (Cambridge, Cambridge University Press, 2007), p. 190.

British tank programme during 1943, but nonetheless recognised the considerable Lend-Lease shipping benefits and accepted the reduction.¹⁰¹

As highlighted in Appendix 6 four British tank firms transferred to locomotive production after 1942, the timing of which was dependent upon the completion of their existing tank contracts. With regards to London Midland Scottish, as discussed in chapter 3 the Covenanter contract at the Crewe location was cancelled during 1942, with the remaining order redistributed amongst Leyland Motors and English Electric. The final Covenanter tank from Crewe was delivered during August 1942 at which point the factory began work on locomotive production. The last Churchill tank from Beyer Peacock was delivered during March 1943 thereby permitting the change to the production of locomotives the same month. In respect of the Matilda, Vulcan Foundry and North British Locomotive finished their tank contracts in May and June 1943 respectively, with the transfer to locomotives likewise occurring in June and July. Upon completing the Matilda contract in February 1943, London Midland at Horwich assembled the Centaur tank until November, at which point the factory began producing locomotives similar to the Crewe location fifteen months earlier.¹⁰²

To demonstrate the effect that this redirection of industrial capacity had upon the order book of the firms concerned, Figure 5.2 below highlights the average value of civilian and military production orders each year at Vulcan Foundry from 1938 to 1945. To begin with the effect of the two large orders during 1938 for 130 Matilda tanks totalling £1,170,000, as discussed in chapter 1 on rearmament, can be clearly displayed on the chart for 1938 and 1939. The continuation orders during 1940 based upon the fighting in France, as discussed in chapter 3, carried the strength of war work into 1941. With the order book declining during 1942 and with the planned completion of the Matilda contract during 1943, Vulcan Foundry needed either another tank order or the transfer of capacity to tank conversion or non-tank work. Vulcan received the latter during 1943 with a considerable order of 160 "Austerity" locomotive engines in May totalling £1,784,800 and again in July for a further 94 engines at £895,700.¹⁰³ The production of military equipment declined during the last years of war when tank work was limited to spares for the Matilda tank, such as during January and June

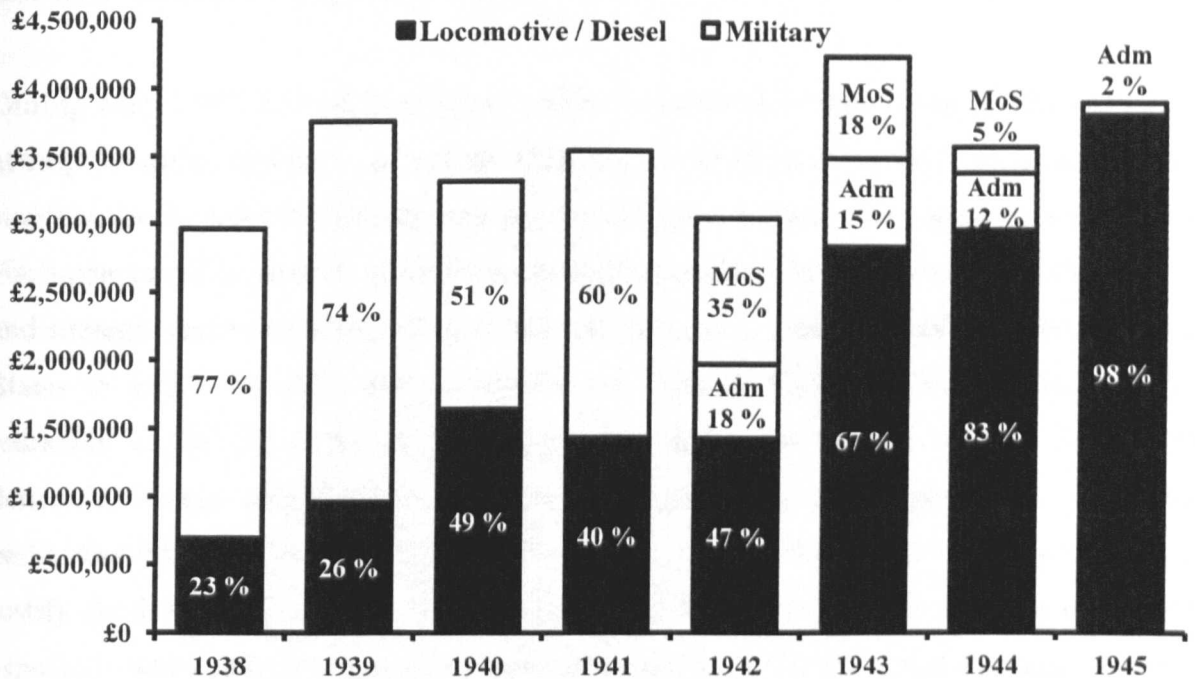
¹⁰¹ TNA, PREM 3/426/15, Churchill to Lyttelton, 13 September 1942.

¹⁰² Tank completion dates for 1942 and 1943: TNA, AVIA 46/188, 'Monthly Deliveries on Infantry and Cruiser Tanks by Firms, 1939-1943', draft official history narrative by D. Hay, after 1950, p. 271; transfer dates to locomotive production: AVIA 22/454, 'Tank Capacity', 28 October 1944.

¹⁰³ Bodleian Library, Department of Special Collections and Western Manuscripts, Oxford, Vulcan Foundry, MS. Marconi 2740, 11 May 1943 and 13 July 1943.

1943.¹⁰⁴ With the growing expectation of an end to the war during 1945, in February Vulcan Foundry received an order for 100 “Liberation” locomotives for £1,237,800.¹⁰⁵

Figure 5.2 Vulcan Foundry – average value of production orders from 1938-1945¹⁰⁶



NB: The division of Ministry of Supply and Admiralty work was identified from February 1942 onwards.

To put the importance of locomotive production into context, the number of locomotives required for civilian and military use to the end of 1943 was 6,000, whereas the combined programmes were only expected to provide 4,700 for the year.¹⁰⁷ By comparison, Adam Tooze highlights that Germany produced 5,343 locomotives during 1943 upon receipt of a substantial redirection of labour, which also increased the tank workforce by over 60 per cent.¹⁰⁸ Whilst Britain had already arranged for the ‘maximum turn-over’ to locomotive production as described above, Lyttelton confirmed that requests had been made to the United States to consider increasing their own programme. In respect of the total number of tanks expected under Lend-Lease during 1943 following the transfer of some British capacity to locomotive work, an agreement was reached whereby Britain would receive 12,000

¹⁰⁴ BLO, MS. Marconi 2740, 12 January 1943 and 8 June 1943.

¹⁰⁵ BLO, MS. Marconi 2740, 12 February 1945.

¹⁰⁶ Yearly averages taken from monthly figures reported in BLO, MS. Marconi 2739, Board Minutes 1934-1940 and MS. Marconi 2740, Board Minutes 1940-1945 inclusive.

¹⁰⁷ TNA, CAB 66/31/48, ‘Report by the Minister of Production on his visit to America’, 9 December 1942, Appendix C.

¹⁰⁸ A. Tooze, *The Wages of Destruction: The Making and Breaking of the Nazi Economy* (London, Allen Lane, 2006), p. 567.

Medium tanks from the original production target of 40,000 vehicles.¹⁰⁹ This expectation compares favourably against the 10,110 Lend-Lease Medium tanks assigned to Britain during 1943 as shown in Table 5.4 above, especially when the tank programme in the United States had been reduced as explained below.

During May 1943, Lend-Lease liaison officer Averell Harriman wrote to Churchill in an attempt to entice Britain to accept an additional 3,000 tanks from the United States, whilst simultaneously reducing British tank production even further. To support his suggestion, Harriman raised a number of inter-connecting arguments that provided industrial, political and strategic justification for Britain to become increasingly more dependent upon the United States to satisfy the tank requirements of the General Staff. To begin with, despite a reduction in the United States tank programme during the autumn of 1942 to meet the demands for more shipbuilding and escort vessels, a substantial overproduction of Sherman tanks was still forecast. Harriman argued that President Roosevelt could not politically justify the loss of 'thousands' of workers if tank output in United States was cut further, especially when tank production had been advertised as part of the 'great war achievement of the Administration and of American industry'. Furthermore, following the Russian decision to standardise around the Valentine tank for the Red Army, as discussed in the next chapter, American tanks were no longer sought under the Russian supply protocols thereby adding to the production surplus. In relation to British industry Harriman requested an increase in locomotive production, which was probably acted upon during November 1943 with the transfer of London Midland Scottish at Horwich from Centaur to locomotive work above.¹¹⁰

The Australian War Cabinet took similar advantage of overproduction in the United States during 1943 by seeking 310 Sherman tanks under Lend-Lease at the expense of cancelling their unsatisfactory tank programme in July. The decision received the support from General Douglas MacArthur and meant the standardisation with American and British armoured units and the redirection of the skilled workforce to urgent ship repair and the construction of small craft and railway wagons.¹¹¹ The request for Sherman tanks remained unfulfilled by June 1944 with little prospect of improvement based upon the demand on armour during the

¹⁰⁹ TNA, CAB 66/31/48, 'Report by the Minister of Production', 9 December 1942, Appendix C.

¹¹⁰ NCL, Cherwell G.368/48-52, Harriman to Churchill, 25 May 1943.

¹¹¹ NAA, A816, 45/302/184, 'Review of Australian Tank Production Policy', 12 July 1943; Commander-in-Chief, Southwest Pacific Area, General MacArthur to Curtin, 14 August 1943.

Normandy campaign and in to 1945 discussed below.¹¹² By the end of January 1945 the Australian authorities had abandoned the Sherman in favour of 310 British Churchill tanks, and despite an attempt to secure 150 of these heavily armoured vehicles for the post-war army, the Australian authorities cancelled the order in January 1946.¹¹³

As highlighted in the previous chapter, the decision to accept a further 3,000 Lend-Lease tanks at the further expense of Centaur production was approved by Churchill in July 1943, with the adjustment taking effect against British tank requirements for 1944. In making this decision the British authorities stipulated that as many tanks as possible should be the latest production models mounting the new high-velocity 76 mm gun. Harriman confirmed that an estimated 4,000 Sherman tanks would mount the larger gun during 1944, or 3,500 if Britain wanted 1,000 Self-Propelled tanks amongst the Lend-Lease deliveries.¹¹⁴

The American 76 mm tank gun was meant to provide the Sherman tank with greater armour piercing capability, as the existing 75 mm gun with a muzzle velocity of 2,050 feet per second (fps), could not penetrate the latest German armour. Whilst the new gun was measured at 2,600 fps, firing trials in the United States revealed that APCBC shot could only penetrate 102 mm of armour, or the equivalent frontal armour on the German Tiger, at no more than 300 yards.¹¹⁵ The 76 mm gun was also under consideration by the British authorities during 1943 for the new Comet tank, with the benefits of standardising ammunition and spares requirements with the United States, thereby relieving British industry of supplying the same. However the War Office decided upon the British high-velocity 77 mm gun instead, which had greater armour-piercing performance and avoided a complete redesign of the turret, mounting and stowage for the Comet tank.¹¹⁶

An alternative to mounting the 76 mm gun on the Sherman tank was to incorporate the high velocity and available British 17-pounder gun. Brigadier Macleod Ross, who was the British chief technical liaison officer at the Detroit Tank Automotive Centre from 1942 to 1945,

¹¹² NAA, A816, 45/302/184, Curtin to MacArthur, 10 June 1944; 'Australian Tank Policy', 5 January 1945.

¹¹³ NAA, A816, 45/302/184, Curtin to MacArthur, 31 January 1945; Defence Committee, 25 January 1946.

¹¹⁴ NCL, Cherwell G369/9, Harriman to Cherwell, 21 July 1943.

¹¹⁵ APCBC – Armour Piercing, Capped, Ballistic Capped; TNA, WO 185/6, Director-General of Artillery, E. M. C. Clarke to Chairman, Armoured Fighting Vehicle Division, E. R. Micklem, 30 July 1943.

¹¹⁶ TNA, WO 185/6, Micklem to DCIGS Lt-General R. Weeks, 13 August 1943; WO 185/6, Director Royal Armoured Corps to Tank Board, 13 September 1943; WO 185/6, 'Specification of A.34', 20 December 1943.

criticises the U.S. Ordnance for not adopting the British gun simply because it was 'Not Invented Here'.¹¹⁷ This decision was despite: the availability of 17-pounder drawings that showed how the gun could be mounted onto the Chrysler model Sherman; comparable firing trials with the much larger American 90 mm gun; and the offer to supply 200 guns and recoil mechanisms per month from Britain.¹¹⁸

This condemnation of the American 76 mm and the U.S. Ordnance was not limited to just a British perspective, as demonstrated by General Bradley when recounting the events during the Normandy campaign. In short, General Eisenhower reacted angrily towards the combat limitations of the new 76 mm armed Sherman tanks, despite receiving earlier assurances from the U.S. Ordnance that this gun would be sufficient to engage all German armour. To gain an increase in firepower, Bradley asked whether British industry could convert U.S. Army Sherman tanks to carry the 17-pounder gun as demonstrated by the British Firefly. However this was not possible as Royal Ordnance Factory capacity was already 'overloaded' with existing work to meet the requirements of the British General Staff.¹¹⁹

The total number of Sherman tanks expected to be supplied under Lend-Lease during 1944 was fixed at 8,961 with a value of \$485 million or approximately \$54,123 per tank.¹²⁰ The U.S. official history highlights that the estimated basic cost of the Sherman tank varied for each manufacturer. To demonstrate, by the spring of 1943 the cost of each Sherman at the Chrysler Tank Arsenal was \$42,400, compared to \$70,000 at the Federal Machine and Welder Company. The main reasons for this disparity were that the arsenal was wholly owned by the government whilst Federal Machine plant was privately owned, and that the prices related to different models of Sherman tank. Furthermore, the initial contract price for each Sherman tank at the new Fisher Tank Arsenal was \$67,173, although this was significantly reduced to become one of the lowest overall when actual production costs had been calculated.¹²¹ When considering the different size of total output from these three firms, the variations in contract price and the ability of Fisher to lower the cost with experience becomes more apparent. Whilst being unable to separate between particular models and

¹¹⁷ G. Macleod Ross, *The Business of Tanks, 1933 to 1945*, in collaboration with Major-General Sir Campbell Clarke (Ilfracombe, Arthur H. Stockwell, 1976), pp. 41 & 311.

¹¹⁸ *Ibid.*, pp. 284-288.

¹¹⁹ O. N. Bradley, *A Soldier's Story of Allied Campaigns from Tunis to the Elbe* (London, Eyre & Spottiswoode, 1951), pp. 322-323.

¹²⁰ TNA, CAB 66/56/36, War Cabinet, 'Supplies from North America in Stage II', 23 October 1944.

¹²¹ Thomson and Mayo, *Procurement and Supply*, p. 256.

types, Chrysler produced 22,234 tanks throughout the war, compared to Fisher with 13,137 tanks, whilst Federal Machine only delivered 540.¹²²

Based upon the figures highlighted by the British official history, the Dollar-Sterling exchange rate during Lend-Lease was valued at \$5.3 to £1. This meant by using the \$54,123 average cost price above, each Sherman tank delivered to Britain during 1944 was worth £10,211, compared to the estimated £10,000 cost of the Cromwell tank after March 1941.¹²³ These similarities are out of proportion when considering the differences in total production shown in Table 5.4 above, with the economies of scale that should have resulted in a much lower cost price from American industry. In reality the overall value of providing these tanks to Britain was actually greater when including the shipping costs, which R. G. D. Allen estimates at just over 10 per cent of the total Lend-Lease aid provided to the British Empire during 1944.¹²⁴ The fourth and final section of this chapter will examine the implications upon front line strength of reducing the tank programmes within the United States and Britain, especially following the breakout from Normandy.

During the final quarter of 1943, the overall capacity of the American tank programme was reduced from 8,000 to 6,600 tanks per month, following the redirection of four firms, namely Lima, Pullman-Standard, Ford and Pacific Car and Foundry. In 1944 a further four firms, American Car and Foundry, Baldwin, Marmon-Herrington and Fisher, also ceased tank activity resulting in monthly capacity falling even further to 4,000 tanks. One of the problems with these changes to the tank programme was that rather than monthly output increasing through the concentration of resources amongst the remaining firms, the proportion of output continued unchanged at about half of the total monthly capacity.¹²⁵

In respect of British industry examined during the previous chapter, the tank programme for 1945 was reduced during October 1944 under the expectation of the war ending by 31 March 1945. By mid-November 1944, the four firms involved in Comet production received notification that the programme was being curtailed by an overall 24 per cent. As shown in Table 5.6 the effect on each firm varied with differences in the actual reduction and

¹²² *Ibid.*, p. 242.

¹²³ Lend-Lease exchange rate: Hancock and Gowing, *British War Economy*, p. 376n; Cromwell cost: Table 3.2 in chapter 3.

¹²⁴ R. C. D. Allen, 'Mutual Aid Between the U.S. and The British Empire, 1941-45', *Journal of the Royal Statistical Society*, Vol. 109, No. 3 (1946), p. 263.

¹²⁵ Thomson and Mayo, *Procurement and Supply*, pp. 256-257.

completion dates, with the majority due to finish by July 1945 including the gradual reduction common in the months before.

Table 5.6 Reduction in Comet tank contract during November 1944¹²⁶

Comet Tank Firms	Original Contract	Changes 01-Nov-44	Completion Date	Net Reduction	Percentage Reduction
Leyland Motors	825	772	Dec-45	53	6.4
John Fowler	350	262	Jul-45	88	25.1
English Electric	500	351	Sep-45	149	29.8
Metropolitan-Cammell	325	130	Jul-45	195	60.0
Overall Position	2000	1515		485	24.3

When considering the 8,961 Sherman tanks due under Lend-Lease for 1944 as highlighted above, by October there was already an accumulative shortfall of nearly 3,500 tanks, which was expected to be carried over to fulfil the 1945 programme.¹²⁷ This deficit was later exacerbated by the cancellation of Lend-Lease Sherman tanks from November 1944, which the War Department admitted to British officials in Washington during December was partly because they had 'underestimated their tank requirements for 1944'.¹²⁸ From the British point of view, the Secretary of State for War P. J. Grigg claimed that the American shortage also related to miscalculating the minimum requirements for both wastage and reserves. Furthermore and as a response that was no different from Britain, the War Department had cut back production in anticipation of an earlier victory against Germany.¹²⁹ To demonstrate this in greater detail, Figure 5.3 below displays the 5,492 Sherman tanks delivered to Britain during 1944 compared against the 8,961 tanks planned for the year supplied on a prorated basis, resulting in an overall deficit of 3,469 Sherman tanks. The monthly output of British front line tanks is included to demonstrate the dependency upon tanks from the United States to make up the difference in British requirements.

Overall, the number of Shermans received from the United States during 1944 was 2,350 tanks greater than British front line output, although this was still less than the expected 5,819 surplus tanks had the full Lend-Lease quota been delivered. The rate of Lend-Lease deliveries was more erratic than British output which as discussed in the previous chapter was

¹²⁶ TNA, AVIA 22/454, DGAFV, C. D. Gibb to Regional Controllers, 'Curtailed of Production of Cromwell, Comet, Challenger & S.P.2', 14 November 1944.

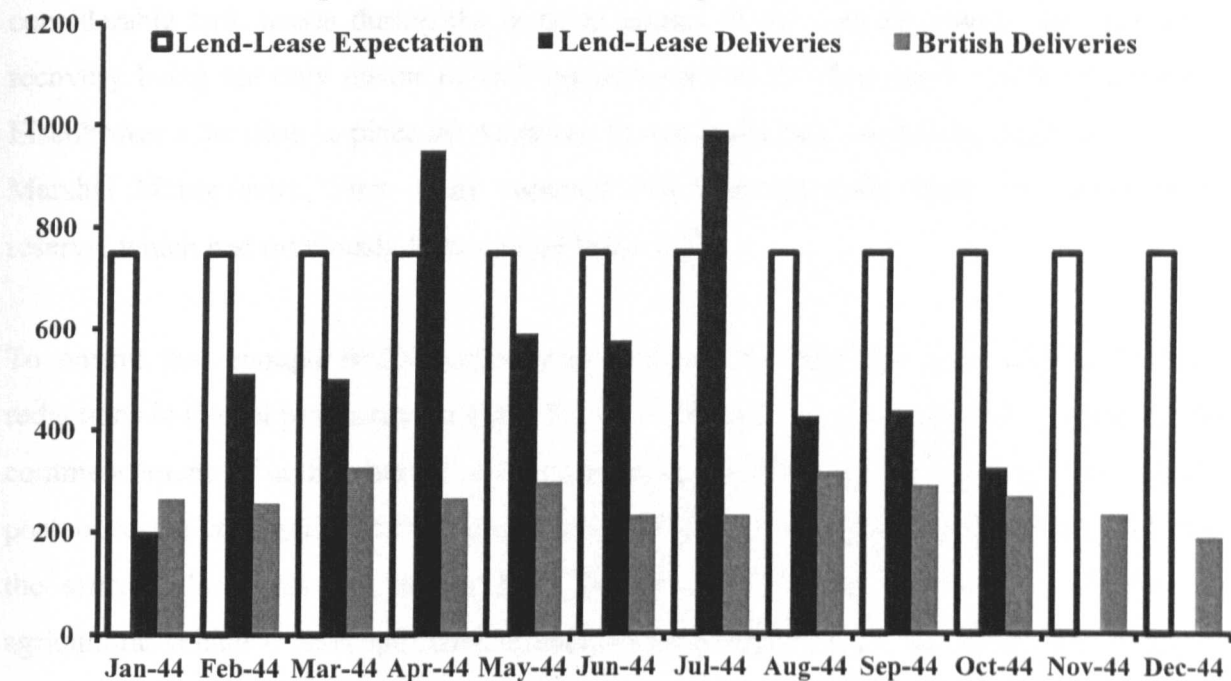
¹²⁷ TNA, PREM 3/427/9, 'Tank Production in 1945', 6 October 1944.

¹²⁸ TNA, BT 87/137, BAS & BSM, Washington to Ministry of Supply and War Office, 6 December 1944.

¹²⁹ TNA, BT 87/137, 'Assignments from U.S. War Department', by Grigg, 15 December 1944.

susceptible to sudden changes, such as factory holidays and replacing battlefield losses. On balance this last reason can account for the reduced number of Lend-Lease deliveries from August until October with more Sherman tanks being provided to U.S. armoured divisions during and after the Normandy campaign, instead supplying these tanks to Britain.

Figure 5.3 Monthly deliveries of 5,492 Sherman tanks compared against the 8,961 tanks expected for 1944 and the output of 3,142 British front line tanks¹³⁰



NB: British front line: 1,062 Churchill and Heavy Churchill tanks, 2,080 Cromwell and Challenger tanks.

The first problem for the British authorities caused by this shortage was an expected depletion of reserves at a rate of 500 Sherman tanks per month, resulting in a complete exhaustion in Italy by mid-April 1945 and in north-west Europe by mid-June. The second and more immediate concern was a shortage of Sherman tanks suitable for conversion to the 17-pounder armed Firefly.¹³¹ John Buckley has provided some recent scholarship regarding the decisions relating to the Firefly conversion, including the discussions at Tank Board meetings and the use of this vehicle during the Normandy campaign.¹³²

The combination of diminishing reserves and fewer Firefly tanks than anticipated brought about the same kind of anxiety that existed following the Dunkirk evacuations in 1940 with the serious shortages in equipment. In replying to the Select Committee on National

¹³⁰ Lend-Lease deliveries: Ibid; British output: CAB 120/356, 'A.F.V Production' January to December 1944.

¹³¹ TNA, BT 87/137, 'Assignments', 15 December 1944.

¹³² J. Buckley, *British Armour in the Normandy Campaign 1944* (Frank Cass, London and New York, 2006), pp. 23, 25-26, 83, 108-116, 168-173.

Expenditure during August 1944, the War Cabinet emphasised that the availability of Sherman tanks in 'considerable numbers' during 1943 had in part removed this 'fear of a quantitative deficiency'.¹³³ The situation facing the British authorities at the end of 1944 was now reminiscent of 1940, especially when the analysis by Grigg above was made the day before the German Ardennes offensive and the increased use of Allied armour as a result. In an example of this pressure on front line strength, the U.S. First Army had sustained considerable tank losses during the opening phases of the German attack, with battlefield recovery being the only means of tank replacements in the short-term. Following General Eisenhower's decision to place all American forces in the north under the command of Field Marshal Montgomery, First Army received 300 Sherman tanks from 21st Army Group reserve, which had previously been denied to them.¹³⁴

To ensure that enough British tanks were available to front line units during 1945 the reductions in Comet production in Table 5.6 were immediately reversed, thereby delaying the commencement of a number of civilian programmes.¹³⁵ Accordingly, Leyland Motors postponed the conversion of their production facilities to 'heavy wheeled vehicles' for both the army and civilian use, whilst John Fowler cancelled the transfer of production to agricultural vehicles. Metropolitan-Cammell was still employed on war production, although capacity that was meant to begin work on the Neptune amphibious vehicle was now retained for continued Comet production.¹³⁶ With regards to the Firefly, a practical solution was reached early in 1945 whereby Britain would receive 90 rebuilt Sherman tanks from the United States capable of mounting the 17-pounder gun, in exchange for 90 unsuitable Shermans already with British units.¹³⁷

A similar response to this tank shortage occurred in the United States at the beginning of 1945, with an 'all-out effort' to increase tank production of all types by February, including 10,000 of the new heavy Pershing tank. Upon reviewing the available capacity, it was recognised that these production requirements could only be achieved by re-employing the previous tank firms above at a cost and timescale that proved prohibitive. By March 1945 the

¹³³ Cmd. 6865, 'Reply', 2 August 1944, in *War-Time*, p. 50.

¹³⁴ L. Mayo, *United States Army in World War II, The Technical Services, The Ordnance Department: On Beachhead and Battlefront* (Washington, Department of the Army, 1968), reprinted 1971, p. 312.

¹³⁵ TNA, AVIA 22/454, 'Amendment', Gibb to Regional Controllers, Ministry of Supply, 15 December 1944.

¹³⁶ TNA, BT 87/137, War Cabinet, 'Assignments from United States War Department – reactions on United Kingdom production plans', by Minister of Supply, 23 December 1944.

¹³⁷ TNA, CAB 120/358, 'Record of decisions taken at meeting held on 20 January 1945', 22 January 1945.

United States deemed the end of the war in Europe to be close enough to issue cancellation notices to the remaining tank firms, with production ceasing altogether by November.¹³⁸

In conclusion, this chapter has examined the different effects that war production in the United States and Canada had upon the British tank programme and war effort overall. American industry produced 88,410 tanks during the war with 79 per cent of this output concentrated in just five out of the 17 firms. With regard to the supply of tanks to Britain, this chapter has reviewed the situation before and after the introduction of Lend-Lease, with the transformation from cash orders to becoming over dependent upon the United States.

Prior to the outbreak of war Britain sought to benefit from the potentially high rate of output and strategically secure production facilities of North America, with the British Supply Board in Ottawa and later British Purchasing Commission in the key location of New York. Following the removal of the arms embargo within the United States, Britain purchased equipment, materials and munitions at the cost of depleting the gold, dollar and other currency reserves. The supply of components to support the production of five tank models in Britain and the Valentine tank in Canada continued into the period of Lend-Lease from at least 18 firms across North America.

Following the defeat of France, the United States refused to manufacture tanks of a foreign design so Britain placed cash orders for American tanks direct from industry, although not without a prior inspection that changed the M3 Medium into the Grant tank. The resulting orders included the cost of the components, final assembly and increasing the productive capacity of the firms concerned. With diminishing financial reserves at the start of 1941, Britain considered replacing the supply of aero-engines from the United States for a small number of Light tanks, but this was impracticable given the overall priority given to aircraft production in Britain.

Despite placing cash orders Britain still competed with the U.S. War Department for the same demands upon the tank programme. American industry expanded through the creation of new facilities and tank arsenals and by taking over British purchases and capacity at either a heavily discounted or no cost. This competition was demonstrated by the expected output of

¹³⁸ Thomson and Mayo, *Procurement and Supply*, p. 259.

Grant tanks from June 1941, which had British deliveries capped after six months, whilst U.S. Army allocations grew each month over the same period. Initial factory visits by British representatives revealed that American industry suffered from component shortages similar to British industry, although in contrast welded tanks were mass produced by eliminating the machining of armour plate.

The introduction of Lend-Lease eliminated the financial difficulties and permitted Britain to continue pursuing an offensive strategy in all theatres of war. The significance of Lend-Lease was also reflected by the Canadian response to offer interest-free credit, gifts of war supplies and later direct aid. Whilst Lend-Lease was designed to defend the United States, the promise of large numbers of reliable and battleworthy tanks permitted the British to concentrate upon quality production and other war work.

The supply of aid from the United States and Canada was complemented by the mutual exchange of tank information between the Western Allies, together with the co-ordination and co-operation in respect of planning. This agreement was highly successful and any restrictions were due to administrative rather than security concerns. Britain received numerous technical and industrial reports during the war, whilst providing the North American authorities with full access to tank production and testing information.

Whilst the 45,000 tanks desired by President Roosevelt for 1942 was impracticable, the programme expanded by a factor of five over the year and during 1943 eventually delivered 4,000 tanks each month across 16 firms. In respect of Lend-Lease Grant or Sherman tanks, these represented 28 per cent of American output during 1942 to 1944, and as a proportion of British front line tank output, the number of Medium tanks grew from 58 per cent in 1942 to an average of 168 per cent across 1943 and 1944.

The considerable demands upon the American tank programme from the United States, Britain and Russia, were met by the higher priority status, the new Fisher Tank Arsenal, and the successful use of committees to overcome shortages in component supply. Greater economies of scale resulted from the large tank orders given to the two tank arsenals to reduce the price of the Sherman tank, although the Lend-Lease price was unexpectedly similar to the cost of the British Cromwell when considering the differences in total output.

Upon arrival in the Middle East and India, American tanks required the same type of workshop corrections that were necessary on British tanks, in order to rectify the numerous manufacturing faults and damage sustained during the sea voyage. The initial shortage of spare parts meant that front line strength was reduced as new Grant tanks were dismantled to provide the components necessary to maintain those Grants on the front line. Whilst the Sherman tank had superseded the Grant in the Middle East and Western theatres, the older tank continued to provide useful support to the British Army in Far East. Similar Grant and Lee tanks were supplied to Australia to replace their limited tank programme, although the vehicles were becoming increasingly obsolete. The Stuart tank was mostly clear of production defects, but the poor design of the fighting compartment required alteration in the workshop before being sent forward.

The increased supply of tanks from the United States from 1943 meant that British tank firms concentrated upon quality output, whilst other firms were used to expand locomotive production with the result of releasing more Lend-Lease shipping space. The new orders for locomotives with Vulcan Foundry increased the proportion of non-military work during the remaining years of war and effectively excluded this firm from further military production. During late 1943 and 1944 the American tank industry was similarly reduced in size, whereby the number of tank firms and production capacity reduced by half.

The effect that the reductions in the British and American tank programmes had upon front line tank units can be measured by the shortages of tanks following the Normandy campaign and during the German Ardennes offensive. American armoured units therefore received all the Sherman tanks resulting in the complete stoppage of Lend-Lease deliveries to Britain, including the Sherman suitable for the vital conversion to the Firefly. For Britain the effect of these shortages of Sherman tanks was reminiscent of the period following Dunkirk, which had ironically been overcome by the large supply of Sherman tanks during 1943.

In response to these concerns, Britain reinstated the full Comet tank programme by reversing the reductions of November 1944 and halted the transfer of these tank firms to civilian and non-tank work. Furthermore, to ensure that British units continued to receive the Firefly, British Sherman tanks unsuitable for the 17-pounder conversion were exchanged with reworked American Sherman tanks. In the United States, a similar plan to reinstate the tank

programme was considered to meet the battlefield demand, however this was deemed too costly and the imminent end to the war in Europe resulted in tank cancellations instead.

Overall the impact of the United States upon the outcome of the war cannot be underestimated with an industry that produced useful tanks in large quantities. However this ability needs to recognise that the emerging American tank programme benefitted from industrial capacity that was partly financed by British orders and tank designs that were inspired by British combat experience. The result of these external influences were vehicles that were designed to fulfil an operationally offensive role from the outset, although American industry had to overcome the initial problems of faulty workmanship and a shortage of spare parts before these tanks could operate and remain battleworthy in the field. Finally, whilst the Sherman tank fulfilled the British General Staff requirements of mobility and reliability, the level of armour protection and firepower remained below the British standard as demonstrated by the welded Cromwell and the 17-pounder gun respectively.

Chapter 6

“Tanks for Russia”

With the previous chapter reviewing the different political, strategic and industrial effects of Britain obtaining tanks from the United States, this chapter will review the similar factors that resulted in Britain supplying tanks to Russia, whilst simultaneously supporting the British war effort. The overall supply of munitions, raw materials, foodstuffs and industrial equipment was provided to Russia by the combined war programmes of Britain, Canada, and the United States, as demonstrated by Appendix 8 for the précis of major items supplied.

The importance of providing tanks towards the Russian war effort should not be underestimated when the Red Army lost 96,000 tanks out of a total 145,000 received from all sources during the war.¹ To put the contribution by the Western Allies into context, Appendix 8 shows that a total of 12,755 tanks were shipped to Russia from Britain, Canada and the United States, representing 8.8 per cent of the total number used by the Red Army. Whilst this number may seem insignificant, as demonstrated by the simultaneous requirement for Britain to obtain tanks from the United States, Britain did not have a surplus stock of tanks to ship to Russia. As a result, the 3,830 tanks sent to Russia by Britain were provided direct from the production line, thereby taking these tanks away from the British army.

To demonstrate these effects in greater detail, the first section of this chapter will review how the Western Allies responded to the German invasion of Russia with annual protocols for the supply of munitions, raw materials and equipment. The role of the British tank industry will be highlighted by ‘Tanks for Russia’ week, whilst the success of this sudden propaganda campaign will be compared against the changes already planned for within the tank programme. The different convoy routes necessary to deliver the aid to Russia will be identified and also that Canadian tanks were still delivered against British protocol commitments via Persia, following the suspension of the Arctic convoys in 1942. In order to cope with the extreme cold on the Eastern Front, the second section will review the necessary modifications or ‘Arcticisation’ of tanks and that this equipment could be tested at Canadian winter facilities beforehand. The third section will examine the supposedly reciprocal agreement between Britain and Russia for the exchange of information and equipment.

¹ J. Erickson, ‘Red Army Battlefield Performance, 1941-1945: the System and the Soldier’, in P. Addison and A. Calder (eds.), *Time to Kill: the Soldier's Experience of War in the West* (London, Pimlico, 1997), p. 239.

In order to examine the Canadian contribution to the supply protocols in greater detail, the fourth section of this chapter will highlight the political motivations of the government and experience of industry in providing the 1,388 Valentine tanks to Russia. As a result, this will demonstrate that Canadian industry had to overcome the same types of delays and problems in commencing and maintaining tank production as already highlighted by British and American industry during the course of this study. With the British obliged to provide tanks to the Russian war effort, the fifth section of this chapter will consider how this requirement often conflicted with the demand to equip British armoured units at home and abroad with the same Matilda, Valentine and Churchill tanks. Whilst many of these tanks were 'distributed among quiescent or non-combatant theatres like the Finnish front and the Far East' as stated by Alan Clark, this should not diminish the use of British armour during the defence of Moscow in 1941 and later in 1943 at Kursk.²

Contrary to the generalised claim by Richard Humble that 'the only tanks shipped to Russia from the west which were welcome gifts were Grants and Shermans', the earlier British official history, states that Russia actually preferred the British and Canadian Valentine tank for reasons of a greater supply of spare parts.³ Therefore, the sixth and final section of this chapter will highlight that Russian requirements from the west were dictated by an operational necessity that prioritised the standardisation of equipment through the least number of variations. Strict adherence to this doctrine was shown when the Russian authorities rejected the six-pounder armed Crusader tank as a replacement for obsolete two-pounder armed Valentine tanks. Based upon the commitment to the supply protocols and persistent Russian demand, British Valentine tanks were produced until May 1944 and represented 19 per cent of all British tank output during the war.

Following the German invasion of Russia on 22 June 1941, the type of Lend-Lease mechanism for providing industrial support that already existed with the United States, was not present when Prime Minister Churchill offered Russia all forms of technical and economic assistance.⁴ An Anglo-Soviet agreement of mutual assistance was signed on 12 July 1941, but this was not a treaty and Britain's rejection of an imminent second front in

² A. Clark, *Barbarossa: The Russian-German Conflict 1941-1945* (London, Macmillan, 1985), p. 196.

³ R. Humble, *Tanks* (London, Weidenfeld & Nicolson, 1977), p. 89; W. M. Hancock and M. M. Gowing, *British War Economy* (London, H.M.S.O., 1949), p. 362.

⁴ W. S. Churchill, world broadcast on the German invasion of Russia, 22 June 1941, in C. Eade, *The War Speeches of Winston S. Churchill*, Vol. I (London, Purnell and Cassell, undated), pp. 450-454.

France caused resentment in Russia.⁵ Providing military and civilian supplies in lieu of direct military action was the preferred alternative for Britain, although the service departments were understandably reluctant to deplete the limited supply of modern and reliable weapons, with the expectation of a complete collapse in Russian resistance.⁶ Even against these on-going concerns, by September Churchill confirmed to Parliament that British policy was to continue supplying aid to Russia, even at the expense of the British war effort:

We must be prepared for serious sacrifices in the munitions field in order to meet the needs of Russia . . . It must be remembered that everything that is given to Russia is subtracted from what we are making for ourselves, and in part at least from what would have been sent us by the United States.⁷

To formalise Allied attitude and the supply of aid to Russia, a delegation headed by Minister of Supply Lord Beaverbrook for Britain and Averell Harriman for the United States, resulted in the Moscow or First Protocol.⁸ The long-term approach to Allied discussions with Russia was established by Beaverbrook and Harriman, who refused to permit any contentious issues, such as Russian reluctance to justify their requirements, to prevent agreement.⁹ Lieutenant-General Giffard Martel describes this attitude as a policy of 'appeasement', driven by the concern of forcing Russia into a separate peace with Germany if British diplomats became too dogmatic.¹⁰ In essence, the Allied approach of giving without expectation of any return continued until the end of the war.

Once the First Protocol was signed on 1 October 1941, the programme to supply Russia with aid was considered sacrosanct in British planning, whereby all other priorities conformed to these demands. Whilst Beaverbrook was certainly the most forceful individual to ensure compliance under the Protocol, the different service departments also require recognition for their efforts to now provide what was necessary.¹¹ Deliveries under this first supply protocol continued until the end of June 1942, when it was replaced every twelve months with a new

⁵ J. Beaumont, *British Aid to Russia, 1941-1945: Comrades in Arms* (London, Davis-Poynter, 1980), pp. 29-30; C. Bellamy, *Absolute War, Soviet Russia in the Second World War: a modern history* (London, Pan Books, 2007), p. 410.

⁶ Beaumont, *British Aid to Russia*, pp. 24, 31 & 40; Bellamy, *Absolute War*, p. 415.

⁷ W. S. Churchill, speech to the House of Commons, 9 September 1941, in C. Eade, *The War Speeches of Winston S. Churchill*, Vol. II (London, Purnell and Cassell, undated), p. 80.

⁸ A. J. P. Taylor, *Beaverbrook* (London, History Book Club, 1972), pp. 481-491; see Table 1 in Beaumont, *British Aid to Russia*, pp. 58-60, for a précis of the supplies requested and offered under the First Protocol.

⁹ *Ibid.*, pp. 54-55.

¹⁰ Lieut-General Sir G. Martel, *An Outspoken Soldier: His Views and Memoirs* (London, Sifton Praed & Co., 1949), pp. 211-212 & 255-256.

¹¹ Beaumont, *British Aid to Russia*, pp. 72 & 75-76.

protocol until the Fourth Protocol ended on 30 June 1945. In each case, the agreement followed a negotiation of what the Russian authorities expected to need over the forthcoming period, against what the Western Allies could actually provide. A list of the principal items of military equipment and materials sent by Britain, Canada and the United States between 1941 and 1946, is shown in Appendix 8. The military aid being provided was of mixed quality with useful Valentine and Sherman tanks, trucks and jeeps on the one hand, with outdated equipment such as Matilda tanks, machine-gun firing Hurricane and Kittyhawk fighters on the other. However whether obsolete or not, the aid was essential to deal with the invasion and provided what Russian industry could not for much of the war.¹² Furthermore, and as examined in greater detail below, much of this equipment was requested by the Russian authorities in keeping with their operational doctrine of standardised equipment.

As the Russian fight for survival on the Eastern Front became more desperate during the autumn of 1941, an even greater response from industry was demanded to provide the necessary aid to Russia.¹³ In relation to tank production, a high profile propaganda campaign for increased output in anticipation of the First Protocol was launched by Lord Beaverbrook, with 'Tanks for Russia' week from 22 to 29 September 1941. Government propaganda efforts relating to industry were not unusual with numerous examples of 'War' week campaigns, that were aimed at both stimulating interest in greater munitions output and to combat inflation by encouraging the public to take advantage of savings opportunities.¹⁴

The demand for a sudden increase in tank production brought about a consensus between government and the trade union leadership, with the exploits of the tank industry at the centre. In sponsoring 'Tanks for Russia' week, Beaverbrook placed the responsibility of producing 'more tanks than ever before in the history of our country' upon the shoulders of the workers concerned. For their part, the Trade Union Congress welcomed the prospect of achieving record levels of munitions output to assist 'their Russian comrades'.¹⁵ This open

¹² Bellamy, *Absolute War*, pp. 440-441.

¹³ See Figures 10.4 and 10.5 in Bellamy, *Absolute War*, pp. 254-255 & 258; G. L. Weinberg, *A World at Arms: A Global History of World War II*, Second Edition (New York, Cambridge University Press, 2008), p. 272 detailing Red Army losses amounting to 1.2 million captured during September and October 1941, and that the Germans had advanced to within 50 miles of Moscow.

¹⁴ Such as Warship Weeks during 1941-42, Wings for Victory Weeks in 1943 and Salute the Soldier Weeks in 1944. See A. Calder, *The People's War: Britain 1939-45* (London, Panther Books, 1971), pp. 410-412.

¹⁵ *The Times*, 20 September 1941.

support for the campaign was also expressed by tank factory workers in the Midlands, who pledged 'to break all records from now on in aid of our comrades in Russia'.¹⁶

As part of tank week, the exploits of the tank industry were directly promoted by newspapers and the *Pathé* newsreel with well publicised factory visits by the Soviet Ambassador Ivan Maisky, who appealed for "tanks, please; more tanks; and yet more tanks".¹⁷ These visits portrayed a powerful image of solidarity for British relations towards Russia and of the consensus within British industrial relations to the response. Harold Macmillan MP noted this when he wrote to each firm involved and attributed the success of the day to the 'enthusiasm shown by all present, as well as the subsequent publicity' received on the day.¹⁸

The events surrounding tank week are recounted by Evelyn Waugh in his post-war novel *Officers and gentlemen*, together with the concern that the tanks would supply the Eastern Front at the expense of British demands for the Middle East.¹⁹ Whilst this was accurate in respect of the Matilda and Valentine tanks discussed later, not all the tanks made during this week were sent to Russia as demonstrated by English Electric and Mechanization & Aero who produced Covenanter and Crusader tanks respectively. As a result, the Ambassador's factory visit had to be cancelled for risk of causing 'some embarrassment in handing over to our Russian friends' tanks that would not be available for them to use on the battlefield.²⁰ In any event and as demonstrated in greater detail below, the Russian authorities did not want these two comparatively lightly armoured Cruiser tanks. High profile factory visits continued after tank week for those firms providing munitions to Russia, as shown when King George VI and Queen Elizabeth visited Vulcan Foundry during October to view the Matilda tank.²¹

The Ministry of Supply announcements relating to the success of tank week received a great deal of media publicity, beginning with how the first three days of the scheme had increased

¹⁶ *The Times*, 24 September 1941.

¹⁷ *The Times*, 23 September 1941; 'Tanks for Russia' newsreel 1941 found in, <http://www.britishpathe.com/record.php?id=12948>, accessed 30 September 2010.

¹⁸ The National Archives, Kew, AVIA 11/46, Macmillan to Moyses, Birmingham Railway; Macmillan to Boyd, Metropolitan-Cammell, 27 September 1941.

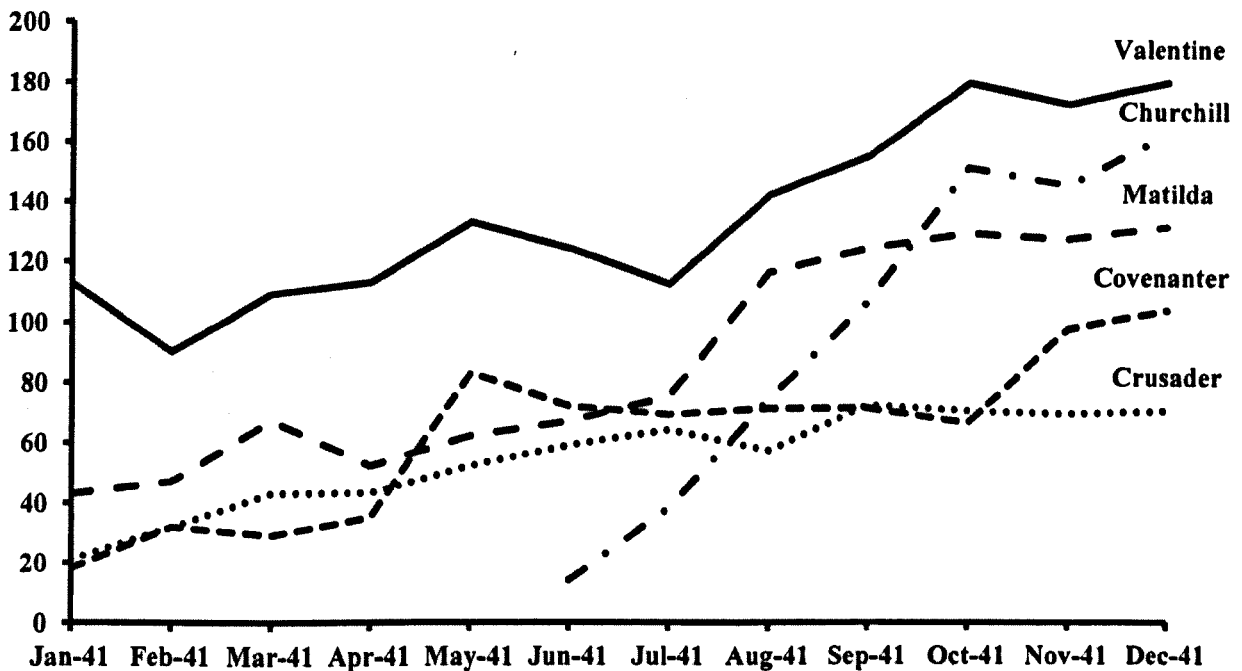
¹⁹ E. Waugh, *Officers and gentlemen: a novel* (London, Chapman & Hall, 1955), pp. 330-331.

²⁰ TNA, AVIA 11/46, Macmillan to Hollander, English Electric; Macmillan to Thomas, Mechanization & Aero, 27 September 1941.

²¹ *The Times*, 31 October 1941; and reported in the following Board Meeting of Vulcan Foundry, Bodleian Library, Department of Special Collections and Western Manuscripts, Oxford, MS. Marconi 2740, Board Minutes 1940-1945, 12 November 1941.

tank output by 50 per cent over the same week in August.²² A few days later, the production figures were stated as 'well ahead' of the 'all-time record' of the week before.²³ By the end of tank week, an increase in output of nearly 20 per cent was reported, with 27 September producing the highest number ever recorded.²⁴ The Ministry concluded the success of tank week by stating that 'more tanks were made during July, August, and September than during the whole of last year'.²⁵ The greater interest in tank output continued during the following week, when the Ministry announced that this period of 'production will constitute another record for the first week's production of any month up to date'.²⁶

Figure 6.1 Monthly deliveries of Infantry and Cruiser tanks, 1941²⁷



The *prima facie* evidence of Ministry announcements relating to the success of tank week have been confirmed by the production figures for 1941 as displayed in Figure 6.1 for each tank model, showing an overall increase in tank output during and after September. Furthermore, when considering Ministry claims regarding the output for July, August and September, the number of Infantry and Cruiser tanks totalled 1,348 compared to 1,224 for the whole of 1940.²⁸ Whilst this analysis excludes the production for any Light tanks, this would

²² *The Times*, 25 September 1941.

²³ *The Times*, 27 September 1941.

²⁴ *The Times*, 29 September 1941.

²⁵ *The Times*, 30 September 1941.

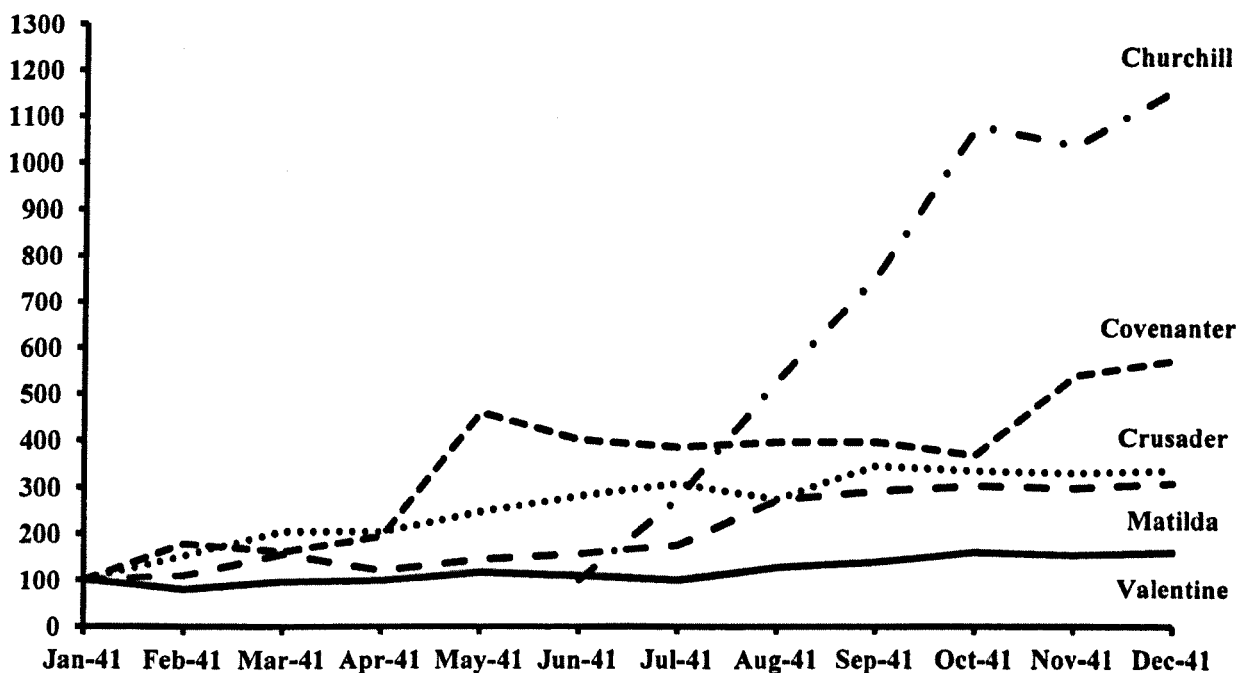
²⁶ *The Times*, 6 October 1941.

²⁷ TNA, AVIA 46/188, 'Monthly Deliveries on Infantry and Cruiser Tanks by Firms, 1939-1943', draft official history narrative by D. Hay, after 1950, p. 270.

²⁸ *Ibid.*, pp. 269-270.

not have changed the outcome by any appreciable value as development problems on the latest Light Mark VII Tetrarch tank meant that no production was possible for the first three months of 1941.²⁹ Following a limited output of six Tetrarch tanks in April, production was severely interrupted after considerable bomb damage at the works of Metropolitan-Cammell resulted in output continuing at irregular levels before terminating in March 1942.³⁰

Figure 6.2 Index of monthly deliveries of Infantry and Cruiser tanks, 1941³¹



The index for the production of Infantry and Cruiser tanks during 1941 is shown in Figure 6.2 and demonstrates that Covenanter, Crusader and Matilda tank production expanded throughout the period, whereas the Valentine tank grew more steadily. An important abnormality was experienced with the Churchill tank which only began production models in June, and thus saw a rapid and large expansion in output whilst the eleven firms involved climbed to their peak level of production. As a proportion of total production, the Churchill tank expanded from just four per cent in June to 20 per cent in September after tank week, and then maintained an average of 23 per cent of all tanks produced during the last three months of 1941. This meant that the growth in tank production during the second half of the year and especially when comparing tank week, must account for pre-planned developments

²⁹ TNA, WO 185/5, 'Directorate of Tank Production, Monthly Report', 6 February and 8 March 1941.

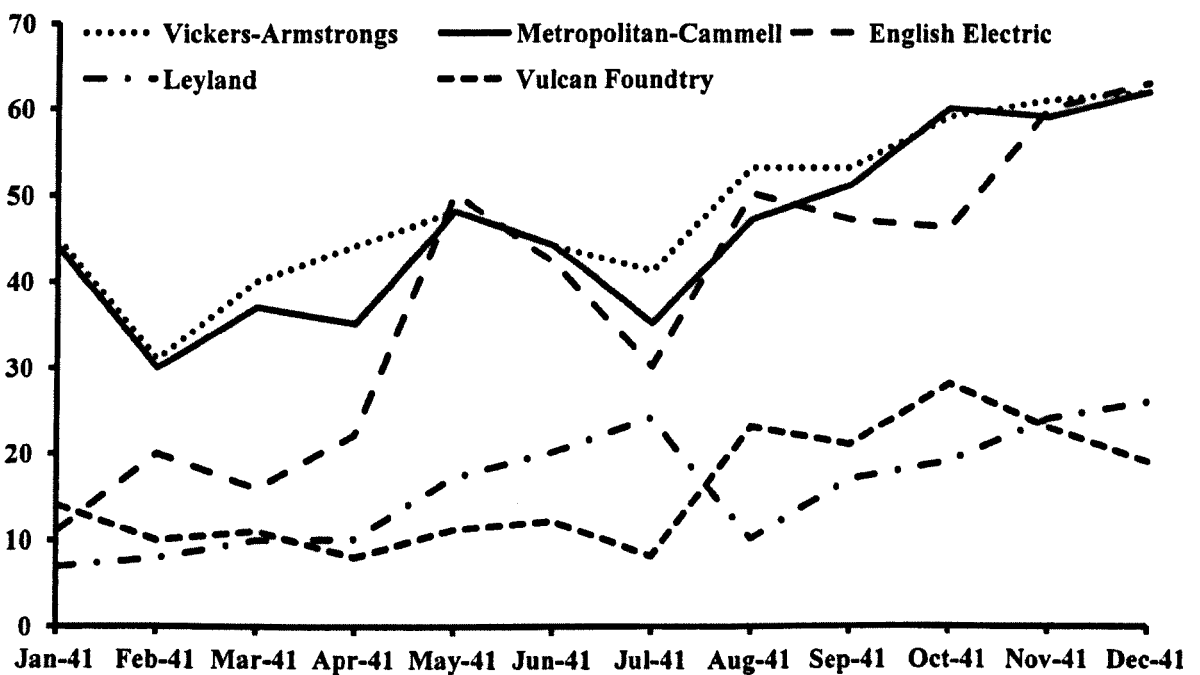
³⁰ Birmingham Archives and Heritage, Metropolitan-Cammell, MS99/2006/024, '625 Air Raid Damage', 23 April 1941; TNA, WO 185/5, 'Directorate', 6 May 1941; WO 185/6, 'A.F.V. Output against Target', 11 April 1942.

³¹ TNA, AVIA 46/188, 'Monthly Deliveries', p. 270.

within the overall tank programme, with particular reference to the introduction and rapid expansion of Churchill production.

The second qualification for the success of tank week found in Figure 6.2 was that in addition to enhancing the overall level of output, neither Churchill production nor the output for the Covenanter and Crusader tank was sent to Russia. As discussed later, only Matilda and Valentine tanks were part of the aid to Russia programme, until the Churchill was considered during the second quarter of 1942. By extrapolating the figures until April 1942, this meant that the proportion of tanks from overall production which could be sent to Russia before the Churchill was included fell from 57 per cent in June 1941 to 41 per cent by March 1942.³²

Figure 6.3 Monthly deliveries of Infantry and Cruiser tanks by firms, 1941³³



As examined during chapter 4, another consideration when evaluating tank week was that during the summer factories took an annual holiday resulting in a fall in output for that week. In respect of Vulcan Foundry during 1941, the number of employees fell from over 2,800 for each of the nine weeks until 19 July to just 407 during the following holiday week, before returning to pre-holiday levels the week after.³⁴ The effect that this holiday had upon production at Vulcan Foundry is shown in Figure 6.3 which also compares the output of four other tank firms, to indicate likely holiday periods as well. The firms selected for these

³² *Ibid.*, pp. 270-271.

³³ *Ibid.*, p. 270.

³⁴ BLO, MS. Marconi 2740, 24 May to 12 August and 10 September 1941.

examples were all producing tanks at the beginning of 1941, thereby eliminating those within the Churchill production group under the parentage of Vauxhall Motors.

The publicity generated by the 'Tanks for Russia' campaign continued during the following months and provided the public with a sense of closure, by highlighting when the tanks were shipped to Russia and upon their use on the battlefield. *The Times* portrayed a series of photographs in October depicting the scenes at a British port, including Matilda tanks being loaded for shipment to Russia via the Arctic convoys.³⁵ The culmination of these combined efforts was highlighted at the end of November 1941 when these tanks 'received their baptism of fire' during the defence of Moscow. With an apparent 'eye-witness' account, the contribution provided by British tanks was given special attention, with particular praise by a Russian commander for the armour protection and armour-piercing capability of the gun.³⁶ This opinion was later strengthened by Russian battalion commander Bryukhov, who considered that tank crews had a better chance of survival in a Matilda or Valentine turret than in a Russian T-34, as the British armour plate was less likely to shatter upon impact.³⁷ These advantages were the consequence of the manufacturing decisions taken in Britain during the rearmament period discussed in chapter 1.

The emphasis upon providing aid for Russia and the promotion of the British tank industry continued during November 1941, when Coventry experienced a 'Women in War Work' week to entice more women to enrol into the munitions industries. This campaign was important because female conscription did not replace volunteerism until the beginning of 1942, although Britain would ultimately direct women further than any other government.³⁸ Part of the November campaign included an exhibition which advertised the brutality of the Nazi regime in Russia and a street parade with women dressed in overalls, riding on tanks and working on aeroplane parts as they travelled. Home-made banners were also employed with messages of "Tanks for women, good for slimming", "Combine beauty with duty" and "Russia doesn't ask for Thanks. What she wants is Britain's Tanks". Despite these efforts to

³⁵ *The Times*, 29 October 1941.

³⁶ *The Times*, 27 November 1941.

³⁷ A. Isaev, 'Against the T-34 the German tanks were crap', in A. Drabkin and O. Sheremet (eds.), *T-34 in Action* (Barnsley, Pen and Sword, 2006), pp. 23-24; see also A. S. Burtsev, 'Our tanks were the best', in *ibid.*, p. 120 for similar testimony on the quality of British armour plate, but more critical of the tanks in respect the inability of the driver to 'bail out' when hit if the turret was turned.

³⁸ P. Summerfield, *Women Workers in the Second World War: Production and Patriarchy in Conflict* (London, Croom Helm Ltd, 1984), pp. 35-36, 55 & 61-62; A. S. Milward, *War, Economy and Society, 1939-1945* (London, Allen Lane, 1977), p. 219.

entice more women to enlist, the number of new recruits fell well short of the target.³⁹ Penny Summerfield attributes this disappointing result to the restriction of offering full-time work only, when part-time opportunities could have relieved some of the concerns by men and women alike, regarding food shopping, providing dinner, and essential housework.⁴⁰ This failure should not however detract from the success of the campaign to continue advertising the necessity of providing still greater amounts of aid to Russia, and of the importance and role of British industry and of its workers to achieve this.

The signing of the First Protocol brought about the practical problems of accelerated production programmes, the re-allocation of munitions, alterations to strategic plans and the re-organization of shipping schedules.⁴¹ The Allies benefitted from having three supply routes available to deliver the aid, although each of these were counter-balanced by individual shortcomings. The Arctic route to Murmansk and Arkhangel'sk had the greatest potential in respect of port capacity, but was the most taxing in respect of the weather and avoiding German attack from Norway. The Pacific route to Vladivostok could not be fully used until late 1942 as Stalin was under diplomatic pressure not to antagonise Japan, and because the risk to British and American shipping was too great.⁴² By mid-1943, over 40 ships per month were brought across the Pacific, but apart from the limitation of port capacity, the three month round trip meant that the United States was unwilling to involve any more ships than necessary.⁴³ The Persian route had the least port capacity and poor communication links into Russia for much of the war, whereby upon reaching peak capacity it became unnecessary, as the other two routes had largely overcome their obstacles.⁴⁴ In respect of Canadian deliveries under the protocol, these were completed using the port facilities and shipping along the United States' eastern seaboard, although heavy congestion and delayed shipments meant a backlog until after April 1942.⁴⁵

³⁹ N. Nakamura, 'Women, Work and War: Industrial Mobilisation and Demobilisation, Coventry and Bolton, 1940-1946' (PhD thesis, University of Warwick, 1984), pp. 85-96.

⁴⁰ Summerfield, *Women Workers in the Second World War*, pp. 38-42.

⁴¹ Beaumont, *British Aid to Russia*, p. 61.

⁴² Bellamy, *Absolute War*, pp. 421-422.

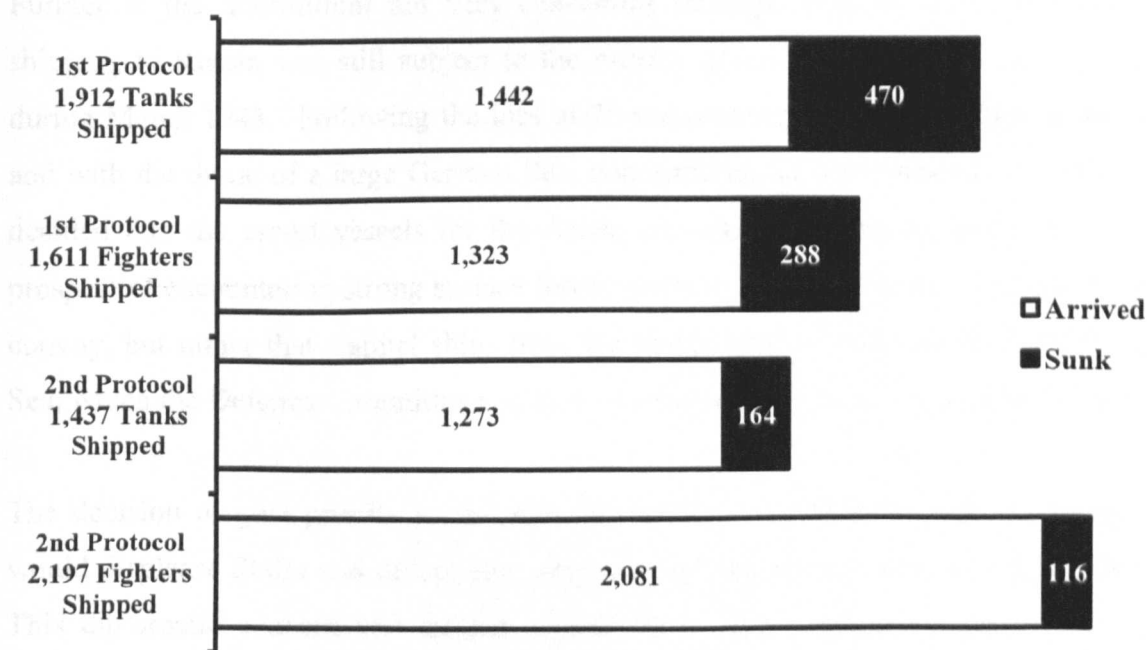
⁴³ TNA, CAB 66/42/25, 'Report on the implementation of the Second Soviet Protocol, with comparisons between the Second and Third Protocols', Section B – Shipping and Routes, 25 October 1943.

⁴⁴ Beaumont, *British Aid to Russia*, pp. 82, 140 & 194.

⁴⁵ *Ibid.*, pp. 77, 103 & 142.

The principal method of carrying British supplies to Russia was through Arctic convoys and was threatened by the German Kriegsmarine and Luftwaffe operating from Norway.⁴⁶ The risk of attack was particularly acute when the convoys were forced to sail, for up to a week in length, within constant German reconnaissance and bomber range due to the expansion of ice from the north during the winter.⁴⁷ The chance to sail further away from the mainland during the summer provided little respite as the perpetual daylight gave no chance for the ships to conceal themselves.⁴⁸ The prospect of an Arctic convoy sustaining heavy losses was always present, although the example of PQ.17 in July 1942 with the sinking of 26 out of 39 ships and the suspension of further convoys until September was the exception and not the rule.⁴⁹ This is demonstrated by the examples in Figure 6.4 which displays a reduction in losses of fighter aircraft and tanks during the Second Protocol, when compared to the First. What the aftermath of PQ.17 did produce however was a decline in Anglo-Soviet relations, with the response by Stalin characterised as ‘tactless’ but with understandable ‘disappointment’, given the deteriorating military situation, particularly after the loss of Sebastopol.⁵⁰

Figure 6.4 Numbers of fighters and tanks shipped to Russia displaying those shipped and sunk from Oct-41 to Jun-43⁵¹



⁴⁶ TNA, CAB 66/24/8, ‘Post-Protocol supplies to Russia’, 26 April 1942, Annex III: Notes by the Vice-Chief of Naval Staff on the limitations imposed by the availability of naval protection, 17 April 1942.

⁴⁷ TNA, CAB 65/30/12, ‘Supplies to Russia’, 18 May 1942; Figure 14.1 in Bellamy, *Absolute War*, p. 412.

⁴⁸ Beaumont, *British Aid to Russia*, pp. 28 & 85.

⁴⁹ Weinberg, *A World at Arms*, pp. 379-380; Beaumont, *British Aid to Russia*, pp. 102, 106-109 & 129.

⁵⁰ *Ibid.*, pp. 109-110.

⁵¹ TNA, CAB 66/28/47, ‘Report on fulfilment of the Moscow Protocol’, Part III, 17 September 1942; CAB 66/42/25, ‘Fulfilment of Second Soviet Protocol’, Minister of Defence, 19 October 1943.

In addition to the different consequences of enemy action, the Arctic convoys were delayed by the strategic necessity to provide supplies for the defence of Malta during 1942 which required multiple convoy operations.⁵² With the preparations for Operation Torch alongside the demands for Russia and Malta, convoy capacity was reduced to exclusivity with the First Sea Lord confirming that it was 'not possible to embark on more than one of these operations at the same time'.⁵³ This inability to operate simultaneous convoys was also due to the industrial capabilities of the United States not producing the number of escorts expected for 1942. As a result, and despite individual sailings to northern Russia, the Arctic convoys were suspended again until December 1942, whereby a large amount of undelivered Second Protocol supplies accumulated and could not be fully recovered by the other routes.⁵⁴ When the Arctic route was closed during 1942, aid being shipped from the United States was redirected to the Persian route resulting in Canadian Valentine tanks, Bren carriers and raw materials being sent under the British schedule, until the Arctic route reopened.⁵⁵ During the suspension after September 1942 until the end of the year, the Persian route provided over 150 Canadian tanks to Russia under British requirements.⁵⁶

Further to the intermittent but very consuming strategic responsibilities overseas, Allied shipping to Russia was still subject to the priority given to the Atlantic convoys as found during March 1943. Following the loss of 20 merchant ships over two days in the Atlantic and with the threat of a large German fleet concentrating in north Norway, the War Cabinet decided that the escort vessels for the Arctic convoys be redirected to the Atlantic. The prospect of encountering strong surface forces en route was not enough to postpone an Arctic convoy, but rather that Capital ships from the Home Fleet would have to enter the Barents Sea, which the Defence Committee had always considered to be an 'unacceptable' risk.⁵⁷

The decision to give priority to the Atlantic convoys was made in full knowledge that it would displease Stalin and potentially weaken Anglo-Soviet relations as it had after PQ.17. This diplomatic concern was further aggravated by the naval requirements of Operation Husky and the postponement of the Arctic convoys until September 1943.⁵⁸ However

⁵² Weinberg, *A World at Arms*, p. 390.

⁵³ TNA, CAB 66/27/24, 'Convoys to Russia', 6 August 1942.

⁵⁴ Beaumont, *British Aid to Russia*, pp. 130-131 & 140.

⁵⁵ TNA, CAB 66/26/47, 'Supplies to Russia', by Eden, 27 July 1942.

⁵⁶ TNA, WO 32/10521, E.C.S. Wade, War Cabinet to Major Swann, RLG, 27 October 1942.

⁵⁷ TNA, CAB 65/37/13, 'Supplies to Russia', 22 March 1943.

⁵⁸ TNA, CAB 65/37/12, 'Communications between the Prime Minister and M. Stalin', 18 March 1943.

Stalin's reply, which was certainly helped by the improved situation on the battlefield and in Russian production, was described by Churchill as 'courageous' and lacked the bitterness of 1942. The closure of the Arctic convoys during 1943 accelerated the existing capacity expansion programme for the Persian route, with an increase from 80,000 to 200,000 tons per month achieved from April to September 1943 respectively.⁵⁹

The chapter on Rearmament emphasised that British pre-war priorities mirrored the strategic reality of Britain both as an island nation and in respect of the likely deployment of ground forces overseas. This meant that whilst efforts were made in tank development to provide equipment to different operational theatres, British tanks were not designed to fight in the extreme winter conditions experienced in Russia. This limitation in British armour was highlighted by the Director-General of Armoured Fighting Vehicles, Major-General Alexander Richardson in December 1941, when he stated that 'prior to the war and even up to a few months ago, we never visualised our tanks having to fight at very low temperatures'.⁶⁰ To rectify this operational deficiency, the second section of this chapter will examine how British and Canadian tanks went through a process of modification or 'Arcticisation' before being shipped to Russia in a battleworthy condition.

During November 1941, the British Military Mission in Moscow provided the War Office with the opinion of the Russian authorities following receipt of the first deliveries of British Valentine tanks. This feedback was based upon Russian tank crews who had been withdrawn from the front to attend an 'intensive' week long course on the Valentine at the tank centre at Kazan. The British instructors at the centre reported that the rank and file appeared to be experienced, that the quality was comparable to British pre-war Tank Corps standards, and that morale was high.⁶¹ During February 1942, the British instructors reported that the average time available to each student at the tank centre was limited to three days, probably as a result of the demand to transfer fully crewed tanks to the front line. Despite the differences in language and frequent misinterpretation, a 'reasonably accurate' instruction book was produced after 'exercising considerable patience on both sides'.⁶² Thereafter, the

⁵⁹ TNA, CAB 65/38/1, 'Supplies to Russia', 5 April 1943; Beaumont, *British Aid to Russia*, pp. 138-140.

⁶⁰ TNA, WO 32/10521, 'Tanks to Russia', DAFV Richardson, 5 December 1941.

⁶¹ Library and Archives Canada, Ottawa, RG 24, volume 9363, file 38/ARM VEH/8, Military Mission to War Office, 21 November 1941.

⁶² LAC, RG 24, volume 2626 part 1, file HQS-3352-37-5, 'Russian Theatre of War: Technical Notes on British and Russian Equipment', Para. 15. Training of Russian Tank Crews at Kazan, 28 February 1942.

British instructors were relegated to providing 'occasional expert advice' as the Russian staff now considered themselves capable of providing further instruction unaided.⁶³

Important criticism was raised against the operational capabilities of the Valentine tank during the November 1941 visit to the tank centre. To begin with the tracks were deemed to be 'useless' outside of summer conditions as they slipped on frozen ground and were too narrow for travelling through soft snow. With the prospect of operating in temperatures of 40 degrees below zero centigrade, it was stated that British tanks needed: an electrically operated engine heater; a heated tray for warming tools for maintenance to prevent injuries to hands; positioning the fire extinguisher near the exhaust pipe to prevent the pyrene liquid from freezing; and finally drive the tank on to planks of wood when manoeuvres had ended to keep the tracks off the frozen ground.⁶⁴ As Valentine production included the simultaneous programme in Canada examined below, the War Office provided the same information to the Canadian Military authorities in London.⁶⁵ In response, particular concern was raised by the Canadian authorities in respect of the problems with the Valentine tracks, whilst the Department of Munitions and Supply in Ottawa was kept informed of these developments.⁶⁶

In response to Russian criticism, Beaverbrook confirmed to the Soviet Ambassador Britain's 'steadfast resolution to provide the Soviet armies with tanks capable of sustaining the battlefront in the most severe conditions of winter'. Given the now obvious disparity in operational capability, Beaverbrook requested details of Russian technical experience at low temperatures.⁶⁷ The issue of making British tanks battleworthy before being sent to Russia was considered during a special meeting of the executive third Tank Board. Whilst increasing the width of the tracks was deemed impossible, a 'spudded' track could be adopted as a suitable remedy and drawings of the Valentine track complete with spuds was sent to Russia.⁶⁸ With regards to preparing and operating tanks in extreme sub-zero temperatures, a meeting was eventually held in December 1941 between the Controller-General of Research and Development, Oliver Lucas, and representatives of the Russian Embassy. This meeting

⁶³ LAC, HQS-3352-37-5, 'Russian Theatre of War: Technical Notes on British and Russian Equipment No. 2', Para. 20. Instruction School at Kazan, 17 May 1942.

⁶⁴ TNA, WO 185/8, 'Special Meeting of the Tank Board', 25 November 1941, Appendix A: Military Mission to War Office, 21 November 1941.

⁶⁵ LAC, 38/ARM VEH/8, War Office to Canadian Military Headquarters, London, 25 November 1941

⁶⁶ LAC, 38/ARM VEH/8, CMH to War Office, 1 December 1941.

⁶⁷ TNA, WO 185/8, 'Special', Appendix E: Beaverbrook to Soviet Ambassador, 25 November 1941.

⁶⁸ TNA, WO 185/8, 'Special', 25 November 1941.

demonstrated the sheer differences in combat environment that troops on the Eastern Front had to contend with when compared with British experience to date.

- (i) Tanks operate in temperatures down to -40°F [equivalent to minus 40° centigrade].
- (ii) If a tank is to be in the open for a period of days without being run, all water and oil is drained off and the battery removed, the latter is kept in a warm room.
- (iii) In preparing to start, the radiators and engine are filled with hot water and the oil is warmed before being returned.
- (iv) In field operations the important parts of the tank are prevented from reaching temperatures much below freezing point by (a) closing all flaps and shutters, air louvers being provided with effective flaps. (b) Covering the tank with a fitted tarpaulin. (c) Inserting heating stoves in the body of the machine, preferably in the engine compartment. If necessary the engine is started up at intervals during the coldest weather.⁶⁹

Without direct reference to the Soviet-Finnish War, much of Russian understanding regarding winter combat would have originated from this costly encounter.⁷⁰ As an on-going response to the problem, daily Committee meetings were held at the War Office to deal with the additional equipment and modifications to British tanks.⁷¹ In respect of adjustments to the Churchill tank in preparation of being added to the shipments to Russia discussed below, Lucas informed Beaverbrook that this tank would not start in conditions any lower than minus 18 degrees centigrade and therefore required modification.⁷²

Taking into account the Arctic convoy difficulties discussed above, matters were further complicated by the additional time necessary to complete the modifications at a location away from both the factory and port. In June 1942, DAFV Richardson wrote that 'from the time a tank comes off production, there is an unavoidable time lag of, approximately, ten days, due to travelling time and the necessity for fitting Russian equipment at Chilwell before the tank is available at the port for loading'.⁷³ The Churchill tank was particularly susceptible to this delay during the loading of convoys PQ.18 and PQ.19 in July 1942. The PQ.18 convoy was due to ship 87 Churchill tanks, but was not expected to load more than 57 vehicles due to the delays in transport and modification. In order to make up this shortfall

⁶⁹ TNA, WO 185/8, '8th Meeting of the Tank Board (Reconstituted)', 15 December 1941.

⁷⁰ Beaumont, *British Aid to Russia*, p. 25; Bellamy, *Absolute War*, p. 80; R. M. Citino, *Blitzkrieg to Desert Storm: The Evolution of Operational Warfare* (Lawrence, University of Kansas, 2004), pp. 80-83.

⁷¹ TNA, WO 185/8, '8th Meeting', 15 December 1941.

⁷² TNA, AVIA 11/12, Lucas to Minister, 5 December 1941.

⁷³ TNA, WO 32/10521, Note by DAFV Richardson, 12 June 1942.

under the Protocol, it was decided that a further 30 Matilda tanks would be shipped instead, as these tanks could be adapted sooner. The later PQ.19 convoy was expected to address this imbalance with an additional 30 Churchill tanks, at the expense of Matilda tanks.⁷⁴

A possible reason for the lack of available Churchill tanks was claimed in the aftermath of loading PQ.18 to have been a shortage of 'war flats' necessary to carry this heavy tank from the manufacturers to Chilwell.⁷⁵ This implies that the shipping of aid to Russia was not only limited to the time and distances involved to transport and modify each vehicle, but was also affected by a lack of appropriate transportation equipment. The Director of Movements at the War Office later refuted this assertion by confirming that the 'availability of flat wagons' was already 'in step with tank production'.⁷⁶ Whether this statement was accurate or not, the shipping of tanks to Russia was subject to seemingly unavoidable delays to ensure their 'battleworthiness' before these vehicles reached the dock for loading.

With the expectation of winter seasons in Canada similar to the Eastern Front, equipment being considered for the 'Arcticisation' of tanks to Russia could be tested at Camp Borden in southern Ontario or the Shilo research centre in southern Manitoba. In addition to Canadian Valentine tanks, Britain took advantage of these facilities during the winter of 1942 and 1943, by sending a Churchill tank and three sets of tracks for testing in the snow.⁷⁷ The process of Arcticisation that began in 1942 continued throughout the war, as demonstrated by the agreement to ship one Comet tank to Russia for trial in 1945, but not before being sent from the factory to Chilwell for modification and then on to port for loading.⁷⁸

Apart from preparing tanks for the extreme conditions of winter, the executive fifth Tank Board and Armoured Fighting Vehicle (AFV) Liaison Committee reviewed during chapter 2, both examined the various possibilities of cooling the tanks for tropical climates. One option discussed during February 1943 for the humid jungle conditions of the Far East was to install a refrigerating system into the fighting compartment of the tank.⁷⁹ Based upon the investigations carried out until May 1943, the General Staff decided that refrigeration was

⁷⁴ TNA, WO 32/10521, Richardson to ACIGS, 23 June 1942.

⁷⁵ TNA, WO 32/10521, 'Supplies of tanks to the U.S.S.R.', 9 July 1942.

⁷⁶ TNA, WO 32/10521, Director of Movements to Army Council, 10 August 1942.

⁷⁷ LAC, RG 24, volume 2596 part 1, file HQS-3352-3, 'Cold Weather Tests', 15 December 1942, 5 and 26 January 1943.

⁷⁸ TNA, WO 32/10521, 'Shipments to Russia', 13 February 1945.

⁷⁹ TNA, WO 185/7, '15th A.F.V. Liaison Meeting', 9 February 1943.

impracticable due to weight considerations, although further consideration was given to the development of ventilated suits.⁸⁰ During January 1945 the Canadian Technical Liaison Officer attached to the Experimental Wing at Farnborough, reported to the Canadian authorities in London that 'Tropicalisation' field trials were being carried out on the suit and fan type of ventilation equipment.⁸¹ By March, both of these ventilation projects had been successfully tested in the latest Sherman tank, providing an operational range estimated at 2,000 miles.⁸² As discussed during the previous chapter, these tests were carried out under the exchange of information and military equipment between the Western Allies, which was similarly attempted with Russia as examined below during the third section of this chapter.

Whilst the U.S. official history correctly states that a 'free exchange of technical data between the Western Allies and the USSR was never obtained'⁸³, a formal agreement of exchange was achieved between Britain and Russia. However this quickly became a one-sided arrangement that was no doubt linked to the policy of 'appeasement' argued by Martel, in which the Russian authorities only reciprocated once the information or equipment had become outdated enough for continued secrecy to no longer matter. The agreement was signed during September 1942 and stipulated that either government would:

furnish to each other on request all information, including any necessary specifications, plans, etc., relating to weapons, devices or processes which at present are, or in the future may be, employed by them for the prosecution of the war against the common enemy. They will also furnish such information spontaneously as regards new weapons, devices or processes which they may employ and which they consider would be of interest to the other Government.

Furthermore, the agreement addressed the possibility that either government might have reservations on the release of specific information or equipment, especially if such examples had not yet been exposed to the enemy.⁸⁴ British policy towards Russia until this time had already divulged 'anything that the enemy knows about or that is in use in quantity against him, but nothing that is under development, experimental, not yet in service or considered not

⁸⁰ TNA, WO 185/8, '30th Meeting of the Tank Board', 18 May 1943.

⁸¹ LAC, RG 24, volume 9360, file 38/AFV PROGRESS/3, TLO to CMH, 31 January 1945.

⁸² LAC, 38/AFV PROGRESS/3, TLO to CMH, 28 March 1945.

⁸³ C. M. Green, H. C. Thomson and P. C. Roots, *United States Army in World War II, The Technical Services, The Ordnance Department: Planning Munitions for War* (Washington, Department of the Army, 1955), reprinted 1970, p. 274.

⁸⁴ TNA, CAB 111/28, Foreign Office to Moscow, 7 September 1942.

yet to have got into the enemy's hands'.⁸⁵ Even with these limitations in place, there was already a high standard of technical disclosure to Russian engineers before the September agreement, with visits to factories, the witnessing of firing trials and the providing of specifications and production drawings for various weapons and military equipment.⁸⁶ In respect of restricted disclosure, one example was the latest types of naval radio direction finder or RDF equipment that had not been permitted to leave Britain on security grounds.⁸⁷

As a result of the new agreement, the key items of army equipment requested by Britain in 'direct invocation', consisted of examples of the T-34 and KV-1 tanks and anti-tank rifles. The Russians had no similar requests to make indicating that the British had already provided whatever had been requested to date. By comparison, a similar situation was experienced in respect of naval equipment with the Russians not making any requests, whereas the British notably sought details of the lubricants used for automatic guns under Arctic conditions. The reverse was experienced for aerial equipment with the British making no requests, whilst the Russians sought night fighter equipment and methods of locating and paralysing German radio-beacons.⁸⁸ Britain continued to co-operate under the agreement as demonstrated when the Russian Mission in Britain viewed the new Cromwell tank, during the experimental stages at the Fighting Vehicle Proving Establishment at Chobham in November 1942.⁸⁹

As the Red Army advanced towards the German border the Russian authorities maintained their interest in the developments of western armour, especially after the successful Normandy campaign. During October 1944, the Soviet Trade Delegation (STD) requested information of the new A.30 Challenger tank as part of their planned visit to a number of war factories, including the Birmingham Railway Carriage and Wagon Company. Information regarding this modified Cromwell tank had not yet been disclosed to the Russian authorities, although they would have known of its existence and probable appearance given that it was deployed to Normandy during July and shared many similarities with the base vehicle. In the circumstances, the firm was instructed not to draw any unnecessary attention to the

⁸⁵ TNA, CAB 111/28, Brigadier R. Firebrace, Chief Liaison Officer, Russian Liaison Group to E. P. Donaldson, Allied Supplies Executive, 24 August 1942.

⁸⁶ TNA, CAB 111/28, Firebrace to Donaldson, 22 August 1942.

⁸⁷ TNA, CAB 111/28, 'Draft Telegram', August 1942.

⁸⁸ TNA, CAB 111/28, 'Requests and Disclosures', 30 September 1942.

⁸⁹ TNA, WO 185/7, 3rd A.F.V. Liaison Meeting, 5 November 1942.

Challenger, nor provide any details regarding its specification, performance or production.⁹⁰ This is an example of the seemingly impossible position that was occasionally imposed on industry, when the authorities attempted to balance continued good relations with an important ally and that of maintaining weapon secrecy. The response by Birmingham Railway to this situation was both pragmatic and compliant. As Challenger production dominated the factory, it was 'very difficult to in any way restrict information' as they were 'in all stages of assembly'. However, restrictions to information would be adopted as instructed, whilst being sensitive not to create an impression of withholding details which they 'obviously' possessed.⁹¹ It seems likely that Russian interest was motivated by the opportunity to examine how the British converted their 17-pounder anti-tank gun into a tank gun with full traverse, and may also explain Britain's continued reluctance to disclose. These restrictions were relaxed in February 1945 with an offer to supply technical details and arrange for a demonstration. The Soviet Military Mission accepted this proposal together with a repeated request for a Challenger tank to be shipped to Russia, thus confirming their continued interest to inspect this tank.⁹²

The battlefield performance of 'Hobart's Funnies' also peaked Russian interest with a request during November 1944 for the flame-throwing Crocodile Churchill tank and the mine-sweeping Crab Sherman tank to be sent to Russia.⁹³ Despite being used in Normandy these vehicles were still restricted, and in the case of the Crab for reasons beyond maintaining secrecy, as operational necessity correctly took precedence over political requirements. The Royal Armoured Corps was understandably 'most reluctant' to ship any Crab tanks to Russia as they were still in 'urgent operational demand and the conversion programme can barely keep pace' with the 'critically short' number of Sherman tanks available.⁹⁴ This last comment referred to the cessation of Lend-Lease deliveries discussed in the previous chapter.

As identified above, this overall adherence by Britain throughout the war was not reciprocated. The AFV Liaison Meeting reported in January 1943 that the British Military Mission in Moscow had been asked to request the shipment of tanks sought under the

⁹⁰ Staffordshire Record Office, Stafford, Birmingham Railway Carriage and Wagon Company, D831/1/6/2/M, Micklem to Moyses, 18 October 1944.

⁹¹ SRO, D831/1/6/2/M, Moyses to Micklem, 21 October 1944.

⁹² TNA, WO 32/10521, Lieut-General A. F. Vasiliev, Soviet Military Mission to Firebrace, 5 February 1945.

⁹³ TNA, WO 32/10521, Soloviev, STD to Firebrace, 9 November 1944.

⁹⁴ TNA, WO 32/10521, DRAC to DLM, 2 December 1944.

agreement.⁹⁵ This absence of co-operation seemingly continued without improvement until a T-34 and KV-1 tank was eventually sent to Britain later in 1943, but not necessarily as a result of the agreement. In the opinion of Joan Beaumont, the diplomatic situation in Russia improved when Lieutenant-General Martel was appointed as head of the Military Mission, together with his reputation as a tank expert and having witnessed Russian tank manoeuvres in 1936. This created an initially strong feeling of co-operation which included the opportunity for Martel to visit the battlefield, a privilege which would have otherwise taken many months to be awarded.⁹⁶ Whilst this new relationship did not last, and Beaumont attributes this to Martel's outspokenness, the temporary thaw in Russian attitude gave the British access to certain technical information which had otherwise been denied to them.⁹⁷ Similarly in 1943, the United States received their first T-34 tank for examination at the Aberdeen Proving Ground, as the Russian authorities recognised that some equipment had to be given to balance the amounts of material now being provided in aid.⁹⁸ Whilst a Foreign Office representative was permitted to visit the industrial area of the Urals in April 1943, this was without the same preparations that were afforded to Russian officials in Britain.⁹⁹

It can be reasonably argued that Russian equipment was more suitably directed towards the military campaign on the Eastern Front during 1941 and 1942, which saw the destruction of all existing mechanised corps and 37 per cent of all tank and motorised divisions. With regard to actual numbers, the Red Army lost 22,600 out of 23,106 tanks in 1941, and still lost 22,400 out of 43,500 in 1943 when Russian tank production had largely recovered.¹⁰⁰ However, by February 1945 and when the Red Army had now advanced well into German territory, the British were still making repeated requests for equipment and information that had failed to materialise to date.¹⁰¹ With the exception of some ad hoc shipments above, the experience of the United States was not dissimilar with the majority of Russian equipment coming from captured German sources who had taken it from the Red Army previously.¹⁰²

⁹⁵ TNA, WO 185/7, '11th A.F.V. Liaison Meeting', 7 January 1943.

⁹⁶ Beaumont, *British Aid to Russia*, pp. 114 & 159-160.

⁹⁷ *Ibid.*, p. 160

⁹⁸ Green, et al., *Planning Munitions for War*, p. 274.

⁹⁹ TNA, CAB 66/38/4, 'A Visit to the Urals', 20 June 1943, including note by G. M. Wilson, 30 April 1943.

¹⁰⁰ Erickson, 'Red Army Battlefield Performance', pp. 236-237.

¹⁰¹ TNA, WO 32/10521, Firebrace to Vasiliev, 1 February 1945.

¹⁰² Green, et al., *Planning Munitions for War*, p. 274.

The fourth section of this chapter will highlight the Canadian contribution to the supply of tanks to Russia, including the motivations of the Canadian government and the experience of Canadian industry. Overall, only 34 per cent of Canadian war production went to the Canadian forces, whereas 12 per cent was provided to the United States and the remaining 54 per cent was sent to Britain, other Empire countries and Allied nations.¹⁰³ The extent of the Canadian tank programme is shown in Appendix 9 for 5,794 tanks. This highlights that apart from the Valentine tank at the Canadian Pacific Railway, the Montreal Locomotive Works produced the Canadian RAM tank, the Grizzly tank based upon the American Sherman, and tank adaptations to include Command tanks, the 25-pounder Sexton Self-Propelled gun, and together with the Waterloo Manufacturing Company, a small number of Anti-Aircraft tanks.

As reviewed in chapter 3, Britain sought to benefit from Canadian industry as early as October 1939 and later placed production orders with Canadian Pacific for 300 Valentine tanks during June 1940 following the evacuations from France and the need for quantity production. Similarly, the Canadian government raised their own order with Canadian Pacific for 488 Valentine tanks necessary to equip a Canadian army tank brigade. For Britain, the importance of receiving a Canadian tank brigade equipped with Valentine tanks from Canadian production was emphasised during January 1941 by David Margesson as the new British Secretary of State for War. Margesson confirmed to visiting Canadian officers that Britain was “entirely agreeable to Canada having priority on Canadian production” of Valentine tanks, under the expectation that the Canadian tank brigade would be sent to Britain in the summer of 1941.¹⁰⁴ As examined later, this anticipated programme ended with the requirement to ship these tanks to Russia after the German invasion in June.

Having received orders for the Valentine tank in June 1940, the Canadian Pacific instructed their representatives in London to acquire the specifications and drawings.¹⁰⁵ The Ministry of Supply suggested that Canadian Pacific send some members to Vickers-Armstrongs in Newcastle-upon-Tyne to obtain the necessary manufacturing information.¹⁰⁶ Vickers contacted the Canadian Military Headquarters in London to confirm that ‘every possible

¹⁰³ C. P. Stacey, *Arms, Men and Governments: The War Policies of Canada, 1939-1945* (Ottawa, Queen's Printer, 1970), p. 488.

¹⁰⁴ Quoted in C. P. Stacey, *Six Years of War: The Army in Canada, Britain and the Pacific*, Volume I (Ottawa, Queen's Printer, 1956), p. 90.

¹⁰⁵ LAC, RG 24, volume 9377, file 38/TANKS/1, Department of Munitions and Supply, Ottawa to CMH, 10 June 1940.

¹⁰⁶ LAC, 38/TANKS/1, CMH to Department of National Defence, Ottawa, 14 June 1940.

assistance in connection with the manufacture' of the Valentine tank would be provided to the Canadian Pacific employees during their visit organised for 19 June 1940.¹⁰⁷

The ability to mass produce the Valentine tank in Canada as per British General Staff requirements in June 1940, was doubted by the Canadian Minister of Munitions and Supply, Clarence Howe, when he declared in August that this tank was 'about as difficult to build as anything that could be imagined'.¹⁰⁸ Compared to the production of British Valentine tanks from June 1940 until June 1942, this opinion is not supported as 3,007 tanks were delivered at an average of 120 tanks per month from just three firms. In terms of British industry this was mass production when compared against Churchill output at an average of 131 tanks per month from eleven firms and Crusader output of 110 tanks per month from nine firms, across the first two years of production respectively.¹⁰⁹ Furthermore, the particular obstacles for Valentine production in Canada were no different than that experienced by Britain and the United States, namely: the time taken to expand industrial capacity; shortages in the supply of components; and the lack of skilled labour for tank assembly.

During September 1940, the Canadian government received notification that the British War Office required greater numbers of Cruiser instead of Infantry tanks based upon the combat experience in France discussed in chapter 3.¹¹⁰ Similarly, the Canadian General Staff expressed the desire to produce the American M3 Medium tank, although continued with the Valentine contracts in the short-term under the expectation of receiving the first deliveries in February 1941. Valentine output was meant to expand to three tanks per day by June to complete the British order by the end of August 1941, and the Canadian order by February 1942.¹¹¹ The Canadian government decided that upon completion the 488 tanks would be offered to Britain in the event that the Canadian tank brigade was no longer required and replaced by an armoured brigade equipped with the preferred Medium tanks.¹¹²

As discussed during the previous chapters, tank firms were reliant upon sub-contractors to provide most, if not all, of the component requirements to commence and then maintain the

¹⁰⁷ LAC, 38/TANKS/1, Vickers-Armstrongs to CMH, 15 June 1940; CMH to Vickers, 18 June 1940.

¹⁰⁸ LAC, RG 24, volume 2596 part 1, file HQS-3352-3, vol. 1, C. D. Howe to Col. J. L. Ralston, Minister of National Defence, 27 August 1940.

¹⁰⁹ TNA, AVIA 46/188, 'Monthly Deliveries', pp. 269-271.

¹¹⁰ LAC, RG 24, volume 2596 part 1, file HQS-3352-4, memo by Maj-General H. Crerar, 19 September 1940.

¹¹¹ LAC, HQS-3352-4, tank meeting in Washington, 20 September 1940.

¹¹² LAC, HQS-3352-4, Ralston to Crerar, 26 September 1940.

required rate of output. During October 1940 the Joint Committee on Tank Development discussed in chapter 2, stated that the only firm that had produced armour and bullet proof plate in Canada was Dominion Foundries and Steel. Given that the Canadian war programme included the Valentine tank, American Medium tanks, Universal Carriers, armoured cars, aircraft and naval production, an increase in armour plate capacity was clearly required. To achieve these programmes, Dominion was authorised to construct new plant to provide the plate necessary for the output of three Valentine tanks per day, whilst other steel firms were introduced to armour production under an industrial expansion scheme similar to that already discussed in relation to Britain and United States.¹¹³

Whilst the first production Valentine tank was due in February 1941 as highlighted above, by late January Canadian Pacific reported that this was unlikely because the absence of component drawings had meant that the firm had to devise their own based upon the sample tanks from Britain.¹¹⁴ Despite increasing the capacity for armour plate for the Valentine, the output of complete sets of plate on a mass produced basis took time to achieve, as demonstrated when Dominion Foundries delivered the first two sets in February. Canadian Pacific used these plates to begin assembling two Valentine hulls, although the first production tank was delayed because of shortages in the other components and in particular the turret.¹¹⁵ The components for 12 tanks were received during May, although Canadian Pacific now reported that the chief bottle-neck related to the amount of labour available for fitting and machining the armour plate to assemble the tanks. The first tank from Canadian Pacific was completed later in May representing 11 months since the order in June 1940.¹¹⁶

As highlighted during chapter 3 this was two months sooner than the first tank from Vickers-Armstrongs. Despite entering full production, the rate of output at Canadian Pacific continued to be delayed by a series of unsatisfactory and time consuming production techniques, as identified by an army officer during a three day factory visit in October 1941:

They are still using paint brushes instead of spray guns. They are still installing Bogey wheel springs or shock absorber springs with a hand jack operated by two men instead of an air or hydraulic jack . . . One man took over two hours to fit a hinge on the door . . . All he used was a cold chisel and a file . . . They are manufacturing

¹¹³ LAC, HQS-3352-3, vol. 1, Meeting: 'Re: Armour Plate for Tanks', 31 October 1940.

¹¹⁴ LAC, HQS-3352-3, vol. 1, sixth meeting of the Joint Committee on Tank Development, 24 January 1941.

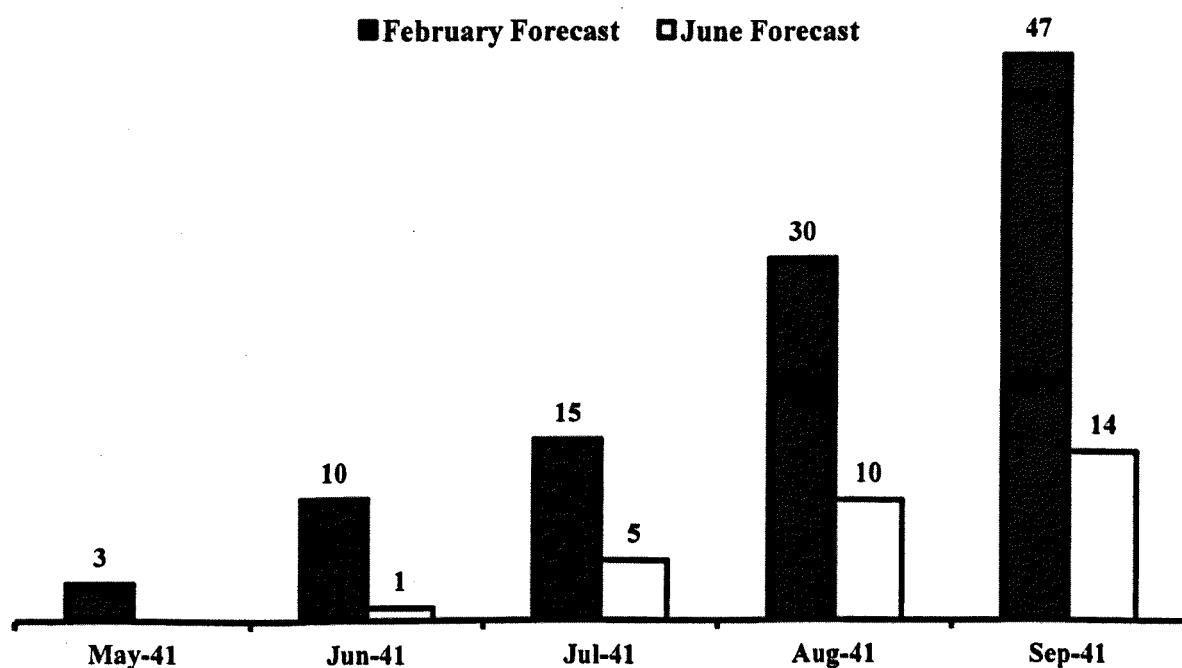
¹¹⁵ LAC, HQS-3352-3, vol. 1, eighth meeting, 18 February 1941.

¹¹⁶ LAC, HQS-3352-3, vol. 1, eleventh meeting, 1 May 1941; fourteenth meeting, 29 May 1941.

practically everything by hand and certainly have not the equipment or machinery at the present time to increase their production. I think a good production man possibly from the United States could increase production to almost double in from thirty to sixty days.¹¹⁷

As demonstrated in Figure 6.5, the combination of these continuing delays to the Canadian Valentine programme meant that February production forecast had to be lowered in June. As a result of these changes the total number of tanks to be produced between May and September 1941 was 71 per cent fewer than expected, together with 48 per cent fewer tanks when comparing the opening four months of each forecast.

Figure 6.5 Forecast of first Valentine deliveries from Canadian Pacific Railway¹¹⁸



In response to the requirements under the First Protocol during October 1941, Britain took over the Valentine programme in Canada and increased the total order to 1,420 tanks in which all but 30 were shipped direct to Russia by May 1943.¹¹⁹ To achieve this and in spite of the unsatisfactory initial production methods above, Canadian Pacific had shipped 420 tanks by April 1942, with the expectation of maintaining an output of 75 tanks per month

¹¹⁷ Lieut-Colonel G. A. Secord to Colonel H. G. Thompson, 11 October 1941, quoted in Historical Section, Army Headquarters, Report No. 38, 'Tank Production in Canada', 27 July 1950, pp. 4-5, found in National Defence and the Canadian Forces at <http://www.forces.gc.ca/site/home-accueil-eng.asp>, accessed 30 September 2010.

¹¹⁸ February forecast: LAC, LAC, HQS-3352-3, vol. 1, Deputy Minister of Munitions and Supply to Master General of the Ordnance, DND, 4 February 1941; June forecast: Historical Section, 'Tank Production', p. 3.

¹¹⁹ *Ibid.*, p. 5; see Appendix 8 for the total of 1,388 instead.

thereafter.¹²⁰ Therefore, Canadian Pacific overcame the production problems and delivered an average of 57 tanks per month across the two years of production, which was greater than British Valentine production above with each of the three firms delivering an average of 40 tanks per month.

The fifth section of this chapter will examine how the requirement to provide tanks to Russia each month affected the supply of similar vehicles to equip British armoured units at home and for operational deployment overseas. To begin with, the vast majority of tanks supplied to Russia were the comparatively well armoured Matilda, Valentine and Churchill tanks, as the limited number of Light tanks in production when the First Protocol commenced prevented them from being sent to Russia in any great number. This was demonstrated by the Light Mark VII Tetrarch tank above, in which development problems and bomb damage to the factory meant that only 50 tanks out of the 100 produced were shipped to Russia.¹²¹

A similarly poor situation continued in respect of the later Light Mark VIII, Harry Hopkins tank, which in November 1941 had a planned total output of 2,400. The War Office requirement at this time however was for only 1,200 tanks, so in order to meet the optimum rate of production it was decided that the other 1,200 tanks would be provided to Russia, whilst retaining the same number of the heavier Infantry tanks for the British army.¹²² This decision was consistent with requirements under the First Protocol, with the Russian authorities accepting Light tanks as part of the aid programme.¹²³ The problem was that whilst production of the Harry Hopkins was due to commence in July 1942, development problems with the suspension meant that production tanks were delayed until July 1943 and therefore none were shipped to Russia.¹²⁴

Under the First Protocol, the combined programmes of the Western Allies were required to provide 500 tanks per month divided equally between Britain and the United States, with Canadian production forming part of British obligations. The monthly forecast of tanks from November 1941 to March 1942 to meet this target is provided in Figure 6.6, demonstrating

¹²⁰ TNA, WO 32/10521, DAFV to ACIGS, 23 June 1942.

¹²¹ D. Fletcher, *The Universal Tank: British Armour in the Second World War, Part 2* (London, H.M.S.O., 1993), p. 42.

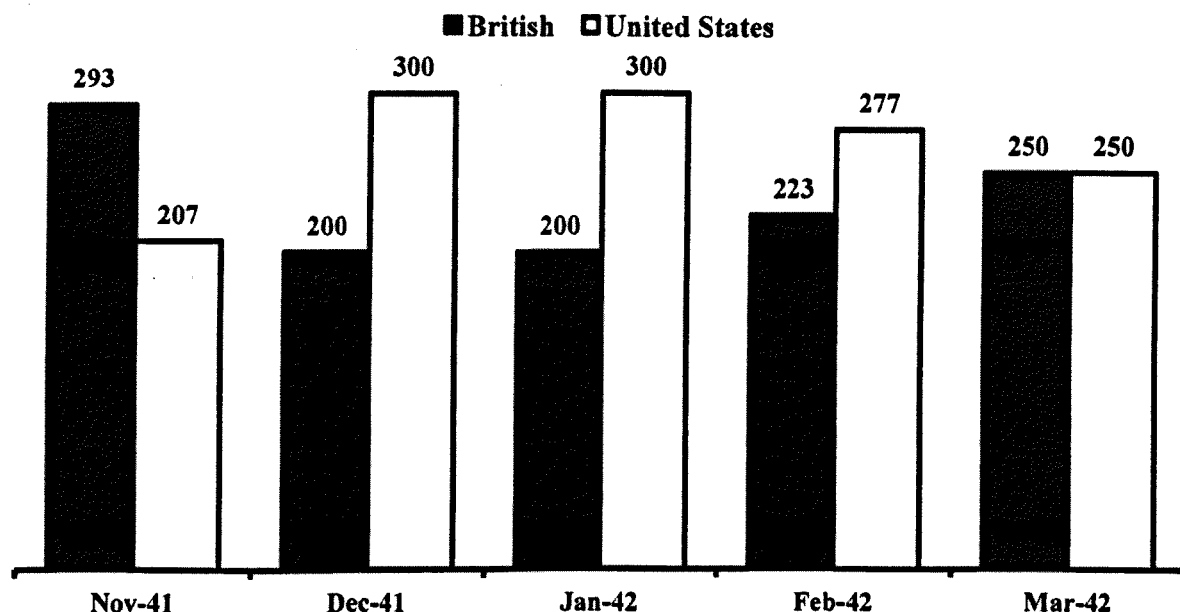
¹²² TNA, BT 87/43, R. J. Sinclair, DGAR to W. Layton, Director-General of Programmes, 7 November 1941.

¹²³ See Table 1 in Beaumont, *British Aid to Russia*, pp. 58-60

¹²⁴ TNA, BT 87/43, Permanent Secretary to Minister to Layton, 8 November 1941; CAB 120/355, 'A.F.V. Production', 7 July 1943

that the United States was expected to provide 84 tanks on Britain's behalf over the period before parity was achieved.¹²⁵ The reasons for the shortfall in British deliveries to Russia until March was not a shortage of the required Matilda or Valentine tanks, but rather the strategic requirements of retaining these tanks for the home forces and deployment to theatres overseas. In respect of the latter concern, the War Office was obligated to provide tanks to India, New Zealand and Australia, in addition to British commitments in the Middle East.¹²⁶

Figure 6.6 Anticipated deliveries of tanks to Russia under the First Protocol¹²⁷



British Empire interests were supplemented by tanks from the United States, with the most notable example by General Marshall in November 1941 to supply 350 M3 Medium tanks direct to the Middle East, at the expense of equipping U.S. Army units.¹²⁸ Whilst Britain was clearly grateful for this assistance, by late 1941 American industry had been unable to meet their commitments to Russia, resulting in Britain supplying the difference whenever possible.¹²⁹ As a result and in a reversal of the original intentions, Britain provided an extra 127 tanks under the First Protocol on behalf of the United States.¹³⁰ This shortfall of American tanks was not due to the lack of importance given to the Eastern Front by the United States, as demonstrated when 50 Light tanks destined for Australia early in 1942 were

¹²⁵ TNA, BT 87/29, War Office to British Purchasing Commission, 11 November 1941.

¹²⁶ TNA, PREM 3/426/5, 'Proposed and allocation of tanks between different theatres', 1 December 1941.

¹²⁷ TNA, PREM 3/426/5, 'Proposed and allocation', 11 November 1941.

¹²⁸ Beaumont, *British Aid to Russia*, p. 65.

¹²⁹ Bellamy, *Absolute War*, p. 421.

¹³⁰ TNA, WO 32/10521, 'Tanks Allocated and Shipped to Russia under the Protocol', 20 October 1942.

redirected to Russia instead.¹³¹ The United States correctly prioritised the immediate requirement for tanks in the defence of Russia over the potential requirement for tanks in the defence of Australia against continuing Japanese military advances.

The concern of providing tanks to Russia alongside the development of armoured divisions in Britain was emphasised during November 1941, when Beaverbrook wanted to increase the number of Valentine tanks sent each month to 150 until March 1942, representing an overall increase of 115 over the period. The understandable concern raised by the Chief of the Imperial General Staff, Sir John Dill, was that 170 Valentine tanks had already been committed from Britain to the Middle East for November, and that the Matilda tank was not a suitable alternative to equip armoured divisions. Churchill agreed with Beaverbrook in this instance by stating that 'some delay in the completion of the equipment of the armoured divisions in Home Forces' was acceptable, to raise the number of Valentine tanks requested for Russia.¹³² The additional 115 Valentine tanks for Russia were added to tank allocations until March, subsidised by a corresponding decrease in the supply of Matilda tanks, which remained with Home Forces or assigned to Australia. The armoured divisions in the Middle East continued to be supplied by the Crusader tank and were unaffected by these changes, as these tanks were not part of the aid to Russia programme.¹³³

A week later the Russian authorities agreed to a higher proportion of Matilda tanks in response to continued War Office concern regarding the effect of allocating Valentine tanks away from the Middle East.¹³⁴ The General Staff believed that this adjustment related to ongoing shipments to Russia, whilst Beaverbrook understood that this was meant to apply to December 1941 only. During December, the objective of Beaverbrook to provide more Valentine tanks to Russia was further supported when Stalin requested that greater numbers of this particular tank be shipped. In response, Beaverbrook informed Churchill that the Ministry of Supply would 'divert the necessary Valentines from the production line in the month of January to provide a gross total of 150 Valentines for Russia'.¹³⁵

¹³¹ National Archives of Australia, A816, 45/302/161, Department of the Army to Department of Defence Co-ordination, 13 March 1942.

¹³² TNA, BT 87/29, 'Defence Committee (Operations)', extract from minutes, 17 November 1941.

¹³³ TNA, PREM 3/426/5, 'Proposed and allocation', 23 November 1941.

¹³⁴ TNA, PREM 3/426/5, 'War Cabinet: Defence Committee (Operations)', 1 December 1941.

¹³⁵ TNA, PREM 3/401/20, Dill to Churchill, 21 December 1941; Beaverbrook to Churchill, 22 December 1941.

The Russian opinion of the Valentine tank in November 1941 was critical but nonetheless accurate, with complaints regarding the lack of high-explosive firepower, weak roof armour and limited operational range.¹³⁶ Further to Stalin's request in December for greater numbers of Valentines, in March 1942 the Russian authorities requested that as many Matilda tanks as possible be replaced by Valentine tanks.¹³⁷ The War Office rejected this proposal for reasons of continued strategic commitments overseas and the precarious spares position, thus making it 'impossible to contemplate sending any extra Valentines to Russia'.¹³⁸

As discussed during chapter 3, the production of tank spares was given greater priority during 1942 and later became a policy of providing spares at the same time as new production tanks. The organisation of spares for tanks being provided under the First Protocol similarly improved during 1942, following the concern at the War Office that the three months worth of spare parts provided with the tanks shipped in October 1941, would be 'nearing exhaustion' during January. The suggestion was that future deliveries would provide six months of spares when the tanks were shipped and including those from Canadian production, followed by a further six months supply three months later, and then six months of spares every six months thereafter.¹³⁹ This programme was impracticable at this time as spares production in Britain could not meet the demand of this scale, and because the Russian system to receive, store and distribute the supply of spare parts was deemed insufficient.¹⁴⁰

After consideration by the Allied Supplies Executive (ASE), the future shipment of spares was agreed at the beginning of April 1942 to supply immediately four months worth of spares to cover all tanks shipped to the end of January 1942. Another four months of spares would be provided at the start of August for all tanks delivered until the end of May, followed by a further four months supplied at the beginning of December for all tanks provided up to the end of September 1942.¹⁴¹ When added to the original three months of spares provided during October 1941, this gave the Russians with a total supply of 15 months of spare parts to cover the number of tanks delivered over the 12 months until September 1942. The additional three months was based upon maintaining the minimum level of two months

¹³⁶ TNA, WO 185/8, 'Special', Appendix A, 21 November 1941.

¹³⁷ TNA, WO 32/10521, War Office to Offices of the War Cabinet, 10 March 1942.

¹³⁸ TNA, WO 32/10521, DAFV to CIGS (through ACIGS), 30 May 1942.

¹³⁹ TNA, WO 32/10518, Deputy Director of Army Equipment to ACIGS, 23 January 1942.

¹⁴⁰ TNA, WO 32/10518, ACIGS to Director-General of Army Equipment, 5 February 1942.

¹⁴¹ TNA, WO 32/10518, memo by Chief Ordnance Officer at Chilwell, 6 April 1942.

‘General Staff reserve’ and a one month ‘safety margin’, although the Middle East continued to receive priority with a minimum of three months reserve and two months safety margin.¹⁴²

Following a demonstration in early 1942, the Russian authorities agreed to 25 Churchill tanks and spares to be sent to Russia for ‘trial under war conditions’, in lieu of the same number of Matildas.¹⁴³ The effect that this seemingly minor change in providing aid to Russia had upon the British tank programme should not be overlooked or underestimated. The executive third Tank Board, which was attended by Vauxhall Motors, confirmed that due to a bottleneck in the production of gear boxes, the supply of 25 Churchill tanks to Russia with 100 per cent gear boxes would mean a loss of 50 tanks for Britain.¹⁴⁴ Despite this detrimental effect upon the British Army, the shipment of 25 Churchill tanks and spares to Russia was planned for April, following ‘modifications in design’ which were regarded as ‘essential to their successful operation’.¹⁴⁵ This concern related to the Churchill “Rework” programme necessary to resolve the various design and reliability problems, and was already delayed due to the construction or modification work to the buildings at some of the manufacturers.¹⁴⁶ As a result, none of the reworked Churchills were shipped in April, as the British authorities rightfully considered it ‘highly undesirable’ to supply unbattleworthy tanks to Russia.¹⁴⁷

The prospect of supplying fully reworked Churchill tanks on a monthly basis under the Second Protocol was clearly at the expense of equipping British army tank brigades with battleworthy tanks. Nevertheless, the War Office planned to provide Russia with 50 Churchill and 50 Matilda tanks over and above requirements, across three convoys in June, July and August 1942.¹⁴⁸ However, the simultaneous requirements for the original and later cancelled Dieppe raid under the codename “Rutter” compelled the CIGS General Brooke to cancel the shipment of these fully modified Churchill tanks to Russia.¹⁴⁹ The plan to send these extra 50 Churchill tanks to Russia was later salvaged for the convoys planned in July

¹⁴² TNA, WO 32/10518, DGAE to ACIGS, 31 January 1942.

¹⁴³ TNA, WO 32/10521, Rear-Admiral N. Kharlamov, SMM to Firebrace, 14 February 1942.

¹⁴⁴ TNA, WO 185/8, ‘12th Meeting of the Tank Board (Reconstituted)’, 17 February 1942.

¹⁴⁵ TNA, WO 32/10521, Donaldson to Kharlamov, 2 March 1942.

¹⁴⁶ TNA, WO 185/8, ‘12th Meeting’, 17 February 1942.

¹⁴⁷ TNA, WO 32/10521, Vauxhall Motors to War Office, 21 March 1942; ‘Supply of Churchill Tanks to U.S.S.R.’, 28 March 1942.

¹⁴⁸ TNA, WO 32/10521, DAFV to CIGS (through ACIGS), 30 May 1942.

¹⁴⁹ TNA, WO 32/10521, Note by DAFV following conversation with CIGS, 1 June 1942.

and August towards a combined shipment of 600 tanks, but with the consequence of delaying the completion of the British 21st, 25th and 34th Army Tank Brigades by three weeks.¹⁵⁰

The on-going requirement to provide tanks to 'other overseas commitments', which had been a dominant theme in decision making, was downgraded to 'an "ad hoc" basis according to the availability of tanks' in August 1942.¹⁵¹ Whilst this eased some of the pressure in forecasting tank allocations, the problem of supplying both British forces and Russian requirements with the latest tank models remained.¹⁵² This situation was particularly acute when British six-pounder gun tanks became available, which the Russian authorities had requested during February 1942 when first discussing the Churchill tank.¹⁵³ Whilst six-pounder gun tanks were eventually shipped under the protocol during 1942, Foreign Secretary Anthony Eden expressed his concern to Secretary of State for War P. J. Grigg in December, 'that insufficient regard is still being paid to the plainly expressed preference of the Russians for tanks armed with the 6-pdr. gun'.¹⁵⁴ The War Office responded by including 20 six-pounder Churchill tanks at the expense of 20 two-pounder tanks in the next shipment. This increased the overall proportion of two-pounder to six-pounder gun tanks, from near parity to 43 and 57 per cent respectively.¹⁵⁵ Limitations regarding the supply of tanks to Russia were still maintained, with Churchill confirming in Cabinet that whilst Britain was obliged to fulfil its commitments, he did not insist that all tanks should be of the six-pounder variety.¹⁵⁶

The sixth and final section of this chapter will review the continued Russian preference for the Valentine tank since December 1941 until the end of the war. From the Russian tactical perspective, the Valentine had greater cross country manoeuvrability, it was less conspicuous, and was less demanding on crew training and maintenance than compared with the Matilda or Churchill tanks.¹⁵⁷ Tank platoon commander Nikolai Zheleznov provides individual testimony by stating that 'the Valentine was a very successful tank, low to the ground, with a powerful gun and a quiet engine'. Zheleznov continues with an example in March 1944 of

¹⁵⁰ TNA, WO 32/10521, ACIGS to Secretary of State for War, 4 June 1942.

¹⁵¹ TNA, WO 32/10521, DAFV to DRAC, DGAE, RLG, et al., 22 August 1942.

¹⁵² TNA, WO 32/10521, 'Tanks for Russia', 26 November 1942.

¹⁵³ TNA, WO 32/10521, Firebrace to SMM, 5 February 1942.

¹⁵⁴ TNA, WO 32/10521, Eden to Grigg, 8 December 1942.

¹⁵⁵ TNA, WO 32/10521, letter to Kharlamov, 15 December 1942.

¹⁵⁶ TNA, WO 32/10521, Donaldson to ACIGS, Watson, 16 December 1942.

¹⁵⁷ TNA, WO 185/6, Military Mission Moscow, 7 August 1942.

how two Valentine tanks, presumably six-pounder armed, used these qualities to outflank and destroy three stationary Tiger tanks, at a range of between 300 to 400 metres.¹⁵⁸

In July 1943, Valentine production came under review by Churchill and the Minister of Supply Andrew Duncan, and despite clearly being an obsolete tank, it was decided that the programme should continue 'in order to meet Russian requests'.¹⁵⁹ The effect of this decision upon the Valentine programme is illustrated in Table 6.1, which shows how Vickers-Armstrongs maintained production until May 1944. Vickers produced over 2,500 Valentine tanks at an average of 52 tanks per month across the four years of continuous production. The final two orders were placed during the First Protocol supplies to Russia and were thus permitted to complete instead of being cancelled earlier and capacity transferred to a more recent tank design, as experienced with obsolete tanks discussed in chapters 3 and 4.

Table 6.1 Valentine tank orders with Vickers-Armstrongs, May-39 to May-44¹⁶⁰

Valentine Tanks Ordered	Order Date	First Delivery Date	First Delivery (months)	Final Delivery Date	Output Length (months)	Average monthly tank output	Contract Length (months)
275	May-39	Jun-40	13	Feb-41	8	34.4	21
300	May-40	Feb-41	9	Sep-41	7	42.9	16
250	Dec-40	Aug-41	8	Dec-41	4	62.5	12
755	May-41	Jan-42	8	Dec-42	11	68.6	19
460	Oct-41	Dec-42	14	Jul-43	7	65.7	21
475	Feb-42	Jun-43	16	May-44	11	43.2	27
2,515			68		48	52.4	116

This example is further supported by Appendix 1 for the whole British tank programme from 1939 to April 1945, in which 6,267 Valentine gun tanks were produced representing 19 per cent of the combined output. Whilst the production of Self-Propelled or Duplex-Drive Valentine tanks, discussed in chapter 4 with the transfer of firms to tank adaptations, were evident during 1944 and 1945, these specialist tanks were not part of the programme up to and including 1943 to any great extent. Therefore in terms of overall output from 1940 to 1943, the Valentine was either the principal production vehicle each year or only marginally second to the Matilda in 1940 and later the Crusader during 1942.

¹⁵⁸ N. Y. Zheleznov, 'If your unit still existed, you had to be with it!' in Drabkin and Sheremet, *T-34 in Action*, pp. 156 & 160.

¹⁵⁹ TNA, CAB 120/357, Notes of discussion between Churchill and Duncan, 23 July 1943.

¹⁶⁰ Cambridge University Library, Manuscripts Department, Vickers-Armstrongs, VICKERS 744, 'Armoured Fighting Vehicles 1937 to 1959', 7 September 1959.

As the war continued through 1943 and into 1944, the consistent Russian preference for the Valentine tank, now stipulated in the Third Protocol, gave Britain the freedom to separate the requirements for providing aid to Russia, from the requirements of supplying tanks to the British army. The benefit of this decision was experienced in January 1944 as Britain was preparing for the invasion of Normandy, when an additional 26 Valentine tanks was added to the next Arctic convoy, without adversely affecting 'the equipment of formations in 21 Army Group'.¹⁶¹ The Russian authorities always reconsidered their requirements prior to each protocol agreement and in April 1944 requested that a selection of Cromwell tanks be shipped for examination, before deciding upon a tank requirement for the Fourth Protocol.¹⁶² In response, the Minister of Production Oliver Lyttelton and Grigg agreed that six Cromwells could be shipped to Russia for trial. However any future deliveries were deemed impossible as all production vehicles were 'needed for impending operations', which was clearly in reference to the forthcoming invasion of Normandy.¹⁶³

The prospect of gaining an increase in firepower with six-pounder gun tanks, complemented separate requests by the Russian authorities for high explosive six-pounder shells.¹⁶⁴ This request followed the tactical concern that early six-pounder armed Valentine tanks lacked any machine guns to engage infantry and lightly armoured targets.¹⁶⁵ A high explosive shell was under production for the six-pounder gun with 100,000 rounds already supplied to the Middle East by February 1943.¹⁶⁶ The legitimacy of this programme was clarified during March 1943 at an AFV Liaison Meeting, which confirmed that there was 'still a General Staff requirement for 6-pdr. H.E.'¹⁶⁷ During May, the output of six-pounder high explosive shells was expected to reach 300,000 per month by October, but the realities of mass production meant that front line troops would not receive these shells in meaningful quantities until late December.¹⁶⁸ Despite these intentions this programme could not be fully realised in light of the experience in North Africa, as British tank armament policy now demanded the greater high explosive capability of the new 75 mm tank gun as discussed in chapter 4.

¹⁶¹ TNA, WO 32/10521, Deputy Director, Royal Armoured Corps, Dunphie to ACIGS Evetts, 7 January 1944.

¹⁶² TNA, BT 87/137, Lyttelton to Grigg, 21 April 1944.

¹⁶³ TNA, BT 87/137, Lyttelton to Grigg, 27 April 1944; Grigg to Lyttelton, 29 April 1944.

¹⁶⁴ TNA, WO 32/10521, letter to Kharlamov, 15 December 1942.

¹⁶⁵ TNA, WO 32/10521, Military Mission, Moscow to War Office, 19 February 1942.

¹⁶⁶ TNA, WO 32/10521, DAFV to DGAR, 27 February 1943.

¹⁶⁷ TNA, WO 185/7, '17th A.F.V. Liaison Meeting', 2 March 1943.

¹⁶⁸ TNA, WO 185/7, '24th A.F.V. Liaison Meeting', 11 May 1943.

Whilst increased firepower was certainly important within Russian requirements, the overriding factor was a Russian approach to operational warfare that gave a greater priority to standardised equipment. In respect of aircraft, this selective policy favoured the Hurricane instead of the Spitfire, to reduce the logistical problems of receiving a combination of both.¹⁶⁹ With regard to tanks, in March 1943 the Russian authorities stated that the only six-pounder armed Crusader tanks they required were the 36 being shipped on a trial basis, because to accept any more 'may increase the variety of designs of tanks used in our Army and bring forth the difficulties in mastering them and in operation, and especially in repair'.¹⁷⁰

Furthermore, in response to the understandable concerns regarding the level of armour protection and reliability of the Crusader tank, the Russian authorities were prepared to accept the familiar but lesser armed two-pounder Valentine tank as an alternative.¹⁷¹ Even with the inclusion of these earlier Valentine tanks, the British could not achieve the Second Protocol requirement of 250 tanks per month, and the Crusader tank was the only means of rectifying this shortfall.¹⁷² However, for the Russians to have accepted the Crusader tank would have meant adding another layer of logistical concerns in respect of spares, maintenance and crew training, in addition to the issues regarding reliability and battleworthiness. After April 1943, these considerations were simplified even further by the exclusion of Churchill and Matilda tanks from future shipments with British and Canadian Valentines being the only tanks provided.¹⁷³ Whilst the Churchill and Matilda tanks were no longer shipped, they were still used by the Russians in combat alongside the Valentines, as demonstrated by the various deployments during the Kursk battles in July 1943.¹⁷⁴

In conclusion, the measure of Allied efforts to supply tanks to Russia was demonstrated by the governmental, strategic and industrial factors, which for a long time during the war placed Russian requirements ahead of the simultaneous requirements of the British war effort. To begin with from a political standpoint, the response by Churchill to the German invasion of Russia provided the foundations for the sustained supply of munitions, raw materials and equipment via formal protocols each year until the end of the war. Whilst the Western Allies were unequivocally committed to this programme, Martel considered that the price of each

¹⁶⁹ Beaumont, *British Aid to Russia*, pp. 66-69; Bellamy, *Absolute War*, pp. 422-423.

¹⁷⁰ TNA, WO 32/10521, D. Borisenko, SMM to Firebrace, 22 March 1943.

¹⁷¹ *Ibid.*

¹⁷² TNA, WO 32/10521, 'Tanks for Russia during first six months of 1943', by ASE, 27 March 1943.

¹⁷³ TNA, WO 32/10521, RLG to R.A.C., 30 April 1943; letter to Soloviev, 30 April 1943.

¹⁷⁴ Bellamy, *Absolute War*, pp. 424, 566 & 582.

protocol included the policy of 'appeasement' in which the Russians were never compelled to justify their requests beforehand. Whilst Martel was correct, it is however difficult to argue against the Allied position given the demands on the Eastern Front in terms of the weapons and materials required and furthermore by the, albeit later unrealistic, fear of driving the Russians into a separate peace with Germany.

As the situation on the Eastern Front became more desperate, the importance of the British tank industry and the factory workers was given greater political emphasis and publicity with Lord Beaverbrook's 'Tanks for Russia' week. This propaganda campaign resulted in a strong image of solidarity towards Russia and for the standard of industrial relations. The media reported the events of the week and for sometime after to compare the level of output achieved and to highlight when the tanks were actually shipped to Russia and finally used on the battlefield. The use of tank production as both a propaganda tool for greater output and for helping the Russian war effort was seen later in 1941, with efforts to recruit more women into industry, although conscription was needed before this could be realised.

The success of tank week can be demonstrated by a cursory review of the increase in output during the latter half of 1941, although this chapter also highlights a number of other factors to explain the changes in production. First and foremost, the overall increase in output attributed to tank week was distorted by the initial production stages of the Churchill tank. Secondly, neither the Churchill nor any Cruiser tank was sent to Russia during 1941, but were otherwise included in the figures reported for the campaign. Finally, when compared to the months before tank week, the manufacturers experienced a fall in production during the summer whilst the factories took their annual holiday.

With regard to the different convoy routes used to supply the aid from the Western Allies, the Arctic route was the most dangerous in terms of weather and German interception, the Pacific route had the longest shipping time and threat of Japanese intervention, and the Persian route had the least port capacity and was ultimately superseded by the other routes. Britain was unable to run Arctic convoys alongside any of the parallel demands for Malta, large scale offensive operations overseas, or against the priority given to the Atlantic convoys.

Even with this policy of 'appeasement', Anglo-Soviet relations were not always harmonious as highlighted by the suspension of the Arctic convoys after PQ.17 in July 1942. However, a

similar suspension during 1943 did not have the same negative impact upon the political relationship, as the military and industrial situation in Russia had improved. Shipments from the United States were provided along the other routes during the convoy suspensions, and whilst this resulted in a large shortfall of British deliveries, Canadian Valentine tanks, Bren carriers and raw materials were still provided towards British obligations.

Once Britain had taken over and increased the Valentine contract in Canada to meet the requirement to supply tanks to Russia, Canadian Valentine production greatly assisted British efforts to meet the First and Second Protocol requirements. Whilst the Canadian authorities preferred the American Medium tanks for their own armoured purposes, the output of Valentine tanks from the Canadian Pacific Railway Company began after an impressive 11 months since the original order. The Canadian Valentine programme still experienced the same problems as British and American industry, with delays caused by the time taken to expand industrial capacity, and the shortages of components and available labour. Furthermore, the early production methods lacked the appropriate machinery and equipment required for mass production, although once this had been resolved, more Valentine tanks were produced each month on average in Canada than by Vickers-Armstrongs in Britain.

The strategic considerations for the Western Allies before providing aid to Russia meant that the tanks were unprepared for the severe cold on the Eastern Front. The tanks therefore had to be modified or 'Arcticised' before they could be shipped, although some of the equipment was tested at Canadian winter facilities beforehand. The programme of 'Arcticisation' demonstrated the sheer differences in combat environment when compared to the other theatres of war, and highlighted the extent of Russian understanding to remain operational during the most extreme winter conditions. The necessary 'Arcticisation' continued throughout the war with a ten day delay in Britain before tanks reached port. Likewise, tanks being provided to the Far East went through a process of 'Tropicalisation', which included increasing the level of ventilation within the fighting compartment.

The Allied 'appeasement' towards Russia was also the preferred policy in relation to the supposedly mutual agreement for an exchange of technical equipment and information. Whilst Britain was not immediately compliant with every request from the Russian authorities to view new equipment or have examples shipped for examination, the overriding principle in any restrictions was one of maintaining secrecy or operational prevention. The

reciprocal nature of the agreement was continually disregarded by the Russian authorities and even with improvements in the military situation on the ground, only an intermittent supply of equipment or information was ever received throughout the war.

The supply of tanks to Russia conflicted with Britain's existing programme in equipping armoured units at home and abroad. Light tanks were not provided in large numbers because of production delays and British Cruiser tanks were not requested under the protocols in favour of Matilda, Valentine and Churchill tanks straight from the production line. The Matilda tank could be shipped to Russia without having any detrimental effects on armoured units at home, although some were still needed for the Middle East and Australia during 1942. In contrast, the Valentine tank was needed in large numbers by Britain to equip new armoured divisions and to reinforce the Middle East. A similar situation existed with the Churchill tank, although this vehicle could not be sent to Russia or British tank brigades overseas until the summer of 1942 when reliability had improved. Britain had to provide more tanks than anticipated during the First Protocol to cover the shortfall from American industry. However this was not due to a lack of priority in the United States, as demonstrated by the cancellation of Light tanks to Australia early in 1942 so that these vehicles could be supplied to the Eastern Front instead. These strategic concerns were removed after April 1943, once the Valentine became the only tank to be provided under the protocol and that Britain no longer required the Valentine except for specialist roles.

The Russian preference for the Valentine tank was based upon the greater tactical performance and Russian operational doctrine that insisted upon standardised equipment to ensure similarity in tank instruction, training, spare parts, maintenance and repair in the field. Adherence to this doctrine was demonstrated when the Russian authorities rejected six-pounder armed Crusader tanks by opting for the continued supply of outdated two-pounder Valentine tanks instead. As demonstrated by Vickers, the British tank programme kept pace with the Russian demand for the Valentine tank, with continuation orders that maintained production long after this tank was obsolete. Ultimately, Valentine production represented 19 per cent of Britain's entire tank programme during the war with more Valentine tanks produced than any other tank from 1940 to 1943.

Overall the Western Allies supplied a large amount of aid to the Russian war effort and maintained this support by overcoming the persistent difficulties without serious disruption.

These obstacles included: the different supply routes to Russia; the other demands on shipping capacity; supplying the same equipment to home and overseas commitments; and the general imbalance in the receipt of technical information with Moscow. The emphasis upon supplying tanks to the Eastern Front was first highlighted by 'Tanks for Russia' week. This evolved into Britain and Canada concentrating upon producing the Valentine tank in accordance with Russian requests to maintain their doctrine of standardised equipment.

Conclusion

This study has provided a greater analysis of the governmental, strategic and industrial influences that affected British tank production from rearmament until the end of the Second World War, as part of a case study of a planned economy at war. This has been achieved by reviewing the material held within numerous national, local and commercial archives which historians have not previously considered in covering the same subject matter. The research has examined the experiences of British tank firms against the different pressures of war, whilst providing greater international context by comparing the British tank programme against the wartime requirements in Canada, the United States and Russia.

In general, whilst the British tank programme was rightfully hindered before the war, a policy of quantity production was introduced at the start of 1937 and pursued into 1942 with the successful introduction of new tank firms across a variety of civilian industries. The serious problems relating to tank reliability and combat effectiveness were unavoidable if the army was to receive any tanks, against the overriding priority given to aircraft production, the necessity of providing tanks to Russia, and before Britain could fully benefit from American industry. The transfer to quality tank production from 1943 onwards was measured by the centralised control brought about by the executive fifth Tank Board, the concentration of effort by fewer tank firms, the higher rate of output for the latest British tank designs under assembly, and finally the operational superiority of these tanks on the front line.

More specifically, this study has shown that the organisational relationship between the 'user' and the 'supplier' within the tank programme evolved over the period under discussion to meet the expected demands upon industry, in accordance with the changes in political and strategic outlook. To begin with, the start of rearmament in 1934 centralised the control and technical direction of tank development under the Director of Mechanization, following the transfer of authority from the Mechanical Warfare Board to the Mechanization Board. The decision to instigate a 'serious' policy of rearmament during 1936 introduced the Director-General of Munitions Production to link together General Staff requirements with the capabilities of industry. Upon assuming the responsibilities of the Master-General of the Ordnance in 1938, the DGMP became the principal authority in supplying the tank programme and by mid-1939 the department had transferred from the War Office to the new Ministry of Supply.

The increased programme of munitions production following the outbreak of war created the Director-General of Tanks and Transport, followed by the formation of the Tank Board in response to the perceived inadequacies of the Chamberlain government. General Staff requirements were brought even closer to the industrial capacity available when each new Minister of Supply changed the authority and organisational structure of the Tank Board. These successive transformations were in response to the strategic priorities that first required the tank industry to concentrate upon quantity output, then carry out essential modifications to existing tanks, and finally introduce new designs as part of the emphasis upon quality. From 1942 the relationship between the 'user' and 'supplier' became synchronized when the Secretary of State for War and the Minister of Supply formulated tank policy on a joint basis, as part of the greater centralisation of the British war economy. The implementation of these macro decisions were carried out by the Armoured Fighting Vehicle Division, which had the executive authority to make micro adjustments to the tank programme. This achieved the necessary synthesis between tactical and production planning which Oliver Lyttelton had highlighted in the introductory chapter as so essential for successful war production.

By reviewing the company archives this study has provided a series of case examples to demonstrate the impact of introducing civilian industry to an emerging and expanding tank programme, against the different pressures of rearmament and fighting a world war. With regards to factory alterations, tank firms introduced air raid precautions in response to the heightened political tensions on the Continent during 1938, and then continued with these efforts throughout the war. Industry avoided the full cost of the increase in capacity necessary for the mass production of the latest Light tank and the Infantry and Cruiser programmes, although the government ensured that these improved facilities were not wholly subsidised by the taxpayer. The geographical locations of the 27 tank firms reflected the greater industrial strength of the Midlands, the North East and North West, with all the firms representing the motor, heavy engineering, agricultural and locomotive industries. The reduction in the tank programme from 1943 onwards meant that some tank firms were moved onto tank adaptations or non-tank work, whilst the government and industry as a whole began the necessary planning for the eventual transfer to civilian production after the war.

In addition to the effects upon individual firms, the archives of industry have provided a further understanding of the experiences of the workers in achieving the demands for increased tank output and greater productive efficiency on the assembly line. To begin with,

in addition to the process of dilution and de-skilling to increase the skilled workforce, tank firms received workers from the Air Ministry and transferred labour between firms on a short-term basis to temporarily boost output. The introduction of women into the workplace compelled firms to provide additional welfare facilities and female conscription permitted firms to operate continuously for seven days a week, although tank Parent firms were reluctant to lose their female administrative staff. Once British tanks had become operationally effective on the front line, the praise from the armoured commanders, the General Staff, and the Ministry of Supply was displayed within the factories to ensure that the workers received credit for their good quality workmanship.

As demonstrated by this study, the annual factory holiday reduced worker tiredness and thus the number of industrial accidents, whereas the marked fall in output became noticeable because the forecast consistently failed to take this predictable interruption into account. A similar reduction in tank output was also sustained during periods of strike action, although these effects were limited when compared against the size of the tank programme as a whole. Finally, the expansion of tank welding within factories introduced male and female workers to new skills, but the concentration of fumes and the lack of suitable ventilation meant an increase in absenteeism and additional shifts to maintain the required rate of output.

In respect of the requirements from the 'user', this study has demonstrated how the General Staff altered the tank programme based upon the experience gained on the battlefield throughout the war. Eventually British tank production achieved the Allied requirement of operational mobility to fight an offensive war, compared to the heavy German tanks that fought strategically defensive battles with fewer numbers and insufficient range. Whilst the General Staff sought improved reliability, greater armour protection and increased firepower in British tanks, these qualities were not provided by industry in sustainable numbers until late 1942 with the Churchill tank, in 1944 with the Cromwell tank, and early in 1945 with the Comet tank. This study has established the reasons to account for these deferments within the overall transformation of the tank programme from quantity to quality output.

First of all, the explicit priority of war production was given to aircraft during rearmament until November 1941 when tank production was placed on an equal basis, although the demand for the Merlin aero-engine delayed the introduction of the Meteor tank engine until 1943. Upon receiving the first tank order, firms took between 13 and 16 months before

delivering their first tank, compared to 11 months by both Chrysler Corporation for the M3 Medium and Canadian Pacific Railway for the Valentine tank. This study has illustrated that the effects of bombing in addition to shortages of labour and materials for the completion of new factories, contributed to the extra time required by British industry. The problem of component shortages affected the tank programme by causing a reduction in monthly output and could delay the transfer of production to a later tank design by a couple of months.

A contradiction in government policy highlighted during this study was that the General Staff demand for a high percentage of reliable tanks was incompatible with the policy of quantity production that neglected the supply of spare parts necessary to maintain these vehicles. Whilst this problem was overturned from 1943 onwards, the standard of official inspection within factories only viewed the completed tank instead of the different stages of assembly such as with aircraft production, therefore permitting some faults on the assembly line to be overlooked. Furthermore, this study has illustrated that in addition to modifications to tank design, the increased reliability of British tanks was supported by improvements in crew maintenance, which meant fewer occasions to repair the vehicle and thus contaminate the mechanical components. Finally, when compared to the servicing requirements for British motor cars before and after the war, the reliability of British tanks was actually rather impressive when considering the vastly different operational usage.

The principal reason why continuation orders were placed without having a General Staff requirement was because an enforced cancellation of the programme would have resulted in a break in production, whilst quantity output was demanded from industry. When the tank programme focused upon quality production from 1943 onwards, the loss of output caused by the elimination of obsolete tanks was accepted, as more tanks were received from the United States. The Valentine tank continued in production until 1944 despite becoming obsolete, because it fulfilled General Staff requirements for the first half the war and then met the Russian demand for standardised equipment for crew training, operations and spare parts.

The final influence upon the British tank programme reviewed during this study concerns the requirements of obtaining tanks from the strategically secure production facilities of North America, whilst British industry simultaneously supplied tanks to the Russian war effort. To begin with, British cash contracts during 1940 funded the enlargement of industrial capacity in some American firms before these factories contributed towards the large number of tanks

produced under Lend-Lease. Whilst British units welcomed American tanks in the Middle East, many vehicles only became operationally effective after the field workshops had rectified the production faults and cannibalised new tanks to reverse the lack of spare parts. Britain became over-dependent upon the supply of American tanks from 1943, however this permitted British industry to concentrate upon improving the Cromwell tank without the pressure of having to deploy this vehicle prematurely.

The importance of the Russian war effort was highlighted in Britain by 'Tanks for Russia' week, although the publicised success of this propaganda campaign was greater than the actual number of extra tanks provided to the Eastern Front. The Australian archives have demonstrated that the priority given to the supply of American tanks to Russia superseded the requirement to provide similar tanks for the defence of Australia against possible Japanese attack. The Canadian archives have demonstrated that large numbers of Valentine tanks were provided to Russia by Canadian industry, against the initial problems of inefficient production methods and shortages in components and skilled labour. Finally, the severe winter conditions on the Eastern Front was illustrated by the extraordinary series of modifications necessary to Arcticise the tanks before they could be used by the Red Army.

Overall, British industry achieved the demands of the government to provide the mass production of tanks during the first half of the war, and then successfully modified the tank programme to quality production for the requirements during the second half. This transition was completed by the concentration of centralised tank policy amongst the 'user' and 'supplier' branches of government, alongside the greater control of war planning within the war economy. Ultimately, the British tank programme adapted in accordance with the changing strategic situation that required tanks to fulfil a mobile offensive role, whilst simultaneously meeting the obligations to Russia and receiving the support from Allied production overseas.

Appendix 1**Table 1.1 British tank production activity¹**

	Up to 1939	1940	1941	1942	1943	1944	Up to Apr-45	Total
Light Mark VI ²	1182	140						1322
Tetrarch ³		15	73	12				100
Harry Hopkins ⁴				6	30	56	12	104
A.11 Infantry	106	33						139
Matilda	24	361	1040	1330	153			2908
Valentine		354	1621	2214	1798	280		6267
Valentine SP						349	178	527
Valentine DD						247		247
Churchill			690	1731	1360	495		4276
Heavy Churchill					4	567	346	917
A.9 Cruiser	76	49						125
A.10 Cruiser	1	159	10					170
Cruiser III	65							65
Cruiser IV	8	257	5					270
Covenanter		9	746	986	29			1770
Crusader		2	652	2340	1684			4678
Crusader Hulls					239			239
Cavalier					375	105		480
Cavalier OP						17		17
Centaur				2	1252	274		1528
Centaur AA						149		149
Centaur Bulldozer						74	23	97
Cromwell X / III					111			111
Cromwell				1	421	1935	79	2436
Challenger						145	47	192
Comet						143	480	623
Sherman DD						693		693
Sherman 17-pdr						1783	291	2074
M-10 17-pdr						790	225	1015
Total Light	1182	155	73	18	30	56	12	1526
Total Infantry	130	748	3351	5275	3315	1342	346	14507
Total Cruiser	150	476	1413	3329	3872	2602	606	12448
Total Conversion	0	0	0	0	239	4102	717	5058
All Total	1462	1379	4837	8622	7456	8102	1681	33539

NB: The figures for 1942 and 1943 have a +/- 15 tanks margin of error following a potential overlap of the reporting for December 1942 and January 1943 with the change from source AVIA 46/188 to CAB 120/355.

¹ For 1939 to 1942 Cruiser and Infantry tanks: TNA, AVIA 46/188, 'Monthly Deliveries on Infantry and Cruiser Tanks by Firms, 1939-1943', draft official history narrative by D. Hay, after 1950, pp. 269-271; For 1943: CAB 120/355, 'A.F.V. Production'; For 1944 and 1945: CAB 120/356, 'A.F.V. Production'.

² Light Mark VI up to 30 June 1940: TNA, AVIA 46/188, 'Deliveries to 30.6.40', p. 65.

³ For Tetrarch: Cambridge University Library, Manuscripts Department, Vickers-Armstrongs, VICKERS 717, 'Summary of War Production for 5 years', 6 February 1945.

⁴ For Harry Hopkins, 1942 to 1944: Ibid; For 1945: TNA, CAB 120/356, 'A.F.V. Production'.

Table 1.2 British tank production activity by percentage

	Up to 1939	1940	1941	1942	1943	1944	Up to Apr-45	% of Total
Light Mark VI	80.8	10.2						3.9
Tetrarch		1.1	1.5	0.14				0.3
Harry Hopkins				0.07	0.4	0.7	0.7	0.3
A.11 Infantry	7.3	2.4						0.4
Matilda	1.6	26.2	21.5	15.4	2.1			8.7
Valentine		25.7	33.5	25.7	24.1	3.5		18.7
Valentine SP						4.3	10.6	1.6
Valentine DD						3.0		0.7
Churchill			14.3	20.1	18.2	6.1		12.7
Heavy Churchill					0.1	7.0	20.6	2.7
A.9 Cruiser	5.2	3.6						0.4
A.10 Cruiser	0.07	11.5	0.2					0.5
Cruiser III	4.4							0.2
Cruiser IV	0.5	18.6	0.1					0.8
Covenanter		0.7	15.4	11.4	0.4			5.3
Crusader		0.1	13.5	27.1	22.6			13.9
Crusader Hulls					3.2			0.7
Cavalier					5.0	1.3		1.4
Cavalier OP						0.2		0.1
Centaur				0.02	16.8	3.4		4.6
Centaur AA						1.8		0.4
Centaur Bulldozer						0.9	1.4	0.3
Cromwell X / III					1.5			0.3
Cromwell				0.01	5.6	23.9	4.7	7.3
Challenger						1.8	2.8	0.6
Comet						1.8	28.6	1.9
Sherman DD						8.6		2.1
Sherman 17-pdr						22.0	17.3	6.2
M-10 17-pdr						9.8	13.4	3.0
Light %	80.8	11.2	1.5	0.2	0.4	0.7	0.7	4.5
Infantry %	8.9	54.3	69.3	61.2	44.5	16.6	20.6	43.3
Cruiser %	10.3	34.5	29.2	38.6	51.9	32.1	36.0	37.1
Conversion %	0.0	0.0	0.0	0.0	3.2	50.6	42.7	15.1
								100.0

Key: AA Anti-Aircraft
DD Duplex-Drive
OP Observation Post
SP Self-Propelled
X / III Centaur tank fitted with Meteor engine

Appendix 2**Table 2 Tank Engines under experimentation and trial from 1934 to 1940¹**

Tank Class and Mark	Weight (Tons)	Engine Manufacturer	Fuel Type	Maximum H.P.	Mechanization Board Report
Light					
Mark II, IIA, IIB		Rolls Royce	Petrol	20/25	1934-36
Mark III		Ford	Petrol	81	1935-36
Mark IV		Meadows	Petrol	105	1934-36
Mark V		Meadows	Petrol	105	1934-36
		Armstrong Whitworth-Kadenacy	Petrol	96	1935-38
		Perkins Wolf	Diesel	88	1938-40
Mark VI, VIA		Meadows	Petrol	105	1934-36
		Armstrong Whitworth-Kadenacy	Petrol	96	1935-38
Mark L4.E1		Meadows	Petrol	105	1934-36
Mark VII	7.00	Meadows	Petrol	180	1940
Mark VIII	8.75	Meadows	Petrol	180	1940
Medium					
Mark I		Armstrong Siddeley	Petrol	90	1934-35
Mark II**		Armstrong Siddeley	Petrol	90	1934-35
Mark III	16.00	Armstrong Siddeley	Petrol	180	1934-35
A6.E3	16.00	Armstrong Siddeley	Petrol	180	1934-35
A7.E1 & E2	18.20	Armstrong Siddeley	Petrol	120	1934-35
A7.E3	18.20	Associated Equipment Company	Diesel	126	1934/36
A8.E1	17.50	Rolls Royce	Petrol	133	1934-35
Cruiser					
A.9 Mark I	12.50	Rolls Royce	Petrol	133	1934-35
	12.50	John Fowler & Co (Leeds)	Diesel	80	1938-40
	12.50	Associated Equipment Company	Petrol	200	1940
A.10 Mark II	13.75	Rolls Royce	Petrol	133	1934-35
	13.75	John Fowler & Co (Leeds)	Diesel	80	1938-40
	13.75	Associated Equipment Company	Petrol	200	1940
A.13 Mark IV	18.00	Nuffield Liberty	Petrol	350-411	1936-40
A.13 Covenanter	16.00	Meadows	Petrol	282	1940
A.15 Crusader		John Fowler & Co (Leeds)	Diesel	375	1940
Infantry Tank					
A.11 Mark I		Ford	Petrol	81	1935-36
A.12 Matilda		Associated Equipment Company	Diesel	100	1937-38
		John Fowler & Co (Leeds)	Diesel	80	1938-40
		Leyland Motors	Diesel	96	1938-40
		Perkins Wolf	Diesel	120	1938-40

¹ TNA, WO 194/57, First to Sixth and Final Report of the Mechanization Board, 1934 to 1940.

Appendix 3

Table 3 Total production for each tank model by each firm, up to 1939-1942¹

Name of Tank Firm (Alphabetically)	Light Mark VI	A.9 Cruiser	A.10 Cruiser	Cruiser Mark III	Cruiser Mark IV	Covenanter	Crusader	A.11 Infantry	Matilda	Valentine	Churchill	Total by Firm
Beyer Peacock											178	178
Birmingham Railway			75							1202	127	1404
Broom & Wade											219	219
Charles Roberts & Co											108	108
Crabtree			10									10
Dennis Bros											205	205
English Electric						1088						1088
Fodens							488					488
Gloucester Railway											235	235
Harland & Wolff		75							275		73	423
John Fowler & Co	88								578			666
Leyland Motors						494					394	888
London Midland Scot					30	159			400			589
Lysaght							184					184
M.G. Cars							230					230
Mech. & Aero				65	240		841					1146
Metro-Cammell			75							1381	284	1740
Milners Safes							195					195
Morris Commercial							305					305
Morris Ind. Exports							87					87
Newton Chambers											291	291
North British Loco	147								545			692
Ruston & Hornsby	100								400			500
Ruston-Bucyrus							276					276
Vauxhall Motors											307	307
Vickers-Armstrongs	743	50	10					139		1606		2548
Vulcan Foundry	244								557			801
West's Gas Improve							388					388
Total by Tank	1322	125	170	65	270	1741	2994	139	2755	4189	2421	16191

Key: Parent Firm

¹ TNA, AVIA 46/188, 'Monthly Deliveries', pp. 269-271

Appendix 4

Table 4 Index of major tank contractors by location, identifying the components required for each tank programme, as at April 1941¹

Town or City	Contractor	Covenanter	Crusader	Matilda	Valentine	Churchill	Tank Component	
Abingdon	M.G. Cars		X				Tu	
Bath	Stothert & Pitt	X	X			X	GM	
Bedford	Britannia Iron & Steel Works	X	X				Tr	
Belfast	Harland & Wolff			X			SU/FD	
	Harland & Wolff				X		GM	
Billingham	Davy & United Steel Co			X			AP	
Birmingham	Austin Motor Co					X	E, SU/FD, S	
	Ericsson Eng. Works		X				GM	
	J. Lucas & Co				X	X	PT	
	Mechanization & Aero		X				E, GB, S, Tu, GM, SMM	
	Morris Motors (Pressings)					X	Tr	
	Parkinson Gas Stove Co					X	Tr	
	Radiation	X	X				Tr	
	Wolseley Motors		X				S	
	Bradford	Crofts	X					BP
		English Electric	X					S, Tu
Jowett Cars			X		X		GM	
Knowles & Co		X					BP	
Coventry	Armstrong-Siddeley			X			GB	
	Daimler Ltd	X	X				SU/FD	
	Morris Motors (Engines)		X				E, GB, Tr	
	Self-Changing Gear			X			GB	
	Self-Changing Gear	X				X	SU/FD	
Crewe	London Midland Scottish			X			SU/FD	
Darlington	Stephenson & Hawthorn				X		S	
Derby	Leys Malleable Castings	X	X				Tr	
	London Midland Scottish	X					Tu	
	Qualcast Ltd	X	X				Tr	
Doncaster	L.N.E. Railway Co		X				GM	
Dunstable	Bagshawe & Co	X	X				Tr	
Eastbourne	Howard Pneumatic Eng. Co				X		SMM	
Falkirk	Carron Iron Works					X	Tr	
	Federated Foundries					X	Tr	
	Harland Eng. Co	X					BP	
Glasgow	London Midland Scottish			X			SU/FD	
	Mirrlees, Watson & Co	X	X				GM	
	North British Locomotive			X			SU/FD	

¹ TNA, AVIA 22/454, 'Major Tank and Tank Component Contractors', 11 April 1941.

Town or City continued	Contractor	Covenanter	Crusader	Matilda	Valentine	Churchill	Tank Component
	Singer Mftg Co					X	Tr
	W. Beardmore & Co		X	X		X	AP
Guildford	Dennis Bros	X					S
Hove	Edwards Clifford & Co	X	X				SMM
Huddersfield	David Brown & Co					X	GB
Ketley	Allied Ironfounders					X	Tr
Kilmarnock	A. Barclay & Sons	X	X		X		SMM
Leamington Spa	Ford Motor Co					X	Tr
Leeds	J. King & Co	X	X				Tr
	Oxley Engineering	X					Tu
	R.W. Crabtree & Co				X		SU/FD
Leyland	Leyland Motors	X		X			E
	Leyland Motors	X		X	X		SU/FD
	Leyland Motors	X					Tu
Lincoln	Harrison & Co	X	X				Tr
	Ransomes, Sims & Jeffries		X				S
	Robey & Co			X			GM
	Ruston & Hornsby Ltd	X	X	X			Tr
	Ruston-Bucyrus		X				Tu
Liverpool	Laystall Eng. Co	X	X				Tr
London	Ford Motor Co	X	X	X		X	Tr
	Powered Mountings	X	X	X			PT
Loughborough	Brush Electrical Co			X		X	GM
Luton	Davis Gas Stove		X				Tr
	Vauxhall Motors					X	E, SU/FD, S
Maidstone	Tilling Stevens					X	GM
Manchester	Crossley Bros		X		X		GM
	West's Gas Improvement Co		X				S, Tu
Meltham	David Brown & Co	X				X	GB
	David Brown & Co	X					SU/FD
Middlesborough	S. Durham Iron & Steel Co		X				AP
Motherwell	Clyde Alloy Steel	X	X	X	X	X	AP
	Colvilles			X		X	AP
Newcastle-upon-Tyne	Vickers-Armstrongs				X		Tr
Oakengates	J. Maddocks & Co	X	X				Tr
Oxford	Morris Motors		X				SU/FD
Paisley	Fullerton Hodgart & Barclay				X		GM
Penistone	David Brown & Co	X		X	X		AP
Ripley	Butterfly Co					X	Tr
Sandbach	Fodens		X				Tu, S
Sheffield	Allen Edgar & Co		X	X			AP
	English Steel Corporation	X	X	X	X	X	AP
	H. Johnson Foster	X	X				AP
	Hadfields	X		X			AP
Sheffield	S. Osborn & Co	X	X	X			AP

Town or city continued	Tank Contractor	Covenanter	Crusader	Matilda	Valentine	Churchill	Tank Component
	Thomas Firth & John Brown					X	Tr, AP
Southall	AEC				X		E
	AEC			X			GB
Swindon	G.W. Railway Co			X			SU/FD
Tipton	Beans Industries			X	X		SU/FD
	W.G. Allen		X				Tu
Wakefield	Hyland	X	X				SMM
Ware	D. Wickham Co				X		GM
Warrington	Owen Rubery	X	X				SMM
Wednesbury	F.H. Lloyd & Co					X	Tr
	F.H. Lloyd & Co	X	X	X		X	AP
Wolverhampton	Chubb & Sons, Lock & Safe		X		X		SMM
	Chubb & Sons, Lock & Safe					X	GM
	Crane Foundries	X	X				Tr
	Henry Meadows & Co				X		SU/FD
	Henry Meadows & Co	X					E
	Henry Meadows & Co	X			X		GB

Key:

AP	Armour castings, armour plate or bullet proof plate
BP	Machining bullet proof plate
E	Engines
GB	Gear boxes
GM	Gun mountings
PT	Power traverse
SU/FD	Steering unit and final drive
SMM	Smoke mortar mountings
S	Suspension
Tu	Turret
Tr	Tracks
X	Component applicable to each tank programme

Appendix 5

Table 5 **Changing nature of Government policy towards factory enhancements during the war, as illustrated by a sample of tank production orders**

Procedure Agreed between Ministry and Firm	Firm	Date of Seal	Plant and Equipment	Building Work
a) Government grant as a percentage of the total cost.	Metropolitan-Cammell ¹	Jul-40	£12,900	
		Jul-40	£28,697	
		Jul-40	£140,000	
b) Ministry to buy additional plant and equipment from the company within 3 years.	Mechanization & Aero ²	Aug-40	£192,000	
c) 60% reimbursement, with the company retaining ownership of new equipment.	Gloucestershire Railway ³	Oct-40	£25,680	
d) Full reimbursement, with option for company to buy equipment at termination of agreement.	Morris Commercial Cars ⁴	Sep-41	£7,000	
		Aug-42	£270,188	
		Sep-42	£85,790	
		Dec-43	£2,120	
	Mechanization & Aero ⁵	Aug-42	£40,080	
		Nov-42	£14,050	
		Dec-43	£15,213	
Nuffield Exports ⁶	Dec-44	£2,812		
e) Company to pay the Ministry the value of building enhancement at termination of agreement.	Morris Commercial Cars ⁷	Aug-42		£2,250
		Sep-42		£1,450
	Nuffield Exports ⁸	Dec-44		£5,525
f) Ministry pays 50% of building work which the Company owns outright.	Mechanization & Aero ⁹	Apr-45		£5,997
			£836,530	£15,222

¹ Birmingham Archives and Heritage, Birmingham Central Library, Metropolitan-Cammell, MS 99/2006/024, '567: Machine Tools for Tanks', 17 July 1940.

² Modern Records Centre, Warwick, Nuffield Mechanization & Aero, MSS.226/NM/1/1/1, Directors' meetings, 1935-1944, 10 August 1940.

³ Gloucestershire Archives, Gloucester, Gloucester Railway Carriage & Wagon Company, D 4791/6/19, Directors' Minute Books, 1939-1944, '375. Capital Expenditure', 25 October 1940.

⁴ MRC, Morris Commercial Cars, MSS.226/MC/1/3, Directors' and general meetings, 22 September 1941; 28 August 1942; 8 September 1942; 3 December 1943.

⁵ MRC, MSS.226/NM/1/1/1, 10 August 1942; 17 November 1942; 22 December 1943.

⁶ MRC, Nuffield Exports, MSS.226/NE/1/1/1, Minutes of Directors' meetings, 1933-1948, 21 December 1944.

⁷ MRC, MSS.226/MC/1/3, 28 August 1942; 8 September 1942.

⁸ MRC, MSS.226/NE/1/1/1, 21 December 1944.

⁹ MRC, MSS.226/NM/1/1/2, Directors' meetings, 1945-1947, 17 April 1945.

Appendix 6**Table 6** Changes in British tank capacity, 1942 to 1945¹

	Tank Firm	Tank Work 1942	Changes to Tank Work 1943-1945	Changes to Tank Conversions or Non Tank Work 1943-1945
1	Beyer Peacock	Churchill		Locomotives
2	Birmingham Railway	Valentine / Churchill	Cromwell / Challenger	Engineering Stores
3	Broom & Wade	Churchill	Churchill	
4	Charles Roberts	Churchill	Churchill	
5	Dennis	Churchill	Churchill	
6	English Electric	Covenanter	Centaur / Cromwell / Comet	
7	Fodens	Crusader	Centaur	Wheeled Vehicles
8	Gloucester Railway	Churchill	Churchill	
9	Harland & Wolff	Matilda / Churchill	Centaur	Admiralty
10	John Fowler	Matilda	Centaur / Cromwell / Comet	
11	<u>Leyland Motors</u>	Covenanter / Churchill	Centaur / Cromwell / Comet	
12	<u>London Midland Scottish</u>	Matilda / Covenanter	Centaur	Locomotives
13	Lysaght	Crusader		Sherman DD
14	M.G. Cars	Crusader		Churchill AVRE
15	<u>Mechanization & Aero</u>	<u>Crusader</u>	<u>Cavalier</u> / Centaur	Centaur AA
16	Metropolitan-Cammell	Valentine / Churchill	Cromwell / Comet	Valentine DD / Sherman DD
17	Milner's Safe	Crusader		Sherman 'Crab' Flail
18	Morris Commercial Cars	Crusader		Wheeled Vehicles
19	Morris Industries Exports	Crusader		Crusader AA
20	Newton Chambers	Churchill	Churchill	
21	North British Locomotive	Matilda		Locomotives
22	Ruston & Hornsby	Matilda	Cavalier	Crusader Towing Vehicles
23	Ruston-Bucyrus	Crusader	Centaur	Engineering Stores
24	<u>Vauxhall Motors</u>	Churchill	<u>Churchill</u>	
25	<u>Vickers-Armstrongs</u>	Valentine	<u>Valentine</u>	
26	<u>Vulcan Foundry</u>	<u>Matilda</u>		Locomotives
27	West's Gas	Crusader	Centaur	Crusader AA

Key: — Parent Firm AVRE Armoured Vehicle Royal Engineers
 AA Anti-Aircraft DD Duplex-Drive

¹ TNA, AVIA 22/454, 'Centaur/Cromwell Planning', 9 November 1943; AVIA 22/454, 'Tank Capacity', 28 October 1944.

Appendix 7**Table 7 Tank orders and maximum potential capacity at March 1942 and Tank production in the United States by facility, 1940-1945¹**

Tank Assembly Firm		Planned Monthly Output at March 1942	On Order at March 1942	Total Production 1940-1945	Percentage of Total Output
Chrysler Detroit Tank Arsenal		1000	8752	22234	25.2
American Car and Foundry	b	1000	12520	15224	17.2
Fisher Tank Arsenal	b	500	2625	13137	14.9
Cadillac Motor Company		1500	3266	10142	11.5
Pressed Steel		400	2601	8648	9.8
Pullman-Standard	a	400	2600	3926	4.4
American Locomotive Works		150	1685	2985	3.4
Baldwin Locomotive Works	b	300	2615	2515	2.9
Massey Harris Company		100	500	2473	2.8
Ford Motor Company	a	500	2350	1690	1.9
Lima Locomotive	a	200	1055	1655	1.9
Montreal Locomotive Works		250	2457	1144	1.3
Marmon-Herrington	b			1070	1.2
Pacific Car and Foundry	a	150	925	926	1.0
Federal Machine		100	650	540	0.6
Rock Island Arsenal				94	0.1
International Harvester				7	0.01
Total		6550	44601	88410	100.00

Key: a Ceased tank work during final quarter 1943
b Ceased tank work during 1944

¹ Heritage Motor Centre Motor Museum, Gaydon, Papers of Sir Miles Thomas, 80/20/1/5 & 6/4, Tank Engine Mission to USA, 'Appendix A to U.S. Tank Committee Plan', 30 March 1942; H. C. Thomson and L. Mayo, *United States Army in World War II, The Technical Services, The Ordnance Department: Procurement and Supply* (Washington, Department of the Army, 1960), reprinted 1968, pp. 242 & 256-257.

Appendix 8

Table 8 Major items supplied to the USSR between 1-Oct-41 and 31-Mar-1946¹

1. *Military Supplies* (British Protocol deliveries unless otherwise stated)

(a) Army

Mechanised / Motorised	Total	British	Canadian	United States
All Tanks	12,755	3,830	1,388	7,537
All Vehicles, Lorries and Jeeps	431,729	4,343		427,386
Bren Carriers, Charging and Starting	2,560	1,212	1,348	
Motor Cycles	36,891	1,721		35,170
Tyres	3,858,000	72,000		3,786,000

(b) Navy

Ships:	Total
Battleship	1
Destroyers	9
Submarines	4
Motor mine-sweepers	5
Mine-sweeping trawlers	9

(c) Air

Aircraft:	Total	British	United States
All types	22,206	4,282	17,924
Aircraft Engines		976	

2. *Raw Materials, Foodstuffs, Industrial Plant* (British Protocol deliveries unless otherwise stated)

Raw Material:	Total	British	Canadian
Aluminium (tons)	32,000	2,000	30,000
Copper (tons)	40,000	13,000	27,000
Total value and other raw materials	£47,841,000		

Foodstuffs:	British	United States
Total value of all	£8,210,000	\$1,312,000,000

Industry:	Total
Machine Tools	£13,081,000
Power Plant	£12,264,000
Electrical Equipment	£9,091,000
Various machinery	£4,691,000
Miscellaneous industrial equipment	£5,201,000
Total value and other minor items	£45,616,000

¹ For United Kingdom and Canada: Prime Minister Clement Attlee to House of Commons in *Parliamentary Debates*, vol. 421, cols. 2516-2519, 16 April 1946; For the United States: B. B. Schofield, *The Russian Convoys* (London, Batsford, 1964), pp. 213-214.

Appendix 9**Table 9 Canadian tank production, 1941 to 1944¹**

Tank	Manufacturer	Production Dates	Total Output
Valentine	Canadian Pacific Railway	1941-1943	1420
RAM I & II	Montreal Locomotive Works	1941-1943	1949
Grizzly	Montreal Locomotive Works	1943	188
Command / OP	Montreal Locomotive Works	1943	84
Sexton SP	Montreal Locomotive Works	1943-1945	2150
AA Quad Skink	Montreal Locomotive Works / Waterloo Manufacturing Co.	1944	3
TOTAL			5794

¹ Historical Section, Army Headquarters, Report No. 38, 'Tank Production in Canada', 27 July 1950, p. 1, found in National Defence and the Canadian Forces at <http://www.forces.gc.ca/site/home-accueil-eng.asp>, accessed 30 September 2010.

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| CAB 66/26/47 | Supplies to Russia: Memorandum by the Secretary of State for Foreign Affairs, 1942 |
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| CAB 67/8/7 | Holidays: Memo circulated by Minister of Labour and National Service, 1940 |
| CAB 68/2/39 | Supply and Production: Third Monthly Report, 1939 |
| CAB 68/3/29 | Supply and Production: Fourth Monthly Report, 1939 |
| CAB 68/4/27 | Supply and Production: Fifth Monthly Report, 1940 |
| CAB 68/5/14 | Supply and Production: Sixth Monthly Report, 1940 |
| CAB 68/5/51 | Supply and Production: Seventh Monthly Report, 1940 |
| CAB 68/6/7 | Supply and Production: Eighth Monthly Report, 1940 |
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| CAB 98/20 | Tank Parliament, 1941 |
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CAB 120/358	Tanks: production and allocation, 1945
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