WARS AND THE RISE OF INDUSTRIAL CIVILIZATION, 1640-1740[1]

ECONOMIC historians are faced with the task of reconsidering modern European history as a whole. No age is more in need of reinterpretation than the hundred years or so which began in England with the outbreak of the Civil War and in France with the accession of the infant Louis XIV. Tawney, his associates, and pupils have revealed the main features of English agrarian, industrial, commercial, and financial development in early modern times. With the copious data provided in the nineteenth and early twentieth centuries, Clapham, his associates, and pupils have built recent English economic history into a solid edifice on massive and precise statistical foundations. But Continental and British economic history have still to be brought into appropriate relationship to each other. And even in modern English economic history, an unfilled gap of more than a century remains. The materials that have been thrown into it are inadequate from about 1640 down to 1740, the year in which the war of the Austrian Succession broke out. The task of arranging such materials as are available into a durable pattern has not been seriously faced. So our knowledge of the place of these hundred years in the rise of industrialism both in Great Britain and on the Continent is vague.

In attempting to make that place clearer, even by the roughest sort of sketch, a scholar does not serve truth by keeping the economic sides separate from the rest of history. The opportunity to rewrite economic history affords an opportunity to write integral history. Among the strands (usually examined independently) that need to be interwoven,

[1]The research in connection with this subject has been undertaken with the help of funds generously provided by the Social Science Research Council. The present essay is concerned mainly with the interrelations between wars and the progress of science and invention. It is part of a larger study of wars and the rise of European industrial civilization from the Reformation to the twentieth century. Two versions of an earlier essay, dealing with an earlier period, are already in print ("War and Economic Progress, 1540-1640," by J. U. Nef, *Economic History Review*, vol. XII, 1942, pp. 13-38; and "War and the Early Industrial Revolution," in *Economic Problems of War and Its Aftermath*, edited by C. W. Wright, Chicago, 1942, pp. 1-53).

I am deeply grateful to Professor Earl J. Hamilton and Professor Harold A. Innis, for the encouragement they have given me to pursue this study in these difficult times. Dr. Hamilton first suggested that I conduct researches in the economic history of war, researches which, he rightly thinks, should have a bearing upon the problems of international relations, national policy and education in America, as the second world war draws to a close and in the years that follow it. Together with his associates, Professor Arthur H. Cole and Dr. Innis, of the Subcommittee on Grants-in-Aid of the Economic History Research Committee, he obtained for me the grant from the Social Science Research Council. Dr. Innis honoured me by an invitation to deliver a lecture on the subject at the University of Toronto in March, 1943. This essay is the outcome. He has also suggested several valuable references.

My obligations to Miss Stella Lange, of St. Mary's College, are very heavy. With an initiative, a skill, and an accuracy that would be difficult to equal, she has helped me with my researches and has saved me much time and tiresome toil.

those of economic progress and wars have a special interest for the present age. In the nineteenth and early twentieth centuries the material aspects of life took on an importance disproportionate to man's nature, which has been left by social science almost at the mercy of events and so-called social processes. In our own time war has once more become an ever-present danger for the Western peoples, after many had thought of it as a relic of barbarism, destined to recur, if at all, only in small short instalments. No subjects that are of more than fleeting concern command greater general attention today, especially in the United States, than economics and war. A history of the interrelations between them leads naturally into every aspect of modern history, including the history of the mind. If the paths of knowledge that confront a historian of wars and the rise of industrialism were explored and connected, might this not help to break down the artificial barriers which have been thrown up between the social sciences and between the various humanistic studies? Might this not help also to prepare the way for a history of Western civilization as a whole during the past four centuries, a history of the kind that is needed if man is again to see his place in the universe in its proper proportions?

I. Economic Progress

What stands out when we compare the course of European economic development in the hundred years which begin in 1640 and in those which precede that date? The heroic industrial progress characteristic of England during the life of Shakespeare (1564-1616) was not repeated there or anywhere else. Nor was there anywhere commercial expansion at a rate at all comparable to that characteristic of Holland during the lives of Hals (1580-1666) and Rembrandt (1607-69).

The two states which emerged as the greatest political powers during the hundred years from 1640 to 1740—France and Great Britain—became no less indisputably the greatest economic powers. When Louis XIII died in 1643, French industry and trade were in a very depressed state. French Mediterranean commerce with the Levant fell precipitously during the twenties and thirties of the seventeenth century. Notwithstanding Richelieu's success in keeping the country out of the worst fighting of the Thirty Years' War, the north was little more prosperous than the south. In contrast, at the outbreak of the war of the Austrian Succession, France was rich. The basic industries—mining, metallurgy, and textiles—were all enjoying a moderate boom, destined to continue, with a few setbacks, until the French Revolution. The luxury manufactures, in which the country had provided models for Europe ever since the torch of Renaissance culture passed from Italy to France, were more widely esteemed than ever. With the introduction here and there of coal-burning furnaces, industries such as glass making, sugar refining, and soap boiling were taking new leases on lives not yet robust in terms of the volume of output. It must not be supposed that the country had been continually prosperous between 1643 and 1740.

There were only two periods of striking industrial and commercial progress—the sixties and seventies of the seventeenth century, when Colbert was responsible for the economic policies of the Crown, and the thirties of the eighteenth, after France had recovered from the losses of Louis XIV's last wars and from the financial collapse in 1720 associated with John Law's schemes for reforming the national finances. On balance, the production of cereal crops and industrial commodities was substantially greater in the 1730's than in the 1630's. France had acquired more territory. Wealth had increased moderately in the new and the old provinces alike. But it would be rash to assume that the annual dividend within all these provinces, considered as a unit, had doubled. In terms of real income it was probably not up by more than fifty per cent.[2]

In England economic growth, measured simply by volume of output, was probably somewhat more rapid than in France. But the difference between the two countries in the rate of growth, so great during the late sixteenth and early seventeenth centuries, was no longer striking from 1640 to 1740. In France the annual dividend increased much more than during the previous hundred years, when it had been apparently almost stationary. In Great Britain there was a marked slowing down in the pace of economic expansion, which had been phenomenal from about 1570 to 1620.

As the rates of industrial growth in the two countries converged, the nature of industrial organization and the character of industrial labour grew more alike, especially after the Treaty of Utrecht in 1713. Each country retained, of course, industrial characteristics of its own. In early modern times the British had concentrated upon comforts and conveniences, produced at a low cost with the help of water- or horse-driven machinery and powerful furnaces. The French had concentrated upon objects of artistic craftsmanship, whose use and contemplation added to the splendour and style of living. While the British had emphasized economic quantity and efficiency, the French had emphasized aesthetic quality and form. In Great Britain it had been the heavy industries, in France the artistic, which progressed most rapidly.

Early in the eighteenth century, the more homely commodities of British workmanship began to attract steadily increasing attention in France and other Continental countries. English methods of mining, of smelting, and of manufacturing glass with coal fuel in place of charcoal, made their way across the Channel. As the English were learning with the help of the French to make beautiful objects, the French were

[2]Savary des Bruslons, *Dictionnaire universel de commerce* (1726) (Geneva, 1742, vol. I, part 2, pp. 16-17). We have here a comparison of the consumption of various foodstuffs in Paris in 1634, 1659, and at the end of Louis XIV's reign (1722 "mais qui paroit avoir été dressé quelques années auparavant"). This shows that consumption had increased by about a fourth. But, as the final figures are for the end of a period of prolonged warfare, we may reasonably assume that there was a considerable further increase by 1740. See also vol. I, part 2, *passim*. I do not suggest that the consumption in Paris is necessarily a good barometer of consumption in France as a whole.

learning with the help of the English to make substantial and practical ones to be diffused widely among the population. While France and England had tended to grow apart in their industrial life during the late sixteenth and much of the seventeenth centuries, there was now a marked tendency for them to draw together.

Conditions in Germany and the rest of central Europe are complicated for the historian by the fact that when the century 1640 to 1740 opened, these regions were in the last stages of one of the most fearful wars known to history. The number of people in the area of the German Empire (as bounded from 1871 to 1914) was reduced from nearly 21 millions on the eve of the Thirty Years' War, to rather less than 13½ millions around 1650, when that war was over.[3] It is easy to exaggerate the economic disintegration which had taken place, just as it is easy to exaggerate the part played by the long war in the disintegration.[4] Yet there can be little question that the volume of output in Germany and Austria combined, was smaller in 1640 than that in the predominantly French territory bounded on the east by the Scheldt, the Meuse, and the Alps, and on the south-west by the Pyrenees. A century before, in 1540, Germany and Austria had probably produced a somewhat larger volume of goods than had come from this same French territory.

Most of the economic history of central Europe during the decades following the Treaty of Westphalia (1648) is the history of slow and often retarded recuperation from an exceptionally serious economic collapse, the origins of which go back into the sixteenth century. The recovery was well under way, at any rate in Austria and the north, before the end of the seventeenth century. By the twenties and thirties of the eighteenth, industrial enterprise in many parts of central Europe was beginning to thrive. It was administered by methods which owed almost as much to French bureaucratic models as to the past experience of the German Renaissance princes in dealing with financiers like the early Fuggers. It was supplied with equipment which owed almost as much to English inventors and technicians as to the central European engineers, whose knowledge had been summed up by Georg Agricola (1494-1555). Germany was being drawn into the orbit of general European civilization more strongly than at any time since the "renaissance" of the twelfth and thirteenth centuries.

Spain and the Low Countries, the southern half of which were under Spanish control until the Treaty of Utrecht, present something of an exception in the history of substantial, if slow and interrupted, economic progress characteristic of Europe during the hundred years preceding 1740. Population, industrial output, and trade all declined considerably in the seventeenth century. The forties and fifties were a particularly dismal time for Spanish economic life, though the crushing defeats suffered at the hands of France were probably not accompanied by as

[3]M. J. Elsas, *Umriss einer Geschichte der Preise und Löhne in Deutschland* (Leiden, 1936), vol. I, p. 78.

[4]Cf. Nef, "War and Economic Progress, 1540-1640," pp. 36-7.

complete a collapse as the one which occurred in central Europe during the Thirty Years' War. But recovery in Spain was delayed longer than in Germany. It began only after 1700. It had hardly gone far enough by 1740 to make up for the decline characteristic of the time when Louis XIV ruled France and aimed to control the fortunes of the neighbouring country across the Pyrenees. While, in central Europe, production was certainly greater in the 1730's than in the 1630's, in Spain it was in all probability somewhat smaller.[5]

The age was not more favourable for the economic life of the districts which form modern Belgium, and which the French king was also out to control. The link between the Low Countries and Spain was finally broken in 1713, when Belgium passed under Austrian sovereignty. But it was not until the accession of Maria Theresa, in 1740, that the southern Low Countries began to participate in the currents of economic progress characteristic of most of continental Europe during the greater part of the eighteenth century.

The economic fortunes of Holland started to fall at the very time when those of most other states were rising strikingly. In the accelerated industrial and commercial progress which began all over Europe in the 1730's and 1740's, Holland had no part. It now appears that the commercial position of the Dutch, as the sea carriers for most of the foreign trade of northern Europe, was maintained until about 1730, though several Dutch industries, such as the textile manufacture at Leiden, had been on the wane since at least the beginning of the eighteenth century.[6] Relatively speaking, Holland was probably somewhat less important as a European economic power in the thirties of the eighteenth century than in the thirties of the seventeenth. It is probable, nevertheless, that the Dutch national income had increased somewhat. Holland fared better in a material way than the rest of the Low Countries. She fared much better than Spain during the second half of the seventeenth century, for the long wars between France and Spain played into the hands of the Dutch, who wrested from the Spaniards a large part of the foreign commerce. They retained control of it until the War of the Spanish Succession.[7]

For Europe as a whole, the hundred years from 1640 to 1740 were more prosperous than those from 1540 to 1640. The concentration of capital in considerable blocks—in factories, large workshops, or putting-out enterprises—was at least as striking. The volume of production

[5]Cf. E. J. Hamilton, "The Decline of Spain" (*Economic History Review*, vol. VIII, 1938, pp. 170-1); "Monetary Disorder and Economic Decadence in Spain, 1651-1700" (*Journal of Political Economy*, vol. LI, 1943, pp. 492-3); "Money and Economic Recovery in Spain, 1701-1746" (*Journal of Modern History*, vol. XV, 1943, pp. 192-3, 206).

[6]Charles Wilson, "The Economic Decline of the Netherlands" (*Economic History Review*, vol. IX, 1939, pp. 111-13, 127); *Anglo-Dutch Commerce and Finance in the Eighteenth Century* (Cambridge, 1941), pp. 16-19, 24, and *passim*. Cf. G. N. Clark, *The Dutch Alliance and the War against French Trade, 1688-97* (Manchester, 1923), p. 133.

[7]Cf. Savary des Bruslons, *Dictionnaire universel de commerce*, vol. I, part 2, p. 317.

probably grew at a slightly more rapid pace. Yet, when we say these things, we have to remember that during the earlier century most countries had not been prosperous. The exceptions were Great Britain, Holland, and probably Sweden. There the rate of development had been very much more rapid than in the later century. But these were not the largest nor the most populous countries. All told, they had little more than a tenth of the population of Europe. All told, they had fewer inhabitants than France or even than Germany at the end of the Thirty Years' War. In the century following the dissolution of the English monasteries, what is most remarkable is the contrast between industrial and commercial development in these small countries and in the rest of Europe. In the century beginning with the English Civil War, the resemblances are more impressive than the contrasts.

II. Limited Warfare

(*i*) Much the same may be said about the history of warfare. From 1540 to 1640, or at any rate from 1558 to 1640, Great Britain was a peaceful island facing a Continent continually drenched with blood. From 1648 to 1740, or at any rate from 1659 to 1740, bloodshed on the Continent tended to diminish. Wars for limited dynastic objectives succeeded wars to the death, brought on, at least ostensibly, by religious issues. The Treaty of Utrecht, in 1713, was followed by nearly three decades more peaceful than any since the French king, Charles VIII, had marched his army into Italy more than two hundred years before. For Michelet that treaty brought to an end what he called two centuries of European warfare.

But 1642 marked the outbreak in Great Britain of what was, in terms of numbers engaged and of actual destruction, the most serious fighting that has ever taken place within the island. While the English Civil War was short compared with the long and terrible struggles that were ending in the 1640's in central Europe, England was involved in wars of one kind and another much more frequently between 1640 and 1740 than during the previous hundred years. Warfare was still a less important factor in the normal life of the country than in that of France and other continental states, large and small. But the differences were ceasing to be conspicuous.

Military establishments increased considerably in size and in cost between 1640 and 1740. Yet the damage done by armies to the ordinary existence of the inhabitants, or to human sympathy among the peoples of Europe, was reduced as time went on. War on land was becoming something of a game. Battles were fought; on occasions there was even terrible carnage. It would be a mistake to assume that sin greatly diminished as religious toleration grew! Human nature was by no means purged of the cruelty and the evil which make it so ugly. But there were fewer opportunities for venting cruelty and lust and fewer causes for the fears which goad even peacefully-disposed men into battle. Except among the nobility, who furnished most of the officers, and whose

code made warfare an obligation, like the fighting of duels,[8] the task of soldiering, especially among the English, carried with it no special honour like that attached in more recent times to dying for one's country. The only special loyalty felt by the private, even on the Continent, was a personal one to the prince for whom he fought.[9] Between the Treaty of Utrecht and the French Revolution, battles were episodes, struggles for dynastic advantages, without any central pan-European plot involving the common people. The destruction of life and property was light, except in Germany and to the east. In 1704, the decisive year of the War of the Spanish Succession, the year of Schellenberg, Blenheim and Malaga, not more than two thousand British soldiers and sailors fell in action; not more than three thousand others died of wounds, of disease, or of any causes traceable to the war.[10] Even among the warlike inhabitants of central Europe, there was a lull from heavy fighting until the accession of Frederick the Great in 1740.

The moderate, regulated nature of the warfare is revealed again and again in the practices and the writings of the eighteenth century.[11] Let us take, for example, the memoirs of a cultivated man of the world and a great man of letters, Goldoni. In 1733, he was engaged as secretary to the minister of the Venetian Republic in Milan at the time of the so-called war of Don Carlos, in which the king of Sardinia, on behalf of that prince, combined his forces with those of France and Spain against the house of Austria. Goldoni was present at the siege of Milan by the allies and several weeks later at Parma, where the rival armies met in a death grapple outside the town. In neither place were the sympathies of the inhabitants seriously engaged on one side or the other. Their only fear was lest the troops of either army should get within the gates and pillage, but that fear proved groundless. At Parma the citizens ran to the ramparts to watch the battle in the open country beyond, much as a modern city crowd would congregate to watch a tremendous fire which the fire department manages somehow to keep under control.

The relations between the officers of the fighting armies were of a kind that would astonish the participants in modern warfare. Goldoni gives us an account of these relations before the armies had reached

[8]Cf. Barre-Duparcq, "Des Imitations militaires" (*Séances et Travaux de l'Académie des Sciences morales et politiques*, vol. LXXVI, 1866, p. 374); *Calendar of State Papers, Domestic*, 1671, p. 287.

[9]Cf. Tobias Smollett, *Roderick Random*, chap. XLIV, and *passim*. See also Robert Boyle, *Works* (London, 1772), vol. I, p. xxix. For wholesale desertions from the French army in the summer of 1671, see *Calendar of State Papers, Domestic*, 1671, p. 448; cf. *Mémoires de M. Goldoni* (Paris, 1787), vol. I, p. 247 (reference to French and Piedmontese soldiers deserting with impunity in 1733).

[10]G. M. Trevelyan, *England under Queen Anne. Blenheim* (London, 1930), vol. I, p. 433.

[11]Cf. A. J. Toynbee, *A Study of History* (London, 1939), vol. IV, pp. 142-50, 158-62; Count Saxe (1696-1750), *Reveries or Memoirs upon the Art of War* (London, 1757), p. 85; W. S. Churchill, *Marlborough, His Life and Times*, vol. III (New York, 1935), pp. 97-8; etc.

Parma. He visited the camp of the allies near Crema, during a three-day armistice which they had readily granted the Germans during the siege of Pizzighetone.

> A bridge thrown over the breach afforded a communication between the besiegers and the besieged: tables were spread in every quarter, and the officers entertained one another by turns: within and without, under tents and arbours, there was nothing but balls, entertainments, and concerts. All the people of the environs flocked there on foot, on horse-back, and in carriages: provisions arrived from every quarter; abundance was seen in a moment, and there was no want of stage doctors and tumblers. It was a charming fair, a delightful rendezvous.[12]

After the armistice, the allied army obligingly moved toward Parma, nearer to Venice. Goldoni's diplomatic duties were lightened. He found time to apply himself successfully to the "more agreeable" occupation of completing one of the delightful plays with which he charmed the audiences of his own age and of the nineteenth century.[13]

(*ii*) There was no such reduction in sea as in land fighting. About the time of the first Anglo-Dutch war of 1652-3, the great ships of the line, the mainstay of the new fleets, began to be built in a form which was still characteristic in the early Victorian era. In length, in breadth, and in the size of the fighting decks (with long rows of muzzle-loading guns), there was little increase in the battleships for two hundred years, until the advent of the ironclads at the battle of Hampton Roads in 1862.[14] The hull of a ship of the line "ranged some two hundred feet from the figurehead under the great bowsprit to the ornate windows of the cabin at the stern."[15] She bulged at the sides, measuring more than fifty feet across, at least half the breadth of the most stupendous ocean liner launched before 1940, a vessel which weighed something like fifty times as much. For more than two centuries, the strategy of war at sea was determined largely by the number of the wooden battleships available to put into the line of battle. While organized, as well as unorganized, violence on land tended to diminish after the middle of the seventeenth century, naval engagements became more frequent, at any rate in the northern and western waters about Europe.

For all this, the damage done the economic life of the chief European powers by sea warfare was not comparable to that caused by the terrible land warfare of the late sixteenth and early seventeenth centuries. In the struggles between Holland and England during the 1650's, 1660's, and 1670's, efforts were made by the Dutch naval commanders to spoil

[12] *Memoirs of Goldoni*, translated from the original French by John Black (London, 1814), vol. I, p. 207 (a reference for which I am indebted to Professor Ulrich A. Middeldorf). The translation of this passage from the French seems to me to be almost perfect (cf. *Mémoires de M. Goldoni*, Paris, 1787, vol. I, pp. 246-7).

[13] *Memoirs of Goldoni*, vol. I, pp. 201-16; *Mémoires de M. Goldoni*, vol. I, pp. 240-57.

[14] R. G. Albion, *Forests and Sea Power: The Timber Problem of the Royal Navy, 1652-1862* (Cambridge, Mass., 1926), pp. vii-viii, 3-5. Cf. F. L. Robertson, *The Evolution of Naval Armament* (London, 1921), pp. 21, 25, 31, 33, 50.

[15] Albion, *Forests and Sea Power*, p. 3.

the fishing and other trades in the North Sea,[16] and to block or at least disrupt the passage from the Tyne and Wear to London, with the object of preventing the regular movements of coal-laden colliers, in fleets, a traffic upon which the capital had become dependent for adequate supplies of fuel.[17] But, as has almost always been the fate of efforts to win wars by blows at the economic life of the enemy, these efforts fell short of their objective. The harm done in war-time by foreign battleships and smaller vessels to the coasting trade of Great Britain diminished after the second Anglo-Dutch war of 1665-7.[18] In the long wars of the late seventeenth and early eighteenth centuries, when Holland and England were allies against France, the chief threats were no longer to English coastwise trade. They were to international trade generally. Much mischief was accomplished by both sides: French privateers, principally the notorious Dunkirkers which had harried shipping for at least a century, captured or sank multitudes of British merchant vessels during the war of the Dutch Alliance (1688-97) and again during the War of the Spanish Succession (1701-13). One authority puts the number of prizes taken by the Dunkirkers alone in the later war at 1,614.[19]

The English and the Dutch, in their turn, attempted to organize a wholehearted war on French commerce. But there were many traditional and practical difficulties in the way. One important obstacle was the natural reluctance of the Dutch to give up any part of their own trade, which had usually thrived in time of war, and which regained a measure of its old prosperity during the eighteenth century only when other countries were hindered by wars from trading directly with each other.[20] Transactions with the enemy through a third neutral state were a well-recognized and not altogether disreputable form of early eighteenth-century commerce, to which the French gave a special name—"commerce précaire." All belligerents engaged in such trade to a considerable extent.[21] The dependence of the Dutch upon their shipping, their role as carriers for other states, had made "business as usual" in war-time their settled policy, not only at home, but with their enemies. They aimed to fight in so far as possible without disturbing the industrial and

[16]Cf. *Calendar of State Papers, Domestic*, 1665-6, p. 372, and other references too numerous to cite.

[17]Cf. J. U. Nef, *The Rise of the British Coal Industry* (London, 1932), vol. II, pp. 263-5, 285, 287-8, 296-8, 301; cf. also *Calendar of State Papers, Domestic, passim*, e.g. 1666-7, p. 327; 1667, pp. xxv, 94, 190, 241, 294, 479-80.

[18]Nef, *The Rise of the British Coal Industry*, Appendix D(i).

[19]Henri Malo, *La grande Guerre des Corsaires, Dunkerque 1702-15* (Paris, 1925), p. 126.

[20]Cf. Wilson, *Anglo-Dutch Commerce and Finance*, pp. 16-17, 19; P.-D. Huet, *A View of the Dutch Trade* (1698, 2nd English ed., London, 1722), p. v; Lemontey, *Essai sur l'établissement monarchique de Louis XIV, Oeuvres*, vol. V, p. 61 (as cited by Barre-Duparcq, *Séances et Travaux de l'Académie des Sciences morales et politiques*, vol. LXXXIII [1868], p. 252, n.); *Calendar of State Papers, Domestic*, 1665-6, p. 461.

[21]Savary des Bruslons, *Dictionnaire universel de commerce*, vol. I, part 2, pp. 12, 243. Cf. Colonel de Rochas, *Vauban, sa famille et ses écrits* (Paris, 1910), vol. II, p. 126.

commercial life of Europe.[22] England was never effectively able to bind Holland to renounce all trade with France. Even postal communications were not successfully restricted for long. Letters circulated with a freedom that astonishes the twentieth-century mind, and leads it to wonder whether all the technical improvements in the speed of carriage and the transmission of sounds have actually served to make intimate communications between the Western peoples, and the understanding which might accompany them, more feasible than two hundred and fifty years ago.

The late seventeenth and early eighteenth centuries were an age when tariffs and restrictions upon international commerce were growing as a part of normal commercial policy. In October, 1665, the lord mayor of London was told that the king was so concerned over the sums laid out in purchasing products of foreign manufacture that he had resolved "after the mourning for the king of Spain [is] over, [to] wear nothing inside or out that is not of English manufacture, except linen and calicoes."[23] By the seventies and eighties, duties on the movement of most commodities across national frontiers were high in peace-time.[24] When relations were friendly English parliaments even set about, without complete success, to *prohibit* trade with France. Protective policies were regarded by most statesmen and many respectable writers on economic subjects as a means to domestic prosperity.

Such additional barriers to trade as were erected in war-time generally crumbled almost at once, mainly perhaps because the Dutch were unwilling to accept them. There were several periods during both the long wars with France when no limits were set by the English upon the import of wines and other luxuries (in the cultivating and preparing of which the French excelled) beyond the restrictions imposed by the normally high tariffs. The conception of total war was highly imperfect even among the most chauvinistic Englishmen and Frenchmen.

At the beginning of the war of the Dutch Alliance, an effort was made by England to prevent some neutral states from trading with France, by seizing all their ships which sailed from French ports and by turning back all those bound for France.[25] But the convention which the English got Holland to enter on behalf of this effort was a dead letter almost from the start. By the Treaty of Ryswick, in 1697, which ended the war, the Dutch reestablished their old principle of "free ships, free goods." This meant that all neutral trade, except in a few articles declared contraband, was to be permitted in time of war. Of all wars, the War of the Spanish Succession, which followed, was noted as the one during which "there was the least infraction of neutral rights."[26]

[22]Cf. *Calendar of State Papers, Domestic*, 1665-6, p. 461. [23]*Ibid.*, p. 31.

[24]For a complaint from the city of London about the French "imposts on our manufactures," see *ibid.*, p. 253.

[25]Cf. Savary des Bruslons, *Dictionnaire universel de commerce*, vol. I, part 2, p. 281.

[26]Clark, *The Dutch Alliance and the War against French Trade, 1688-1697*, pp. 4-7, 63-4, 91-2, 106-19, 139-40; Clark, "War Trade and Trade War, 1701-1713" (*Economic History Review*, vol. I, 1928, pp. 263-4, 268-70, 274, 276).

Naval warfare between the great powers in the century from 1640 to 1740 cannot be represented at any time as a single-minded effort on the part of any state to deal a decisive blow to its enemies. That was much more difficult than it became in the twentieth century. One reason was that no power or combination of powers had the means to accomplish it. Attacks on sea commerce were bound to be inadequate, because international trade was hardly of vital importance to any state except Holland. Wars were undoubtedly a factor working against the expansion of European trade; they helped to bring about periodical shrinkages in its volume; but they were probably less important barriers to its growth than the tariffs and prohibitions which were actually far higher and tighter than during the century of fierce warfare on the Continent which preceded.

The principal aims of sea warfare in the century following the Treaty of Westphalia were to gain colonial territory and commercial advantages,[27] the sweets of which accrued to the private merchant, especially in the case of England. When the total conquest of the enemy is not contemplated, wars for the sake of commerce become a contradiction, unless they are restricted in scope and purpose.[28] Even the victors have to offset, against what is gained, the terrific damage done to trade and to manufacturing. An English soldier, writing in 1677 on the art of war, praised the Roman military administration. "But then," he added, "I must say, their Trade was war, and I thank God ours is not."[29] So it is natural to find that war at sea between the chief commercial powers fell somewhat short of being a real national struggle. Toward the end of the second Anglo-Dutch war, there were, according to report, some three thousand English and Scottish seamen serving in the Dutch fleet, perhaps ten per cent or so of all the men Holland had enlisted. More British seamen were going over to the enemy every day, "they have so much encouragement there, and so little at home."[30]

Under the conditions of international politics which prevailed, naval warfare, with its commercial objectives, seems to have served to limit the scope of war. It provided an alternative to land warfare[31] at a time when the three great European powers—France, Great Britain, and Holland—had no common frontiers. It kept down the proportion of

[27]Cf. *Calendar of State Papers, Domestic*, 1689-90, p. 93; Richard Pares, *War and Trade in the West Indies, 1739-1763* (Oxford, 1936), pp. viii, 62.

[28]Jean Lagorgette, *Le Rôle de la guerre* (Paris, 1906), pp. 193, 597; S. R. Coleridge, *The Friend* (London, 1837), vol. II, pp. 89-90; John Houghton, *A Collection for the Improvement of Husbandry and Trade* (London, 1727), vol. I, pp. 204 ff., vol. II, pp. 5, 28, 290; *Calendar of State Papers, Domestic*, 1666-7, pp. 46, 161, 202, 550, 589; 1667, pp. vii, xxx; 1671, p. 562; 1677-8, p. 665.

[29]Earl of Orrery, *A Treatise of the Art of War* (London, 1677), p. 22; cf. p. 14.

[30]*Calendar of State Papers, Domestic*, 1667, p. 207.

[31]Cf. J. A. Williamson, *The Ocean in English History* (Oxford, 1941), p. 179; Pares, *War and Trade in the West Indies*, p. 62.

the population in the armed forces, because the capital required to put a sailor to sea greatly exceeded that required to put a soldier on the march. Naval warfare was a kind of token trial of strength, as long as none of the leading countries was bent on subjugating the others. By its nature, naval warfare is indecisive unless it prepares the way for starvation or for a large-scale invasion.

(*iii*) In the eighteenth century, war had become little more than an unpleasant accident, like a spring flood or a mild earthquake, for the cultural and intellectual life of Europe. It seemed hardly more sensible to Voltaire that persons persisted in this organized shooting, this blowing and shooting of each other to pieces, than that they engaged in private duels. The use of cannon and muskets to settle scores between nations could not be justified on rational grounds. For Voltaire, there seems to have been no such thing as a righteous war, even in the senses in which Aquinas or Grotius had defined one. Voltaire might have said of war what Burckhardt was to say of power—that it is "by its nature evil."[32] He would not admit that there were ever conditions under which good could come of it. "Il faut bien . . . que les hommes aient un peu corrompu la nature, car ils ne sont point nés loups, et ils sont devenus loups."[33] Such a point of view became possible in an age in which many men had lost all belief in original sin, and in which the use of force constituted no serious threat to civilized values.

Gibbon was convinced that resort to war by civilized peoples as an instrument to destroy the independence of other civilized peoples was at an end. He took it for granted that European society had a secure future, under the prevailing political and intellectual conditions. The conquest of the various powerful independent states by any one among their number did not occur to him as even a distant possibility. The armed forces of Europe were exercised in war "by temperate and undecisive contests," which kept large bodies of armed men in trim, ready to consolidate as a single great army to meet barbarian hordes if any should ever appear. The new weapons which had been invented since the discovery of gunpowder were at the disposal of the civilized; the barbarians could acquire a knowledge of them only at the price of ceasing to be barbarous, and hence at the price of ceasing to want to conquer![34] "A philosopher," Gibbon wrote, "may be permitted to enlarge his views, and to consider Europe as one great Republic whose various inhabitants have attained almost the same level of politeness and cultivation. The balance of power will continue to fluctuate . . . , but . . .

[32]Jacob Burckhardt, *Force and Freedom: Reflections on History* (New York, 1943), p. 184.

[33]*Candide* (1759), chap. iv. Cf. *Oeuvres complètes de Voltaire, Correspondence* (Paris, 1880), vol. I, p. 506; L. Walowski, "Le grand dessein de Henri IV," in *Séances et travaux de l'Académie des Sciences morales et politiques*, vol. LIV (1860), pp. 30-59.

[34]This view was widely held (cf. *Encyclopédie méthodique*, Paris, 1784, vol. IV, p. 575).

partial events cannot essentially injure our general state of happiness, the system of arts and laws and manners, which so advantageously distinguish, above the rest of mankind, the Europeans and their colonies."[35]

In their military as in their economic history, Great Britain and the Continental countries grew more alike during the hundred years which follow than during those which precede 1640.[36] Whether we consider the course of war, of industry, of science, or of art, the whole of Europe seems to be drawing together, after the religious disputes of the late middle ages and of early modern times had helped to split it into parts.

III. Influence of Wars on Science and Technology

(*i*) Two opinions concerning the influences of wars on economic life are widely held in the modern world, though they seem flatly to contradict each other. According to one, wars constitute a great destructive force. According to the other, they constitute a great constructive force. Similar contradictory opinions prevail concerning the role played by the economic interests of individuals in the history of wars and concerning the interrelation between wars and the history of civilization.

Perhaps even the learned in our literal minded age need to be reminded by Pascal that statements which contradict each other may both be true.[37] It should be a part of the historians' task to reconcile extreme positions, such as those concerning the economic influences of wars. The experience of warfare in many ages and under various conditions might help to reconcile them, for the influences vary within fairly wide limits according to time and place. War is not a constant. To treat it as one, to call it x in the historical process, is an example of the tendency in modern social science to set up as units of study bundles of changing phenomena that have far less in common through the ages than human nature, about which the same social scientists deny that it is possible to lay down any general propositions. In connection with warfare, a knowledge of its historical variations and their limits might help to reveal the probable consequences both of modern wars for economic life and of modern industrialism for warfare. It might even help men to see more clearly how wide is the range of their freedom, through learning and culture, to influence history for the better.

The Hercules Powder Company recently circulated a paper by my former colleague, Dr. Lionel Edie, in which he wrote with enthusiasm of "the scientific developments growing out of the [present] war." "In the space of two or three years," he told his readers, "you are getting as much scientific progress in this country as you ordinarily get in 40 or

[35] *Decline and Fall of the Roman Empire*, chap. xxxviii (Bury ed. vol. IV, p. 176). Cf. pp. 175-81, especially pp. 176, 178, passages called to my attention by Dr. Hutchins.

[36] Cf. Jacques-A.-H.-Guibert, *Essai général de tactique, précédé d'un Discours sur l'état actuel de la politique et de la science militaire en Europe* (Liége, 1775), p. 12.

[37] ". . . plusieurs choses certaines sont contradites; plusieurs fausses passent sans contradiction" (*Les Pensées*, ed. Adolphe Espiard, Bibliothèque Larousse, Paris, n.d., vol. I, p. 178).

50 years." Dr. Edie made no effort to prove this point, nor did he explain that the words "scientific progress" had for him a limited meaning, which might be misunderstood. Like Dr. Edie, students of history do not always distinguish between fairly obvious divisions of the general subject of science and technology. They speak of "scientific progress" as covering anything from the most general theories about the architecture of the sensible universe to the most narrow and practical aspects of mechanics. Actually the subject divides into a number of parts, all interdependent in varying degrees and in various ways. Among the many possible divisions, three seem especially relevant to an inquiry about the reciprocal relations of wars and economic development.

There are, first, speculations which are primarily of a theoretical and general kind, though they depend, as all investigations of matter or space must, upon the direct observation of the physical world as it exists in nature and also as it is modified by practical farmers, craftsmen, miners, manufacturers, and transport workers. Speculative scientists have also learned from the methods and mechanical contrivances of practical life. But in the actual conduct of theoretical and general speculations the main object is knowledge—the nature of particular classes of things, how they become what they are, and the relations of some of them to others. While the knowledge acquired has often tremendous consequences for practical life, the observations and experiments, like the thought behind them, do not have as a direct objective an increase in the volume of material output, a reduction in human toil, or an improvement in health. Harvey's discovery of the circulation of the blood, for example, was destined to revolutionize the practice of medicine and surgery. It was to encourage Descartes to write a famous passage in which he suggested that physics might help men to understand and then to employ the force and the action of fire, water, air, the stars and the heavens, and thus render themselves "the lords and possessors of nature."[38] Yet Harvey's immediate aim was not to cure illnesses; still less was he out to reduce the manual labour of human beings; he was simply seeking the truth about a particular physiological process. Practical results of fundamental scientific work are generally incidental to it even when they are of momentous consequence. Technological improvement, as such, generally involves a different kind of thought and different methods.

As used widely today, the phrase "scientific progress" covers, secondly, investigations related to the solution of practical problems, which are of significance for scientific theory, and contribute directly or indirectly to general and theoretical knowledge, as well as to practical technological skill. The phrase also covers, in the third place, investi-

[38] *Discours de la méthode* (1637), parts 5 and 6. See the Etienne Gilson edition (Paris, 1925), pp. 50-62. The passage from which I quote is on pp. 61-2. For the shortcomings of Descartes' own method and thought as instruments for the progress of natural science, see Gilson, "Descartes, Harvey et la scolastique" (*Etudes de philosophie mediévale*, Strasbourg, 1921, pp. 244-45). I hope to treat the matter of Descartes' influence on science and technology at some length in another place.

gations which have almost no result beyond the practical one of providing a new technical instrument or process or of improving an old one.

It is naturally difficult to draw lines between these three divisions and particularly between the last two, for it is impossible to know what the consequences for theory of particular technical improvements may be. Yet the spirit which seeks practical results exclusively for their own sake differs in its nature and its consequences from one which regards these results as properly subordinate in the hierarchy of knowledge to general scientific laws.

Dr. Edie had in mind only investigations of the second and third kinds, and almost exclusively investigations of the third kind. He was thinking of machinery and other devices capable of raising the material standard of living.[39] The breakdown in early modern times of the barrier which had separated intellectual from manual work, and therefore science from technology, was of great benefit to science. It helped scientists to make the most of practical experience. But the view, widely held in our time, that there can never be any danger to fundamental theoretical research from an emphasis on technical results, has not been satisfactorily established. There is little historical evidence to support it.[40] There is more to support the thesis, suggested by Francis Bacon and Robert Boyle, that the most useful inventions of the past four centuries have been dependent on the general and theoretical speculations of natural scientists, in the sense that without a growing body of general scientific knowledge of a very high order, characteristic of modern times, we should never have had the technical improvements capable of raising the standard of living to levels reached among civilized societies in the twentieth century.[41] During the past three or four hundred years it has been the more philosophical scientific speculations which have provided the intellectual capital upon which the modern inventor and technician have drawn, without giving back a full equivalent for what they have borrowed. The more narrowly practical "science" becomes, the less capital is likely to be replaced. According to an accepted principle of economics, no society can live indefinitely on its capital. If, then, our object is to examine the relations between wars and scientific progress, it is not enough to confine ourselves to the influence of wars upon technical improvements.

(*ii*) From a misinterpretation of the Bible, our seventeenth-century ancestors assumed that man's life-span had been shortened with the

[39]Lionel D. Edie, *What of Postwar?* (Wilmington, Delaware, 1943), pp. 13-14.

[40]The view that a great emphasis on practical improvement is harmful to theoretical science was common a century ago. See Charles Babbage, *Reflections on the Decline of Science in England* (London, 1830), pp. vii, 1-2, 14-15, 17-18, 30ff., a work called to my attention by Dr. Innis.

[41]Cf. Boyle, *Works* (London, 1772), vol. III, pp. 402-25, 442-55. Views like Boyle's on these matters were common enough among the English scientists who were his contemporaries. References could be multiplied.

march of history. Under the influence of the modern belief in the inevitability of progress, we are in some danger of assuming that longevity is a distinctive achievement of industrial civilization. The chances for reaching middle life *have* increased enormously with the improvements during the past two hundred years in medicine, sanitation, and surgery, and with the remarkable rise in the material standard of living. But for those who last beyond the fifties, the promise of a long Indian summer is not much better in the Canada of Mackenzie King or the United States of Franklin Roosevelt than it was in the England of Hobbes (1588-1679) or the France of Fontenelle (1657-1757).

Among the long-lived men of distinction who appear prominently in the pages of seventeenth- and early eighteenth-century history, Isaac Newton is perhaps the most eminent. He lived from 1642, the year of Galileo's death, until 1727. If Galileo was the greatest scientist of the previous hundred years, Newton was most indisputably the greatest of these. In his time, the leadership in natural science shifted from Italy to England. It shifted from a country where cultivated opinion and public authority looked with distaste, incredulity, and sometimes with downright distrust on the observations and experiments typical of modern science and on the results achieved by great scientists, to a country where cultivated opinion and public authority warmly welcomed such procedures and treated such results as contributions of the first rank to human welfare. By the beginning of the eighteenth century, and even by the Restoration in 1660, natural science had gained a prestige in Great Britain among learned men, and also among the curious in all walks of life, such as the subject had never before possessed.

As England was rather more deeply engaged in wars during the century after 1640 than during the previous one, persons without sober training in historical sociology, who take the line that war is a great constructive force, might pounce on the growing importance of science during the last sixty years of the seventeenth century as support for the thesis that Newton, Boyle, and other contemporary English scientists were products of wars. They might build up a case rather after the fashion of Elie Faure, who concluded from his study of the history of art that great artists and thinkers were in a large measure dependent on wars, because nearly all of them were born, or died, or lived at least a fraction of their lives when a war was going on. Faure's argument is more of a commentary on the incorrigibly belligerent nature of men and nations than a testimonial to his discrimination as a historian.[42]

[42]Faure, *La danse sur le feu et l'eau* (Paris, 1920), pp. 50-2, 59-78. Newton is, in fact, one of a great number of examples whom Faure selects to support his thesis. *Paradise Lost* and the best works of Hobbes, he remarks, were published after "the last and perhaps the most terrible of English civil wars." And then, as a finishing touch, he adds "Isaac Newton saw the light in the very year in which the civil war broke out (1642)"!

I am not suggesting that Faure is wrong in his insistence upon the tragic element in great art or in his remark that war has been an integral part of civilized history (cf. my *The Universities Look for Unity*, New York, 1943, pp. 41-2).

Historical research has already indicated that war was only one of a number of stimuli behind the rise of natural science in Great Britain in the age of Newton, and that the strong desire for peaceful economic development was of even greater importance.[43] According to Professor Clark, still other stimuli were medical progress, problems of the fine arts and musical theory in particular, religious ardour about nature as the work of God, and pure speculation. If a comprehensive view is to be obtained of the influence of wars upon those aspects of the intellectual life of the age which were devoted to science and invention, it is necessary to compare the developments on the practical and the theoretical sides, to consider the bearing of each upon the other and the relation of wars and preparations for war to both.

(*iii*) For England the late seventeenth and early eighteenth centuries were an age full of "projectors," who devoted their skill to mechanical and other utilitarian improvements.[44] Many technical advances were made, but the most successful of them related to the perfection and elaboration of methods and processes discovered earlier both on the Continent and in England, rather than to more fundamental inventions. For example, boring rods to discover the whereabouts of ores and minerals had been introduced between 1600 and 1615 in the Midlands and Northumberland, but it was not until at least the turn of the seventeenth and eighteenth centuries that the instruments were sufficiently improved to make it possible for prospectors to determine, without sinking shafts, the approximate thickness of a seam or its quality.[45]

The "early industrial revolution" of the age of Elizabeth and James I was made possible by sweeping changes in industrial technique of a fundamental character, which pointed the way toward modern times.[46] Before the Civil War the British had already established an independent technical tradition, which they built upon in the age of (for them) more frequent wars which followed. That tradition had been created with the help of technical principles borrowed from abroad—from the Low Countries, Italy and above all from central Europe, where the Germans, the Hungarians, the Poles and the Czechs had excelled in the techniques of mining and metallurgy at the beginning of the sixteenth century.

[43]B. Hessen, "The Social and Economic Roots of Newton's 'Principia' " (*Science at the Crossroads*, London, 1931, pp. 157-74); G. N. Clark, *Science and Social Welfare in the Age of Newton* (Oxford, 1937), pp. 68-91; Nef, *Rise of the British Coal Industry*, vol. I, pp. 240-56.

[44]As used by Defoe, the word "projects" included public works of all kinds. He called Noah's Ark and the Tower of Babel projects! (See *An Essay Upon Projects* in *The Earlier Life and Chief Earlier Works of Daniel Defoe*, ed. Henry Morley, London, 1889, p. 38.)

[45]Nef, *Rise of the British Coal Industry*, vol. II, pp. 446-8.

[46]J. U. Nef, "The Progress of Technology and the Growth of Large-scale Industry in Great Britain, 1540-1640" (*Economic History Review*, vol. V, 1934, pp. 5-18); "Prices and Industrial Capitalism in France and England, 1540-1640" (*ibid.*, vol. VII, 1937, pp. 174, 184).

During the age of Newton the English projectors were also influenced directly by foreign practice, but the influences were of a different kind. They came mainly from different sources. English technicians were now guided and stimulated less by the states of the disintegrated Holy Roman Empire than by France. There was a kind of marriage of the English desire for comfort and material profusion, born at home in the Elizabethan age, with the French desire for order, proportion, harmony and grace, characteristic of the classicism which evolved during the reigns of Louis XIII, Louis XIV, and Louis XV, from 1610 to 1774.

The age of Newton was by no means devoid of technical discoveries which were industrially of a more portentous nature. For the triumph of industrialism, the two most important inventions were the steam engine and the method of substituting coke for charcoal in the blast furnace for producing pig iron. Both inventions were made in the first decade of the eighteenth century. Both were English. Neither was primarily the result of war demands. The search for a steam engine, together with its actual discovery, is explained first and foremost by the need for draining mines. What made this problem especially acute in Great Britain was the tremendous increase in the output of coal during and after the Elizabethan age.[47] The demand for coal was predominantly of a peaceful nature—for heating and cooking to meet the wants of a growing population, and for supplying a large number of industries, most of which thrived more on peace than on war.

As we look back, we can see that the shortage of metal interfered with the carrying on of large offensive operations in the wars of early modern times.[48] But the evidence suggests that the need for metal in war was by no means the chief driving force behind the discovery, apparently in 1709, of a successful method of producing pig iron with mineral fuel. Serious attempts to solve that particular problem had begun early in the peaceful reign of James I, before the outbreak of the Thirty Years' War greatly increased the demand for weapons on the Continent. The discovery of coke, which proved to be an essential step in solving it, seems to have been made in connection with the drying of malt, probably before the Civil War. It would be difficult to show that war did more than peace in early modern times for the expansion of the English brewing industry!

There are, broadly, three ways in which the performance of tasks set by warfare and the preparation for it can contribute to peaceful technological progress. One is by the building of new kinds of furnaces, machines, or public works which prove useful in the carrying on of normal industry and trade as well as in the waging of war. Another is by the discovery of mechanical improvements, designed for weapons, but which are later adapted to add to industrial efficiency, or which help to indicate a method of technical advance that proves fruitful in time of

[47]Nef, *Rise of the British Coal Industry*, vol. I, pp. 242-4, 353-8, and *passim*.
[48]See below, pp. 69ff.

peace. The third is by focusing more talent or greater ardour upon technological inquiries than was devoted to them when military and naval problems were less urgent.

Better naval engineering, advances in the quality of ammunition, in the power and deadliness of firearms, grenades, bombs, mines, mortars and other weapons, improvements in forts, the construction of more defensible harbours—all engaged the attention of British, as of Continental, inventors and technicians in the late seventeenth and early eighteenth centuries.[49] But military requirements raised fewer technical problems than the more continually insistent needs for powerful machinery, better furnaces, and artificially treated raw materials in connection with industries which flourished more in peace than in war. And while the demands of war set many new questions for inventors and mechanics, they also diverted their attention to some extent from the more numerous questions set by the need for peaceful economic progress.[50] In Great Britain, many men in all walks of life had become interested in the second kind of questions during the sixty or seventy years or so preceding the Civil War. The momentum gained by the study of technical improvement could account for the inventiveness of Englishmen in the century that followed, even if it had been as peaceful for England as the previous one. The passion of such persons as John Evelyn (1620-1706) to seek direct knowledge of the physical and biological worlds was partly inherited from the era of the "early industrial revolution."[51] In Evelyn's case it had undoubtedly caught hold of him before the Civil War, which broke out when he was already 22 years old.

Given this momentum, what calls for explanation perhaps is why there was not more technical progress between 1640 and 1740 rather than why there was so much. What is puzzling, particularly in connection with the use of coal in iron making, is why coke was substituted for charcoal only so long after it had been used for drying malt, and why the new process for smelting was little used for making pig iron until 1775, some sixty-five years after it had been discovered.[52] What is puzzling is why it was not until 1785, more than two generations after this invention and the invention of the steam engine, that these and other new devices began to revolutionize industrial organization and to bring about a phenomenal increase in industrial output.[53] If war had been the leading taskmaker for the technician, would he not have accomplished more than he did between about 1625 and 1775 to meet the most urgent need of the armed forces—a great addition to the supplies of metal?

[49]Cf. Defoe, *An Essay upon Projects*, pp. 25, 31-2. And see below, pp. 61ff.

[50]Cf. Clark, *Science and Social Welfare in the Age of Newton*, pp. 17-19, 73-4.

[51]See above, p. 52. Cf. Virginia Wolff, *The Common Reader* (London, 1925), p. 111.

[52]Cf. T. S. Ashton, *Iron and Steel in the Industrial Revolution* (Manchester, 1924), p. 60, and chap. ii.

[53]J. U. Nef, "The Industrial Revolution Reconsidered" (*Journal of Economic History*, vol. III, 1943, pp. 5, 24).

Wars do not seem to have been of decisive importance in the technological progress for which the British became famous in the eighteenth century all over the Continent. The country would almost certainly have taken the lead in practical inventions, even if it had managed to stay out of wars as successfully as in the age of Elizabeth and James I. Defoe's suggestion that the war of the Dutch Alliance was the chief cause of the "general projecting humour of the nation" during the 1690's is an example of his characteristic habit of overstatement in economic matters.[54] He was far from attributing English economic leadership mainly to war, as is evident from his *Complete English Tradesman.* "War has not done it; no, nor so much as helped or assisted to it." In another passage, he suggested that wars had grown milder in the late seventeenth century.[55] But for that, they might have interfered seriously with peaceful technological improvements, as they probably had earlier in central Europe.

(*iv*) Defoe's exuberance over "projects and projectors" should not obscure the fact that the age of Newton was less important for its technical advances and its inventors than for its fundamental theoretical discoveries and for its eminent men of science.[56] To contemporaries, no less than to modern historians, the achievements of Newton and Boyle seemed on a much higher plane than those of the most ingenious projectors or mechanics. No writer would have thought of comparing the intellectual stature of Thomas Newcomen (1663-1729), who set up the first practical fire engine, or the elder Abraham Darby (1677-1717), who introduced coke in smelting, with that of thinkers such as these. It remained for the popular press of recent times to try to raise mere technical inventors to the rank of great intellects. Until after the middle of the eighteenth century, they were classed with mechanics.

The age of Newton was the greatest of all ages for the more philosophical aspects of science. Science had begun to assert a complete independence from the old Aristotelian metaphysics. This it could hardly have done had it not contained metaphysical implications of its own which seemed to be irreconcilable with that metaphysics.[57] Few scientists would quarrel with the statement that Newton was probably the most important synthesizer in the whole of scientific history. The general propositions which he laid down concerning the physical universe have been undermined by the new scientific discoveries of the twentieth century. But Kant and other great metaphysicians who followed Newton felt obliged to conform to these propositions and even to build their philosophical systems around them. With Newton the basic

[54]*Essay upon Projects* (1697), pp. 25, 31.

[55]*The Novels and Miscellaneous Works of Daniel De Foe* (ed. Walter Scott, Oxford, 1841, vol. XVII, pp. 248-9), and see below, p. 67.

[56]Cf. Babbage, *Reflections on the Decline of Science in England*, p. 2.

[57]E. T. Whittaker, "Aristotle, Newton, Einstein" (*Science*, vol. XCVIII, no. 2542, 1943, pp. 249-53), an article called to my attention by Dr. Dallas B. Phemister.

scientific work begun on the Continent in the sixteenth century was carried to a tentative conclusion. Seventy years ago it was still correct to say, as Burckhardt said, that the results achieved by the greatest seventeenth-century scientists "were the foundation of all later consideration of the universe, indeed, of all thought. Hence they rank with the philosophers."[58]

In the age of Newton, problems of practical technology contributed to the progress of natural science in at least two ways. For one thing, questions of economic improvement, and the demand for economic improvements which came from enterprising financial adventurers, from the rising squirearchy, from husbandmen and even from humble industrial managers and foremen, called widespread attention to subjects and methods which were of interest to the scientists. Anyone familiar with Boyle's *Works*, with the early *Philosophical Transactions* (the proceedings of the Royal Society), or with Birch's *History of the Royal Society* will recognize that the scientists were anxious to help in reducing manual labour and diminishing sickness. Practical subjects took on a greater importance than they had had for medieval scientists. Connections between speculative and practical knowledge were more clearly seen.

The growing interest in the economic sides of life also strengthened science in a less tangible way. In recent times there has been a tendency for the creative thinker to suffer something of an eclipse, as a result of the prevailing emphasis upon results which can be measured in terms of material progress. But in the seventeenth and early eighteenth centuries, when an enthusiasm for technological improvements first took possession of the articulate public, above all in England, this added to the prestige of the theoretical scientist. His indirect role as a material benefactor of mankind was more fully recognized, at any rate by influential opinion, than it has been in the United States in recent times. Leading men of letters ranked the greatest living scientists among the few supreme geniuses of all the ages. The enthusiasm of cultured men, including poets, in Great Britain and later even on the Continent for the general theoretical achievements of science was linked closely with the growing interest of country gentlemen and other amateurs in natural history and technological progress.

The utilitarian view may be of great value to fundamental scientific progress and to human welfare under such conditions as prevailed in Europe in early modern times, when formal logic and book learning were overvalued in the schools. Such a view may be of disservice under the conditions which prevail in our time, when the value for truth of all reasoning which is not subject to material verification and which depends partly upon the imaginative faculties of the mind has come to be so widely and so loudly denied.

It is difficult for the historian to keep natural science and practical technology separate in an age like that of the Restoration, when the

[58]Burckhardt, *Force and Freedom*, p. 311.

actual relations between them, and the nature of their interdependence, were more justly understood by the articulate public, at least in Great Britain, than they had been in the middle ages or than they are in the twentieth century. In so far as military and naval needs commanded the attention of "projectors" and successful inventors, the needs were likely to stimulate scientific inquiries. The use of fire-arms of various kinds raised issues unknown to the ancients or to medieval scientists, and the whole science of ballistics developed in Europe in the sixteenth and seventeenth centuries in response to new military questions which seemed to require answers.

Mathematical speculations consequently derived a stimulus from modern warfare. In his numerous writings, Robert Boyle skirted around the use of science for destructive purposes whenever he found this possible.[59] Yet he remarked that mathematics "may be of moment in the practice of gunnery," and he pointed to the work of Galileo and Torricelli in tracing the line of a projectile shot out of a cannon.[60] Natural science was provided with some of its subject matter and helped with some of its methods by war. No doubt the new relation which was felt to exist in early modern times between science and military and naval success did something to increase the prestige of great scientists.

Yet the contribution of warfare to natural science in the age of Newton was probably less important than its contribution to practical technology. At the same time warfare interfered with the growth of scientific knowledge. This conflict was more serious than that between warfare and technological progress.

Among the numerous factors responsible for the rise of modern science, the disinterested search for truth is important. The more general and comprehensive the nature of the scientific work has been, the more indispensable to its success, even to its conduct, has been the love of truth. It has been observed that the greatest scientists are frequently men of singular beauty of character.[61] The driving force behind their labour is a passion for knowledge which resembles that of the great artist for his art, in the sense that the love which both have transcends the self and determines the work done, independently of the ordinary personal motives which are frequently of dominant importance in the lives of more ordinary men. Genius is not at the mercy of circumstances in the same way as talent. It has at once less and more freedom. Genius is not free to enlist in worldly causes because it is already enlisted in a higher cause which transcends time and place. Warfare (with its excitement, its danger, and its drama) puts ordinary men on their

[59]See below, p. 58.

[60]*Works*, p. 428. Cf. *The Life and Works of John Arbuthnot* (1667-1735), ed. Geo. A. Aitken (Oxford, 1892), pp. 426-7; Benjamin Robins, *Neue Grundsätze der Artillerie*, ed. Leonard Euler (Berlin, 1745), preface. (I have been unable to see an English version of this treatise.)

[61]Sir William Bragg, "History in the Archives of the Royal Society" (*Science*, vol. LXXXIX, no. 2316, 1939, pp. 452-3).

mettle. It may lead them to outdo (another name for forgetting) themselves even off the field of battle. For a time, therefore, it may stimulate technical experts and inventors to a higher pitch of thought and labour than they are able to command when their country is at peace. But war is of no help in this way to the very great scientist, any more than it is to the very great artist. Both are on their mettle, both forget themselves, without it. Neither emotional excitement nor a sense of imminent danger were the driving forces behind the achievements of men like Newton and Boyle.

The highly sensitive nature and the love that are part of intellectual and artistic genius, are incompatible with the kind of zeal for contriving new methods of human destruction which can be aroused in men of lesser stature—technical experts and even inventors. European genius in medieval and early modern times had always looked on war with horror. "To clash with violence," wrote Erasmus, "is characteristic of beasts and of gladiators, whom I class among beasts."

Great scientists in the age of Newton held a similar view of war. Boyle was certain that it was no part of a learned man's duty to contribute to these "hellish machines." In 1680 a correspondent chided him for having showered bounties on a certain Dr. Kuffler, to keep the man "from vending his destroying artifice," apparently some form of fireworks. Boyle and Samuel Hartlib, the great expert on farming, had hoped more than twenty years before to get Kuffler sufficiently interested in improvements in husbandry so that he would "desist from all eager pursuits about his dreadful and destroying invention." Such scruples were by no means uncommon in the late seventeenth and eighteenth centuries.[62]

In writing to Boyle, his correspondent advanced the familiar and perennial argument,[63] that new destructive engines, like Kuffler's, had made and would continue to make warfare more humane.[64] We do not know whether Boyle was impressed, but there is no reason to think he had changed the position concerning the scourge that he had taken during the Civil War. In 1646 he wrote from London: "The greater part of men in these parts are pleased to flatter themselves with the hopes of a speedy settlement of things; but for my part, that have always looked upon sin as the chief incendiary of the war, and yet have by careful experience observed the war to multiply and heighten those sins, to which it owes its being, as water and ice, which by a reciprocal generation beget one another, I cannot without presumption expect a recovery in that body, where the physic that should cure, but augments the disease."[65]

Whenever warfare was very serious, its adverse effects on the develop-

[62]Cf. Clark, *Science and Social Welfare in the Age of Newton*, p. 74; Poppe, *Geschichte der Technologie* (Göttingen, 1810), vol. II, pp. 564-5.

[63]Cf. *Histoire de l'Académie Royale des Sciences, 1707*, pp. 120 ff.

[64]Boyle, *Works*, vol. VI, pp. 118-19, 441-2.

[65]*Ibid.*, vol. I, p. xxxi. Cf. vol. I, p. xxix.

ment of scientific knowledge probably more than offset the help which science derived in subject matter, methods, and prestige from new military problems and their solution. In France the long wars of Louis XIV seem to have interfered with the abstruse scientific studies begun in the 1660's.[66] Louvois (1641-91), who got more than four hundred thousand men into the armed forces of France on the eve of his death, expressed the hope in 1684 that the Academy of Science would devote itself to what he called its true objective—"the Glory of the King."[67] It was only during the relatively peaceful decades of the eighteenth century, which followed the Treaty of Utrecht, that a great French school of natural science developed to rival the English.

We live in an age when the temper of mankind, and the kind of publicity which has gained the ascendancy over the public, have given short-term views such prominence that they threaten to black out the results of serious thought and to obscure its nature by confusing it with the fleeting products of technicians. Great creative movements of the human mind, which flower in a number of individual lives, are always the product of a cultural preparation stretching back for decades and even for generations. Quick results are frequently the enemies of great and enduring ones, both for individual lives and for societies. As the principal scientific work of the late seventeenth and early eighteenth centuries was of the kind in which the speculations of the mind and the procedures of research approach closest to philosophy, it was necessarily the fruit, to a much greater degree than the technological advances which accompanied it, of a rich intellectual tradition. To search for its inspiration exclusively in the British history of Newton's lifetime would be to neglect its deeper sources. The "new philosophy" owed much to continental scientists. It owed something to the philosophies of Descartes and Spinoza. But it had germinated in England in the time of John Donne and Francis Bacon, when the nation was almost always at peace, and when the court of James I, for all its weaknesses, and for all the pedantry of the king, was the only court in Europe where the learned professions were in any degree appreciated.[68] Newton and his contemporaries were the heirs to the conception of the *New Atlantis*. According to that conception, it was possible to understand and master the physical universe in the interest of God as well as of man, without setting out to conquer the civilized peoples of the globe. Society in seventeenth-century Great Britain had come to take limited warfare for granted. In modern times this conception of war has been a part of all British philosophy, of all British thought.

Yet, it will be said, the first rich results of the "new philosophy" were

[66]Cf. Clark, *Science and Social Welfare in the Age of Newton*, pp. 17, 19, 73-4; L. F. Alfred Maury, *Les Académies d'autrefois, l'ancienne Académie des Sciences* (Paris, 1864), p. 39; C. W. Cole, *Colbert and a Century of French Mercantilism* (New York, 1939), vol. I, p. 459.

[67]*Histoire de l'Académie Royale des Sciences*, 1666-86, p. 386.

[68]Mark Pattison, *Isaac Casaubon* (ed. 2, Oxford, 1892), pp. 263-4.

harvested in what was for Great Britain a warlike period. In order to understand the relation of wars to science, we have to see these wars in the proper perspective. Only the Civil War brought about any general interruption in the ordinary economic and intellectual life of the country. While some of the other wars turned the attention of scientific groups to military and naval problems, there seems to have been little pressure on individuals to curtail in the interest of victory their more theoretical and general speculations. English life was affected by warfare between 1640 and 1713 more than during the previous seventy-five years. It was still less affected than the life of the Continent.

The more we consider the course of history in relation to science, the more we are drawn to the conclusion that the relative mildness of warfare had far more to do with the progress of natural science in the late seventeenth and eighteenth centuries, than the technical and scientific problems produced by military needs. The respite from fierce and continual fighting, such as had been the lot of England in the later middle ages, such as had been the lot of nearly all Continental countries in early modern times, contributed to the growth of a common European culture and spirit. The interchange of scientific knowledge between the leading scientists of all nations at meetings of the Royal Society was encouraged by the diminution in the bitterness with which wars were waged. No doubt under some conditions a dose of mild wars can do more to help than to hinder science. It is possible that there were certain periods between, say, 1659 and 1789 when such conditions prevailed. But history suggests that it is very difficult to catch the dose which benefits more than it harms the growth of scientific knowledge.

IV. Influence of Science and Technology on Wars

(*i*) If we are concerned with the reciprocal relations between wars and the rise of industrial civilization, the influence of science and technological improvement upon the weapons used and upon the character of wars, is of no less interest than the influence of wars upon science and invention. The role which wars have played in the history of civilization, their effects upon human nature and upon societies, have varied with the varying conditions under which they have been waged. Among the factors which have determined these conditions, the technical means available for conducting them have been important.

In the history of warfare, periods when the advantages lie with the defence oscillate with others when they lie with the offence. As wars are fought, after all, even in our mechanical age, by human beings, these oscillations are not smooth and predictable like those of a swinging pendulum. They are very uneven both in extent and in time. Some occur in the course of a single battle or campaign, others in the course of a war, others still during a series of wars, like those fought by France under Louis XIV, or like the much smaller wars of the English under Charles II against the Moors, or like those, so much vaster in scope and

total in objectives than any previous ones, fought by Germany against much of the world in the twentieth century.

In European history, have not all these relatively short-term oscillations occurred within the range of longer ones which stretch over a century or more? The Gothic age, with its wonderful cathedrals and fortified places, was an age when the attackers in Europe generally met serious and increasing difficulties. With the widespread introduction of firearms at the turn of the fifteenth and sixteenth centuries, old fortresses lost their power to resist attack. An age ensued during which the offence possessed, apart from short-term setbacks, substantial advantages. The age which began with the English Civil War and ended with the War of the Austrian Succession was a period when the defence regained some of the ground lost since the reign of Saint Louis (1226-70).

In spite of the projecting mood which prevailed in Great Britain and to a lesser extent on the Continent, in spite of the frequent direction of this mood to improvements in weapons, the actual advances in the technique of destruction were less remarkable between the Peace of Westphalia and the accession of Frederick the Great than in the sixteenth and early seventeenth centuries. Many ingenious new engines of war were described by their sponsors in papers submitted to the English Crown. There were, for example, in 1664 Captain Samuel Carrington's "fireworks," which he offered to bring over to England or Flanders from Madrid. He promised that they would destroy any enemy vessel in "half an hour." These may have resembled the bomb described by the Marquis of Worcester, the amateur inventor who died in 1667. This bomb could either be carried surreptitiously by a spy in his pocket and planted in a ship of the enemy, or it could be confided to a diver to fasten to the hull.[69] There was also Erasmus Purling's "warlike engine to row with 100 or 120 oars, and 1000 or 1500 men, secured from shot." It was said to be capable of either burning or sinking an entire fleet, whether at sea or in a fortified harbour, "though 100 sail together."[70]

Such prodigious schemes may have died with their inventors, as the methods for boring better cannon of a new metal alloy, devised some years later by Prince Rupert (1619-82), are said to have died with him.[71] It is likely that the schemes of Carrington and Purling were no more practicable than the majority of secret weapons which are invariably noised abroad in time of war. The most portentous conceptions of the age—the submarine and the tank, or armoured car—were not new. Both had been thought of and designed in England at least as early as the reign of James I.[72] It was three centuries afterward before any of

[69]Cf. Marquis of Worcester, *A Century of Inventions* (1663, John Buddle ed., Newcastle, 1778, p. 12).

[70]*Calendar of State Papers, Domestic*, 1664-5, pp. 112, 146; 1665-6, p. 283. Cf. *ibid.*, 1673-5, p. 15, and Boyle, *Works*, vol. V, p. 6. For other new warlike inventions, see Worcester, *A Century of Inventions*, pp. 13-14, 16-18, 23-5, 28-9.

[71]Defoe, *An Essay upon Projects*, p. 40.

[72]Nef, "War and Economic Progress, 1540-1640," p. 19.

these vehicles were to play an important part in wars. Nothing substantial was done about them between 1640 and 1740. Without more information than is at our disposal, it is impossible to say that Sir William Petty's "war chariots"[73] were more artfully conceived than the species of tank which John Napier had found time, in the midst of his mathematical speculations, to plan shortly before his death, in 1617.

Many improvements were actually made in weapons during the late seventeenth and early eighteenth centuries. Like the advances in ordinary industrial technology, these improvements consisted for the most part in the perfection and elaboration of ideas which went back to an earlier age.[74] The new and larger vessels of the English navy, designed when artillery was recognized as the main instrument of naval warfare, were called for by a Commission of Reform in 1618. Phineas Pett, who seems to have been the intellectual father of such warships, was a leading shipwright of King James I, though his ideas received a general embodiment in the navy only with the first Anglo-Dutch war of 1652-3.[75] During the second half of the seventeenth century attacking forces, in their attempts to capture strong places, began to employ a missile which the English dubbed, somewhat inelegantly, a "stink-pot." These stink-pots were ignited at both ends and hurled into forts, where they were intended to do double mischief. They burst into flame and might therefore set any wooden or other inflammable matter ablaze, while they also spread a poisonous gas, so "that men are sufficated with it."[76] For all these venomous properties, the stink-pot was a form of hand grenade. Grenades and bombs came into more extensive use than ever before in the 1670's; the technique of throwing them was greatly improved at about that time;[77] but the bomb had been invented in or before 1588, when, it has been suggested, bombs were heaved for the first time by the besiegers in the Dutch Gelderland.[78]

Even the bayonet, almost always thought of as a discovery of the late seventeenth century, probably had an earlier origin. Like so many of the terrible weapons of war, it was not invented for killing men, but

[73]*The Petty Papers*, ed. Marquis of Lansdowne (London, 1927), vol. II, pp. 71-6.

[74]Cf. *Histoire de l'Académie Royale des Sciences*, 1666-1740, *passim*; M. Gallon, *Machines et Inventions approuvées par l'Académie Royale des Sciences depuis son Etablissement jusqu'à présent* (Paris, 1735), vols. I-VI, *passim.; Philosophical Transactions, passim.*

[75]F. L. Robertson, *The Evolution of Naval Armament* (London, 1921) vol. I, pp. 16, 21, 25.

[76]E. M. G. Routh, *Tangier: England's Lost Atlantic Outpost, 1661-84* (London, 1912), pp. 163, 168.

[77]François Blondel (1617-86), the diplomat and architect, published in 1683, a book called *L'Art de jetter les bombes*, a landmark in the development of the technique (see *Histoire de l'Académie Royale des Sciences*, 1707, pp. 120 ff.; 1716, pp. 79-86; 1731, pp. 72-6).

[78]G. H. M. Poppe, *Geschichte der Technologie*, vol. II, p. 554; *Histoire de l'Académie Royale des Sciences*, 1666-86, pp. 230 ff.; Clifford Walton, *History of the British Standing Army, 1660-1700* (London, 1894), pp. 350 ff.; R. P. Daniel, *Histoire de la Milice françoise* (Paris, 1721), vol. I, pp. 579-80.

was adapted later for the purpose. In a French royal proclamation of 1660, the word *baïonette* is used to describe a sort of dagger which hunters could plug into the ends of their light firearms when engaged in the chase. Possibly it had been used decades before for hunting. When these plug daggers were first issued to troops is not clear, though the practice had begun in the sixties and early seventies. They were served out in large quantities as early as the winter of 1683-4 to the musketeers in an English regiment commanded by young John, Lord Churchill, the future Duke of Marlborough.[79] They were apparently a much more common weapon for English infantry in the eighties than the modern authors of military histories have supposed.[80] But even as late as 1690 the bayonets are said to have been screwed into the muzzles of the pieces. At about this time the iron ring and then the socket were devised making it possible to fire muskets with the bayonets fixed. Not long afterward, as better methods of adjusting the weapon to the barrel of the piece were devised, the use of the new, and much more effective, bayonet became general, first among the French infantry and somewhat later among the other European armies.[81]

During the last two decades of the seventeenth century a substantial increase was obtained by the French in the range of cannon fire, particularly from men-of-war.[82] In 1680 a French engineer named Renau conceived the idea of putting mortars on ships to hurl explosive shells; he invented the bomb-ketch, which was tried out with success in the bombardment of Algiers two years later. In spite of the incredulity of conservative opinion, the bombs from these sturdy little vessels buried, on one occasion, a large number of the inhabitants in the débris of their houses, while, on another, the bombs carried away the best part of the fortifications protecting the town.[83] The *tir à ricochet* was first employed in 1688 at the siege of Philippsbourg, in Baden.[84] This was a device by which cannon were made to spit out missiles which bounded along a stretch of firm, flat earth after the manner of smooth stones skipping over water. Muskets and pistols were made to fire more frequently. More and more, firelocks replaced the clumsy matchlocks (fired with matches) as a means of igniting the powder. The most effective of the two kinds of firelock had been invented earlier in Germany, where it was

[79] *Calendar of State Papers, Domestic*, 1683-4, pp. 111, 400.

[80] See, for example, *ibid.*, 1684-5, p. 130; 1689-90, pp. 145, 238.

[81] James S. D. Scott, *The British Army, Its Origin, Progress, and Equipment* (London, 1868), vol. II, pp. 314-25; Walton, *History of the British Standing Army*, pp. 253, 326, 340-9, 436; Francis Grose, *Military Antiquities* (London, 1786), vol. I, p. 181; J. W. Fortescue, *A History of the British Army* (London, 1899), vol. I, p. 327; Poppe, *Geschichte der Technologie*, vol. II, pp. 537-8; Delbrück, *Geschichte der Kriegskunst im Rahmen der politischen Geschichte* (Berlin, 1900), vol. IV, pp. 218, 305-6. It has not yet been established at just what date the socket bayonet supplanted the older plug bayonet.

[82] Robertson, *Evolution of Naval Armament*, p. 33.

[83] *Histoire de l'Académie Royale des Sciences*, 1719, pp. 103-5.

[84] Barre Duparcq, "Des Imitations militaires," p. 106. Cf. John Muller, *A Treatise of Artillery* (1768), p. 152.

called a snaphance.[85] Snaphance muskets were apparently a part of the standard equipment issued to many English regiments of infantry by the eighties of the seventeenth century.[86] At about the same time cartridges were coming to replace the noisy and dangerous bandaleers.[87] In 1710 a Swiss inventor in Berne discovered how to cast cannons solid and then bore them in such a way that the core could come out as one piece. Some two decades later a shot-maker of Bristol managed to prepare for the first time lead shot which was almost perfectly round.[88]

Yet what seems especially noteworthy is the sluggishness with which important improvements were made during the early age of French and English political hegemony. "Except for sheathing and pumps," writes an historian of the evolution of naval armament, "no important improvement in naval construction was patented between the years 1618 and 1800."[89] When John Muller, perceptor of engineering to the Duke of Gloucester, published his *Treatise of Artillery* in 1768, he remarked that "very little improvement has been made in the proportions of guns since Dilichius, a German, who wrote near 200 years ago.[90] The growth in the power of offensive weapons, so remarkable in the sixteenth century, became impressive again only about the middle of the eighteenth.

(*ii*) In his "Essay on the Usefulness of Mathematical Learning," published in 1700, John Arbuthnot, the famous physician and Tory political writer, explained that "there [is] a force or resistance in the due measures and proportions of the lines and angles of a fortification, which contributes much toward its strength. This art of fortification has been much studied of late, but I dare not affirm that it has attained its utmost perfection."[91] These studies seem to have been rather more fruitful during Arbuthnot's lifetime (1667-1735) than the studies of destructive weapons. Before he wrote this essay, considerable progress had already been made.

The greatest contributions have been sometimes associated with a celebrated and learned Frenchman, the seigneur de Vauban (1633-1707). His mind touched French classical civilization at many points. In the early wars of Louis XIV's reign, when the French were extending their frontiers, he helped to devise new methods of attack, for many strong places

[85]Cf. Firth, *Cromwell's Army*, p. 87.

[86]See e.g. *Calendar of State Papers, Domestic*, Jan.-June, 1683, pp. 366; 1683-4, p. 242; 1684-5, p. 95. Matchlock muskets were still used, however (*ibid.*, 1689-90, p. 238).

[87]Firth, *Cromwell's Army*, pp. 87, 89; Orrery, *A Treatise of the Art of War*, p. 31; Walton, *History of the Standing Army*, p. 328; Hermann Foertsch, *The Art of Modern Warfare* (New York, 1940), pp. 62, 65.

[88]Poppe, *Geschichte der Technologie*, vol. II, pp. 544-6, 574.

[89]Robertson, *Evolution of Naval Armament*, p. 50.

[90]Muller, *A Treatise of Artillery*, p. iii. Cf. Robertson, *Evolution of Naval Armament*, p. 89; G. von Scharnhorst, *Handbuch für Officiere, Erster Theil, Artillerie* (Hanover, 1804), vol. I, pp. 19-20; Savary des Bruslons, *Dictionnaire universel de commerce*, vol. II, p. 495.

[91]George A. Aitken, *The Life and Works of John Arbuthnot* (Oxford, 1892), p. 426.

in the Low Countries and in the valleys of the Moselle and the Rhine were infested by the French armies.[92] It was Vauban who first used the *tir à ricochet.* Yet he is known to have felt some scruples, at least over the name. He thought that it might suggest a mischievous trickery which he repudiated as illegitimate in warfare.[93] Unlike Condé (1621-86), who preceded him as a leader in the French councils of war, Vauban's first object was to save the lives of the troops engaged in battle. According to the writer of one of his obituaries, his "natural humanity" led him always to sacrifice a quick victory for the sake of conserving men.[94] He was an economic thinker of much distinction, and the foremost purpose of state policy for him was the material wellbeing of the French people.[95] This purpose was difficult to reconcile with limitless territorial expansion. As the years went on, Vauban turned more and more to the art of fortress construction. This called for the same measure and proportion which the French were cultivating with such success in the fine arts and in the art of life. From his own adventures in attacking, Vauban had learned better than any soldier of the age how to defend.[96] With the help of ideas derived from his predecessors, he built systems of lowlying forts equipped to return the fire of the enemy. They provided the most effective answer yet devised to attacking artillery, before the violence of which medieval and early modern fortresses had been almost impotent.[97] It became easier to hold off the enemy effectively for a considerable time, if the defenders had sufficient provisions and showed energy and courage. The frontiers of France were embroidered with the new forts. They shielded the entrances to harbours like Dunkirk[98] and Antibes, as travellers ever since Vauban's time have been able to see for themselves.

On the eve of the French Revolution a French soldier, writing about tactics, spoke with something resembling scorn of "the mania for fortress building" a century earlier. He attributed to this the great increase in the expense of warfare.[99] Notwithstanding the efforts made by Vauban and other French strategists to supplant one system of fortresses by others farther east, the lines of fortifications from the Alps to the North Sea were an indication that the political aspirations of the leading power

[92]Cf. *Calendar of State Papers, Domestic,* 1671, p. 139.

[93]Barre Duparcq, "Des Imitations militaires."

[94]*Histoire de l'Académie Royale des Sciences,* 1707, p. 169; Henri Baudrillart, "Vauban, économiste et réformateur" (*Séances et Travaux de l'Académie des Sciences morales et politiques,* vol. LXXXIII, 1868, p. 73).

[95]*Ibid.,* p. 85; A. M. de Boislisle, *Correspondance des contrôleurs généraux des finances avec les intendants des provinces* (Paris, 1883), vol. I, no. 1870.

[96]According to at least one French writer, the Comte de Guibert (1743-90), Vauban's contribution to the attack outdistanced his contributions to the defence (*Essai général de tactique* (1772) (Liége, 1775, vol. I, p. lv, a work called to my attention by Dr. Ulrich Middeldorf). But see below, note 103.

[97]Baudrillart, "Vauban, économiste et reformateur," p. 71. Cf. Colonel de Rochas, *Vauban, sa famille, et ses écrits,* vol. I, pp. 120 ff.

[98]Cf. *Calendar of State Papers, Domestic,* 1671, pp. 219, 287.

[99]Guibert, *Essai général de tactique,* vol. II, pp. 147-8, 151 ff., 158.

on the Continent had limits.[100] The danger to France itself of a "Maginot Line mentality" was not yet serious, partly because the resources in men and weapons of the small German states were too weak to make practicable any project aiming at the annihilation of the French nation.

The full advantages of the improvements in fortifications were realized only after Arbuthnot's essay had appeared and Vauban had died. A French fort, with stone bastions many feet thick, was built as far west as the meadows along the Mississippi, at Chartres in the Illinois country. Such forts stood as symbols of the renewed marriage between warfare and architecture, a less perfect marriage than that represented by thirteenth-century Carcassonne, but in something of the same spirit. It was not until the later years of the War of the Austrian Succession, from 1744 to 1748, that artillery was employed capable of effectively demolishing these strong places.[101] Eventually the growth of industrialism, which was reflected in the more powerful artillery, was destined by various means to play a small part in ending the unified artistic principles and the sense of appropriate size and proportion which the architecture of the seventeenth and eighteenth centuries retained and which nearly all of the numerous architectures of the nineteenth century neglected.

No fortifications have ever been impregnable. The discouragement to taking them always lies, an Englishman observed in 1715, when he edited a sixteenth-century Italian treatise, "with the great loss of Men's lives and expense of Time and Treasure, not the impossibility."[102] Fortifications built in the late seventeenth and early eighteenth centuries were helpful to the defence less for their inherent qualities than for two other reasons. They were numerous and they were established at a time when daring, spirited and powerful attacks were diminishing in frequency. As Marshal Saxe remarked in his memoirs, published in 1757, seven years after his death, "all the ancient fortifications are absolutely good for nothing, *and the modern ones are not much better* . . . ."[103] He was influenced no doubt by the new power of attack first exhibited in the War of the Austrian Succession.

Against the power of resistance embodied in fortifications and their defenders, it is always necessary to weigh both the material means at the disposal of attackers and the intellectual and moral conditions of the political entities which they represent. Neither the material nor the cultural life of Europe, nor the size and character of the armies,[104] in the late seventeenth and early eighteenth centuries were such as to encourage

[100]Cf. *ibid.*, p. 153.

[101]Scharnhorst, *Handbuch für Officiere*, vol. I, p. 18.

[102]Guido Pancirollus (Panciroli), *The History of Many Memorable Things Lost* (English trans., London, 1715, vol. II, pp. 449-50).

[103]Count Saxe, *Reveries or Memoirs upon the Art of War* (London, 1757), p. 90 (my italics). Cf. p. 108 sqq., where the weaknesses of Vauban's fortifications are discussed.

[104]This is a point which I hope to develop in a later essay.

princes or leaders of their armed forces to push attacks relentlessly. In the sixteenth and early seventeenth centuries, fierce battles in which "either you are vanquisher or vanquished" had been an accepted part of warfare.[105] This ceased to be true in the age following the Thirty Years' War and the English Interregnum. "We make War more like Foxes, than Lyons," remarked Robert Boyle's brother, the Earl of Orrery, in 1677, "and you will have twenty Sieges for one Battel."[106] Two decades later Defoe remarked on the great change in the strategy and tactics of campaigning since the Civil War. "Now," he wrote, "it is frequent to have armies of fifty thousand men of a side stand at bay within view of one another, and spend a whole campaign in dodging, or, as it is genteely called, observing one another, and then march off into winter quarters . . . . The present maxims of the war [of the Dutch Alliance] are—"Never fight without a manifest advantage, And always encamp so as not to be forced to it."[107] A German historian has pointed out that at the beginning of the eighteenth century commanders of victorious armies never aimed at the annihilation of a defeated enemy. They expected the troops to get away.[108]

With such maxims and such a view of the tactics of pursuit, a commander was not likely to risk much in storming strong places, or in trying to force the enemy to battle in the open. It was thought better to surround and starve out forts, or to undermine them and take them piecemeal. This was a tedious business, when there were so many forts and when the number was always increasing.

(*iii*) One important explanation of the changes in strategy was economic. European industrial development ran into a snag whenever the supplies of raw materials necessary to it were scarce. In the era of the Reformation, a shortage of ores helped to slow down the expansion which had been going on in central Europe since the late fifteenth century. After the reigns of Elizabeth and James I, an acute shortage of wood helped to postpone the English industrial revolution for a century and a half, in spite of the dress rehearsal in the time of Shakespeare. If wars were increasingly mild in the late seventeenth and early eighteenth centuries, this was partly because of the scarcity of indispensable materials.

In early modern times the most important materials for producing the flow of munitions necessary to smite the enemy were saltpeter, wood, and the various metals. The provision of most of them, in adequate quantities, became increasingly difficult. Now that firearms were the crucial weapons, wars could not be fought effectively on either land or

[105]Lord of Praissac, *The Art of Warre or Militarie Discourses* (English ed. by John Cruso, Cambridge, 1639, p. 29).

[106]Orrery, *A Treatise of the Art of War*, p. 15.

[107]Morley (ed.), *The Earlier Life and the Chief Earlier Works of Daniel Defoe*, p. 135.

[108]Carl von Noorden, *Europäische Geschichte im achtzehnten Jahrhundert* (Düsseldorf, 1870), p. 575.

sea without adequate supplies of gunpowder; nor could gunpowder be had without saltpeter. The authorizations issued by kings and princes to saltpeter men to enter private lands and to ransack cellars, stables, bird-houses, and even bedchambers for the necessary decompositions, were extremely unpopular. They almost always left the sovereigns short of supplies for manufacturing gunpowder. Indian saltpeter, imported to supplement the domestic product,[109] was hard to obtain in large quantities in a hurry, particularly by states without ships. So it was difficult to concentrate what we should now regard as a substantial amount of gunpowder in a particular campaign. It is no wonder that during the second Anglo-Dutch war, an English physician employed by the Emperor of Russia should have written with excitement from Moscow about an English brickmaker there who claimed he had found a means of shooting lead without gunpowder. The physician regrets that this mechanic is not in England to help in the war. "Had he learning," writes the physician, "he would be more famous than Archimedes."[110]

Before the end of Louis XIV's reign, the French had ceased to depend upon imports of saltpeter. They had unearthed what were thought to be inexhaustible supplies at home.[111] But, while the problem of providing gunpowder was less serious in the early eighteenth century than it had been, the forests at the ready disposal of the great European powers were insufficient for conducting anything approaching the total wars to which mankind is becoming accustomed in the twentieth century. Today the Western peoples have freed themselves from the general use of wood in warfare. But, in early modern times, timber was, of course, both the flesh and the bones of men-of-war, as of merchant ships.

Professor Albion has described the immensely difficult and complicated problems which confronted several generations of British admiralty officials in obtaining at home and abroad the various kinds of timber upon which success in war at sea depended. Holland had to build its fleet almost entirely with imported timber, much of which came from the forests of Norway and the Rhineland. During the seventeenth century France was more adequately stocked with wood than Great Britain; her wood was generally of better quality than that imported by the Dutch.[112] This made it the more urgent for England and Holland to maintain control of the sea lanes in the Baltic and the North Sea, which drew timber from Scandinavia, Russia, Poland, East Prussia, and from Bohemia by way of Hamburg. But France began to run short of wood of all kinds at the beginning of the eighteenth century. Many

[109]Cf. *Calendar of State Papers, Domestic*, 1664-5, p. 351; 1670, p. 374; P. D. Huet, *A View of the Dutch Trade* (1698), (2nd English ed., London, 1722, p. 158).

[110]*Calendar of State Papers, Domestic*, 1666-7, p. 442.

[111]Savary des Bruslons, *Dictionnaire universel de commerce*, vol. III, p. 670. The supplies again gave the French government concern in the 1740's, during the War of the Austrian Succession (*Inventaire-Sommaire des Archives départementales*, Marne, série C, vol. I, 1884, p. 359).

[112]Pierre Clément, *Lettres, instructions et mémoires de Colbert* (Paris, 1861), vol. III (2), pp. 305-7. Cf. vol. VII, p. 243.

French provinces were faced with a crisis of deforestation resembling the one undergone by Great Britain as early as the reigns of Elizabeth and James I, when the price of some kinds of ship timber and of firewood had risen three or four times as fast as the price of fish, meat, and many other commodities commonly consumed.[113] By 1721 "bois de futaie," in particular, great trees suitable for building large vessels, had become exceedingly rare in the neighbourhood of any French port.[114]

Until near the end of the eighteenth century the quantity of wood needed as fuel in warfare probably exceeded that needed as building material. The smoke from cannonades was nothing to the smoke from the hundreds of furnaces and boiler rooms, where the metal and the ammunition were produced without which cannonades would have been impossible. It was only in Great Britain, and to a lesser degree in the valley of the Meuse, that the makers of war materials had been emancipated to any considerable extent by the progress of coal mining from the general use of charcoal or firewood in their fires. Even in Great Britain coal was introduced for smelting lead, tin and copper ores only at the turn of the seventeenth and eighteenth centuries. No appreciable use of it was made before 1775 in manufacturing iron, which was more spendthrift of fuel than other metals. So the growing scarcity of wood bore down upon the supply of munitions at least as heavily as upon the supply of ships and transport wagons.

With the general adoption of firearms at the turn of the fifteenth and sixteenth centuries, large supplies of base metals had become more vital in wars than ever before in history.[115] The future of the new warfare depended upon discoveries in the metal industries which would make it possible to turn out iron and eventually steel in almost unlimited quantities. Early in the sixteenth century cast iron cannon balls had begun to replace the stone balls hitherto employed as missiles,[116] and the substitution added continually to the metal needed in warfare. In the main, the artillery in use in the terrible battles of the early seventeenth century was of three materials—of gun metal (a kind of bronze, an alloy of copper and tin), of brass (an alloy of copper and calamine, the ore of zinc), and of cast iron. There were, in addition, some light pieces of wrought iron.

Gustavus Adolphus (1594-1632) tried to meet the difficulties of obtaining enough metal for guns by sponsoring two kinds of new light artillery. One was a so-called "leather-gun," consisting of a tube of copper or bronze, strengthened by rings of iron and covered by a leather

[113]Cf. Nef, "Prices and Industrial Capitalism, 1540-1640," pp. 180-1.

[114]See Boislisle, *Correspondance des contrôleurs généraux*, vol. II, no. 355, also appendix, p. 498. Cf. *Inventaire sommaire des Archives départementales*, Hérault, C, vol. III (1887), p. 382; *ibid.*, Hautes Alpes, E., vol. II, p. 234; Marcel Rouff, *Les mines de charbon en France au XVIII siècle* (Paris, 1922), pp. 21-32; *Histoire de l'Académie Royale des Sciences, 1721*, pp. 244-5.

[115]Cf. A. de Montchrétien, *Traicté de l'économie politique* (1615, ed. Th. Funck-Brentano, Paris, n.d., p. 58).

[116]Poppe, *Geschichte der Technologie*, vol. II, p. 553.

skin.[117] The other was a light iron gun of the same size, which is said to have been invented by one of the Scottish Hamiltons while he was employed in the service of the Swedish king.[118] The first was apparently too weak to fulfil its purpose. As for the second, knowledge of the details of its manufacture are said to have been lost.

The failure of the European ordnance departments to develop satisfactory light artillery for a century after the death of Gustavus,[119] appears to have been at least partly a matter of prejudice. Even expert technicians could not divest themselves of the notion that the longer the cannon were, the farther they would shoot.[120] Between the early seventeenth and the middle of the eighteenth century, cannon makers were encouraged to manufacture even longer and heavier guns, in spite of the imperative need for economizing on metal.[121] During the seventies and eighties of the seventeenth century there was some increase, at any rate in the French navy, in the proportion of the cannon produced which were made of iron.[122] At the turn of the seventeenth and eighteenth centuries, however, with the growing shortage of wood fuel, and the discovery of methods of substituting coal in smelting tin and copper ores, there was some disposition to revert to gun metal and brass. In spite of the fall in the relative price of both, gun metal remained dearer than iron cannon, but they were supposed to be safer for the gun crews because they were said to be less likely to explode when heated by repeated firing.[123]

To add to their difficulties, the ordnance officials of the continental armies were faced in the seventeenth century with a shortage of tin, copper and lead ores. At the end of the middle ages, central Europe had been the chief source of these ores on the Continent. The readily accessible supplies had been worked out in the sixteenth century. At the same time, the advantages of exploiting the mines had diminished because the value of the silver, which many of the lead and copper ores contained, had fallen precipitously after the heavy import of American treasure began.[124] Among the ores indispensable for war, iron alone was still cheap and abundant in many parts of Europe, but the use of iron in any quantity for warfare involved the destruction to feed the furnaces and forges of immense tracts of the dwindling forests.

[117] *Ibid.*, p. 551.

[118] Firth, *Cromwell's Army*, pp. 146-7. Cf. Delbrück, *Geschichte der Kriegskunst im Rahmen der politischen Geschichte*, vol. IV, p. 204.

[119] *Histoire de l'Académie Royale des Sciences*, 1753, pp. 103-4.

[120] Scharnhorst, *Handbüch für Officiere*, pp. 19-20.

[121] Cf. Count Saxe, *Reveries or Memoirs Upon the Art of War*, p. 77.

[122] W. Sombart, *Der Moderne Kapitalismus* (ed. 5, Munich, 1921), vol. I, part 2, p. 751.

[123] Cf. Saxe, *Reveries or Memoirs Upon the Art of War*, pp. 19-20, 279-80, 282-4 and *passim.*; Muller, *A Treatise of Artillery*, pp. iv, xxii-xxiv; Surirey de Saint Rémy, *Mémoires d'Artillerie* (ed. 3, Paris, 1745), vol. I, pp. viii, 79.

[124] Nef, "Silver Production in Central Europe, 1450-1618" (*Journal of Political Economy*, vol. XLIX, 1941, p. 589).

Of the three leading powers, Holland's position in respect to supplies of munitions was the most precarious. The Dutch got nearly all of their iron cannon from Sweden and a few from Russia. Their bullets and other ammunition came almost entirely from Sweden and Germany, their tin from the Indies, their copper from Sweden and Japan.[125] These would be tenuous life lines for a powerful offensive in any age; they were not less so when the voyages could be made only in sailing ships!

France and Great Britain were the only Western states in the early eighteenth century with sufficient resources in manpower and material wealth to fight offensive wars for long. Both were hard put to find metal. Lead, copper, tin, and zinc had always been scarce in France. Like his predecessors, Louis XIV continually issued authorizations or letters patent granting privileges to persons who would search for these ores in various provinces, where it was claimed they were to be found "en grande quantité et d'une aussy bonne qualité que ceux qui viennent d'Alamaigne, Engleterre et autre pays étrangers."[126] In the twenties and thirties of the eighteenth century, Irishmen and Englishmen, as well as French adventurers, were encouraged to undertake large copper mining enterprises in Provence and in the Pyrenees along the Spanish frontier. The results were invariably disappointing.[127] A *mémoire* of 1741 concerning the administration of the mines, says that "la pluspart des entreprises formées en France pour l'exploitations des mines ont échoués."[128]

England was better stocked than France with the ores of copper, tin, lead, and zinc. The English had been more successful than the French in exploiting them. Even so, the metal problem, which has had an important bearing on the whole course of modern history, was nowhere near solution in Great Britain. England was so short of supplies that technical experts busied themselves trying to find ways of making shot, bullets, grenades, bombs and other projectiles out of the dregs and cinders of iron and other metals. One of the masters of a glass works claimed that he had learned a method of manufacturing grenades of glass, cheaper and "better for execution" than iron ones.[129]

In both France and Great Britain the supplies of metal became increasingly inadequate to equip the new armies and navies, which were much larger than any assembled previously in Western history. Lighter cannon would have helped not only to save metal but to increase the mobility of the artillery. Gustavus Adolphus' short-lived pieces are said to have been carried by four soldiers. They could be moved easily and cheaply and this apparently contributed to his victories.[130] But the

[125]Clément, *Lettres, instructions et mémoires de Colbert*, vol. III (2), p. 311.

[126]Archives départementales de la Gironde, IB. 29, f.9.

[127]Archives départementales des Bouches-du-Rhône, C.2301 (Ordonnance of May 3, 1741 and *passim*); *Inventaire-sommaire des archives départementales*, Gers, série C (1882), pp. 27-8.

[128]Archives départementales des Bouches-du-Rhône, C.2301 (Mémoire sur l'execution de l'arrest rendu au Conseil d'Etat du Roy, January 15, 1741).

[129]*Calendar of State Papers, Domestic*, 1680-1, p. 540; 1689-90, pp. 332-3.

[130]*Histoire de l'Académie Royale des Sciences*, 1753, pp. 103-4.

cost of hauling the heavy cannon, which Gustavus's artillery did not replace, was tremendous.[131] In 1639 some 20 horses had been needed to pull the largest, which weighed about 5,600 pounds, and an additional 24 to pull the six wagons full of ammunition needed for the gun to play only a single day.[132]

During the next hundred years, small improvements in the awkward gun carriages[133] helped somewhat in moving artillery. But until the middle decades of the eighteenth century, little was done anywhere in Europe to improve the condition of the roads, or even to keep most of them in repair. The cost of moving bulky vehicles increased. To be of great value, therefore, cannon foundries had to be near the scene of battle. Work at the cannon foundry in the Arsenal of Paris was abandoned after 1670 because the national frontiers had been pushed away from the capital by Louis XIV's armies. It was converted into a foundry for statues and other ornaments, with which to decorate the royal buildings![134] So, for a number of reasons, the concentration of artillery fire deep in the country of the enemy was becoming more difficult than during the Thirty Years' War.[135] An army, on the defensive, near to its cannon foundries and other sources of munitions obviously had great advantages over an army which had advanced long distances from home in a campaign.

(*iv*) Until the seventies of the seventeenth century, the five arms of readily mobile combat troops were "the Sword, the Pike, the Musket, the Pistol, and the Carrabine."[136] It might be supposed that the substitution of bayonets for pikes as weapons for infantry, which became extensive in the eighties and nineties, would have offset to some extent the growth in the defensive temper of armies and their commanding officers. Although the pikes had been shortened since the sixteenth century, they were still long cumbersome weapons at the time of the English Restoration. Sixteen and a half feet was regarded as a suitable length, and their chief use was to "keep off or gall the Enemies Horse." "Few ordinary ammunition pistols do certain Execution much farther off."[137] As adjusted at the turn of the seventeenth and eighteenth centuries, the bayonet made it possible for one soldier both to shoot and stab and to move far more quickly than a pikeman. It was no longer necessary to divide infantry units into pikemen and musketeers.[138] Why, then, did not the bayonet facilitate offensive warfare by making for

[131]Cf. Muller, *A Treatise of Artillery*, pp. v-vi.

[132]Lord of Praissac, *The Art of Warre or Militarie Discourses*, pp. 108 ff.; Saint Rémy, *Mémoires d'Artillerie*, vol. I, pp. 73 ff; vol. II, pp. 259 ff.

[133]Delbrück, *Geschichte der Kriegskunst im Rahmen der politischen Geschichte*, vol. IV, pp. 41-2.

[134]Savary des Bruslons, *Dictionnaire universel de commerce*, vol. II, p. 495.

[135]Cf. Churchill, *Marlborough*, vol. IV, p. 15.

[136]Orrery, *A Treatise of the Art of War*, p. 24.

[137]*Ibid.*, pp. 27-8.

[138]Cf. Walton, *History of the British Standing Army*, pp. 341-3.

greater mobility and by relieving the shortage of metal? After all, the metal in a bayonet is not very extensive, and in the gruesome days through which we are passing, we readily remind ourselves that it can be used again and again, that it is less likely to be destroyed in battle than are artillery pieces and all kinds of mechanical fighting apparatus.

Such reasoning overlooks the fact that Frederick the Great was probably the first commander to make serious use of the bayonet as a weapon of attack.[139] Whatever action the bayonet may have seen when it was still in an experimental stage, it apparently lost at the end of the seventeenth century. "Depuis qu'on la porte toujours on ne s'en sert jamais."[140] Far from encouraging offensive actions, the general adoption of this "demon" of war, as Voltaire called it, seems to have acted at least for some time as a strong deterrent. The Chevalier de Folard (1669-1752), a famous soldier, was actively engaged in Louis XIV's last wars, which spread over some twenty-five years. He attributed the increasingly defensive tactics to the suppression of the pike in favour of the bayonet. Partly as a result, the French troops were encouraged to keep up a distant fire of musketry and almost never to close with the enemy. Folard deplored this development. "A mistaken prudence," he wrote in the twenties of the eighteenth century, "[was] the manifest cause of all our misfortunes in the late war [of the Spanish Succession]." He thought that battles at close quarters were better suited to the quick, impatient, ardent French temperament.[141] But his advice was no more heeded in his own country than was that given, on the eve of the second world war, by General de Gaulle on behalf of a mechanized army.

Under the conditions of warfare prevailing when Folard was a soldier, the use of the new weapon to press home the attack would have involved a reversion to hand to hand fighting of a kind which the general employment of firearms in early modern times had diminished.[142] Firearms had facilitated carnage in the sixteenth century. The farther away and the more impersonal the target, the easier it is for common men, unaccustomed to the sight of human blood and the screams of the wounded, to participate in slaughter. Other things being equal, the horror and terror which men feel instinctively at bloodshed is less likely to be aroused by war with long-range weapons than by the messy and gruesome results of butchery which stare them in the face at close quarters. In the late seventeenth and early eighteenth centuries, although the small firearms were somewhat improved, the guns seem to have been inadequate to mow down the much larger armies at the greater distances which ordinarily separated the troops in battle. At the same time the European peoples, particularly in Great Britain and France, were becoming less

[139]Poppe, *Geschichte der Technologie*, vol. II, p. 538.

[140]Guibert, *Essai général de tactique*, vol. I, pp. 42-3.

[141]This is taken from a translation of Folard, *Commentaires sur Polybe*, 1727-30, made for Lord Frankfort de Montmorency, MS. volume in the Crerar Library, Chicago, pp. 240-1. Cf. Guibert, *Essai général de tactique*, vol. I, p. lvii.

[142]Guibert, *Essai général de tactique*, pp. liii, 244, and *passim*.

inured than their ancestors had been to the infliction of cruel punishments and to any deliberate mortification of human flesh. They were less inclined to engage in close fighting, although the need for this had apparently increased if battles were again to be decisive.

Along with the shortage of wood and metal, the general adoption of the bayonet helps to explain the defensive temper of European armies and their commanders. "We may compare our [land] battles," Folard wrote, "to two fleets that canonade each other during a whole day, and that mutually sink each other and without coming to close quarters."[143] On land there were no vessels to sink, so the casualties could come only when balls, bullets or shot actually tore into flesh. In an age when metal was scarce and shooting still highly inaccurate, this was such an expensive way of killing men that no country was in a position to push it far.

(*v*) Material conditions, resulting partly from the failure of science and technology to meet the problems of scarcity, curbed the power of the European states to attack their neighbours relentlessly. But material conditions do not account adequately for the respite from desperate wars after the Treaty of Westphalia, in 1648, and the Treaty of the Pyrenees, in 1659. While Western Europe was short of the equipment needed by the new armies and navies, the supplies were actually larger than during the religious wars and the Thirty Years' War. France and England were both richer countries than in the sixteenth century. Both were able to divert a larger portion of their annual income to war purposes. The equipment of the officers in the age of Louis XIV left little to desire when it came to elegance or show. They were lavishly supplied with luxuries, even when their armies were short of artillery. Somewhat later, when a portion of the baggage of French and Austrian generals fell into the hands of Frederick the Great, "there was found amongst it whole cases of lavender water and *sans-pareille*; parasols and muffs; monkeys and paroquets."[144]

It is difficult to resist the impression that the enthusiasm of technicians as well as scientists was somewhat lukewarm when it came to solving the material problems which stood in the way of conquests and attempts at conquest. Among the factors which determine the character of wars, two stand out. One is the means available to wage them. The other is the will to wage them among the peoples. Each interacts with the other. If the will is weak, it is partly for want of adequate means. If the means prove inadequate, it is partly because the will is weak.

V. Limited Warfare and the Progress of Civilization

Why was the will to fight diminishing in Western Europe in the late seventeenth and early eighteenth centuries? Why was so little done to overcome the material difficulties in the way of making war on a great

[143]Folard, *Commentaires sur Polybe*, p. 245.

[144]Baron Jomini, *Treatise on Grand Military Operations* (trans. by S. B. Holabird, New York, 1865), vol. I, pp. 177-8.

scale, when subsequent history has shown that all of them can be surmounted?

It is unconvincing to suggest as a reason that the European peoples, in the time of Pascal, Newton, Molière, Swift and Voltaire, were unintelligent as compared with their ancestors of the age of the Renaissance, or their descendants of the twentieth century, when more striking advances were made in the technique of weapons of war. There is a great contrast between the ineptitude of many technicians who turned their hands to improvements in weapons and the extraordinary resourcefulness of the greatest scientists.

This contrast becomes more comprehensible when we remember that science was still close to philosophy and that scientists were often inspired by constructive hopes for mankind. While the help of men of science in the improvement of warships and all sorts of weapons was solicited by the Crown both in France and England, the scientists seldom put their hearts into such work. Nor were they good at it. Few of them were able to adjust their minds effectively to the warlike purposes they were asked to serve. In 1711, for example, the leading English scientists were called in for advice on problems of naval construction. It is recorded that "the intervention of the [natural] philosophers had not any appreciable effect." A three-decker of eighty guns was actually designed by the council of the Royal Society. She was found so deficient in stability that it was deemed necessary to girdle her. As a modern authority has observed, "the impossibility of applying abstract principles to so complex a machine as a sailing ship, moving in elements so variable as air and water, was patent to everyone."[145]

Technical improvements in modern times have owed an enormous debt to the natural scientists. But the debt has been an indirect one. Science has been devoted first to truths concerning the physical universe, and only incidentally to success. It is not always possible to serve success and truth at once. They are different masters. The great philosophical scientists of the age of Newton owed their allegiance first to truth, and they were uncomfortable when they were obliged to deviate from the search for scientific truths to meet the practical needs of the armed forces.

Their attitude was a reflection of a growing love of mankind among the cultured as well as the saintly men of Europe, a love which can be traced back both to great humanists, such as Erasmus, Rabelais, and More, and to great Christian reformers, such as Saint François de Sales and Jeremy Taylor. This love of mankind, combined as it was in Francis Bacon and some of his intellectual followers with a belief in something approaching a material paradise on earth, had its influence even in politics.

At the same time the spread of religious toleration, first in Great Britain and then on the Continent, left the Europeans without issues capable of arousing serious excitement for mass slaughter. In a cele-

[145]Robertson, *Evolution of Naval Armament*, p. 35.

brated passage, Boswell tells us that Samuel Johnson once remarked in a company of cultured men, "Patriotism is the last refuge of a scoundrel." A study of the passage in which the words occur suggests that even as late as 1775 political disputes were regarded as the affairs of princes and politicians, and that it was generally recognized that such persons acted almost always from interested and not infrequently from dishonest motives.[146] The positions in which their conduct placed their countries were still incapable of arousing deep ardour among the intelligent and cultured. Nor had statesmen and politicians yet found a way of appealing effectively to the common people, who were impressed to fight in the wars.

From the time of Pierre de Bérulle (1575-1629), Europeans seem to have had a growing sense of their responsibilities to put into practice the principles which were nourished by both the Christian and the humanist traditions, and by the growing consciousness of European civilization as a harmonious restrained whole. These conceptions were fostered, above all, by the French. French classical civilization cultivated the idea of appropriate size, not only in the arts but in all aspects of worldly life including politics. To exceed the appropriate size seemed to the French mind excessive, and to a true Frenchman of the *grand siècle* excess was the enemy of truth, beauty, and virtue, no less than it was to Aristotle. Moderation, proportion, and reasonableness was what the French mind sought. It also retained from Classical civilization and the Italian Renaissance the sense of metaphorical truth, of the value of wit not simply as an accessory but as an intimate part of life, a sense which the Reformation and the Counter Reformation had done more in other countries to destroy.[147] To go beyond a certain point in political conquests seemed no less disproportionate than to build an edifice too large for the place it occupied and the function it was intended to perform. To the logical and imaginative French mind, the French state naturally extended to the Pyrenees; it should extend in the other direction as far as the Alps and the Rhine. It might be desirable to establish substantial bridgeheads in order to hold the Rhine. But to extend farther in any direction would have been out of harmony with French culture, at a time when it had a great influence at court and through the court on French policy.[148]

No less important, perhaps, in creating the eighteenth-century conception of limited warfare was the disposition, which was spreading all over Europe, to measure well-being in economic terms, to stress comfort and security as the foundations of human happiness. This conception of civilization was fostered above all by the English. It had begun to soften

[146]James Boswell, *The Life of Samuel Johnson* (London, 1857), vol. II, p. 216. I am grateful to Mr. Francis Neilson for reminding me of the whereabouts of this passage.

[147]A point suggested by some lectures on the interrelations of Renaissance art and philosophy given by my colleague, Professor Edgar Wind.

[148]Cf. *Recueil des testaments politiques*, vol. III (Colbert), (Amsterdam, 1749), vol. III, pp. 396-7, 401-2.

the harshness of the English character even as early as the reign of Elizabeth. By the time of Colbert and especially by the time of Vauban, its influence became notable across the Channel. The French mercantile mentality was hardly more eager than the English scientific mentality to push for improvements in the murderous weapons which had been introduced in modern warfare. In his well-known commercial dictionary, Savary des Bruslons (1657-1716) actually regretted that cannon had ever been discovered.[149]

These two streams of civilization—the French and the English—can almost be spoken of as uniting in the eighteenth century to form a great river. The two countries which were in the most favourable position to conquer and subdue other civilized states were disinclined to carry such an excessive and gruesome business to a conclusion. They preferred to leave their European neighbours the liberty to work out their own destiny. Without the development of a European conscience, as part of a desire to order human affairs in the interest of both the dignity and the comfort of the human person, the scarcity of wood and metal, the sluggish progress of technology, and the introduction of the bayonet might have done little to reduce the seriousness of warfare.

To wage modern war to the death for offensive purposes against civilized peoples demands fanaticism in the military leaders, and above all in the supreme leader. It requires from the people an intellectual identification of warlike virtues with civilization. Such conditions were alien to the age of reason. Its whole history has a unity. Industrial development and the development of warfare from 1660 to 1740 appear like two great mirrors in which that unity is reflected. Science and the scientific method were beginning to give men a new sense of their intellectual powers, at a time when they had not entirely lost the wit and imagination, combined with logic, which were all parts of the rational procedure in the early Renaissance. The dominant principle for the eighteenth-century rationalist was that there can be no truth either in life or in art which cannot be understood and explained in the light of reason. "Reason," in the eighteenth-century sense, made much of scientific methods, of observation and experiment, but it left a large place for logic and intuition, even when the conclusions reached in the abstract world of the mind were not susceptible to proof by the methods of natural science.

Rationalism was gradually undermining religious belief. Yet the Christian principles of conduct, which had always been treated by men whom Europeans considered wise, whether they were saints, scholars or artists, as rationally defensible, had hardly begun to lose their strength. The accumulated good of generations had a singular opportunity to influence the people of Europe. Not only was the realm of intelligent speculation wider for the man of culture than it had been in the middle ages or than it was to become in the twentieth century; intelligent

[149]Savary des Bruslons, *Dictionnaire universel de commerce*, vol. II, p. 495.

speculation and imaginative art counted for more. Their influence on history was greater. As the late Geoffrey Scott brought out, rational thought had more influence than ever before or after in Western history, partly because great written works retained the prestige they had possessed before the use of movable type, when they had been exceedingly scarce, and gained the circulation which the printing and publishing business made possible. The circulation of printed matter had not begun to cheapen thought or to destroy taste. It had not yet enabled vulgarity and irresponsibility to command the great majority of readers.

Those powers of the intellect and the imagination, which some of the wisest men of the past regarded as the special gift of God to human beings, actually took an important part in controlling violent passions. If wars were becoming less fierce in the early eighteenth century than they had been after the Reformation, this was partly because civilized peoples were more conscious of their common humanity. This helps to explain why writers like Gibbon could be so confident about the future of civilization. They saw armed quarrels as the products of human imperfections, at a time when Europeans had fallen in love with the perfections of the mind. They found it difficult to believe that the joys of reason, once tasted, could ever be corrupted. They forgot that the noble qualities displayed by many of the greatest scientists were scarce. They did not foresee the difficulty of making reason count among the many, when people should multiply rapidly throughout the world and when mechanical progress should draw them into close proximity.

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