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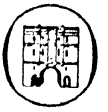
WORLD WITHOUT WAR

BY THE SAME AUTHOR

The World, the Flesh and the Devil
The Social Function of Science
Science for Peace and Socialism
(with M. Cornforth)
The Freedom of Necessity
The Physical Basis of Life
Marx and Science
Science and Industry in the
Twentieth Century
Science in History

J. D. Bernal

WORLD WITHOUT WAR



LONDON
ROUTLEDGE & KEGAN PAUL

First published in Great Britain
by Routledge and Kegan Paul Ltd.
Broadway House
68–74 Carter Lane,
London, E.C.4.

Printed in Great Britain
by Wyman and Sons Ltd.,
London, Fakenham and Reading

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CONTENTS

	Preface	*page* ix
	Acknowledgements	xii
I	Introduction	1
II	Nuclear Warfare	7
III	Building a World at Peace	25
IV	Industry	40
V	Agriculture, Food and Population	61
VI	The Advancement of Science	83
VII	The Economy of a World in Transition	104
VIII	Economic Problems of Industrial Countries	138
IX	Britain's Position in the New Industrial World	155
X	Education and Research for the New World	177
XI	The Political Problems of a Divided World	205
XII	The Time-table of Transformation	225
XIII	The Limits of the Foreseeable Future	264
XIV	Conclusions	283
	Postscript	293
	P.P.S.	296
	Bibliography	297
	Index	302

LIST OF TABLES, FIGURES, AND MAPS

TABLES

I	The Effects of Nuclear Weapons	*page* 10
II	World Military Expenditure: 1950–1957	21
III	Relative Standards of Living	26
IV	Nuclear Power Programmes of Various Countries	48
V	Agricultural Production: Pre- and Post-War	62
VI	Net Food Supplies per Capita	63
VII	Land Use, Agricultural Mechanization and Productivity in Various Countries	67
VIII	Present and Potential Land Use	69
IX	Energy and Steel Utilization in Various Countries	107
X	Estimated Natural Resources of Various Countries	118
XI	Rate of Increase of Steel Production	130
XII	Indices of Industrial Production, Productivity, and Consumer Expenditure	140
XIII	Industrial Employment in Various Countries	158
XIV	Expenditure on Research and Development in Various Countries	163
XV	Scientific and Technological Manpower	185
XVI	Higher Education: Total Enrolment of Students of Science and Technology	187
XVII	Military, Educational and Welfare Expenditure in Various Countries	188
XVIII	The Conditions of Advance	230–1
XIX	Distribution of Foreign Aid	238
XX	International Economic Aid in Gifts and Loans to Underdeveloped Countries, 1954–1956	240
XXI	Capital Available and Economic Needs of Underdeveloped Countries	246

FIGURES

1	Some Contrasts of the Modern World (1955)	*page* 28
2	World Population Trends	65
3	Survival Curves for Various Countries	98
4	Graphs of Steel Production	128–9
5	Flow Sheets of Education	180
6	Past and Future Occupations of Mankind	183

MAPS

I	Present and Proposed Industrial Centres	247
II	Present and Potential Land Use	249

GENERAL NOTE ON THE TABLES

The tables in this book are based on the latest published figures from official and other sources. Whenever possible, United Nations' statistics have been used. In cases where these are not available, estimates have been derived from national sources.

In comparing such statistics it is almost impossible to obtain figures representing precisely the same things in different countries and periods. For example, the relative prices of different kinds of goods vary widely in different countries, and particularly as between socialist and capitalist countries.

The tables are intended to bring out major differences between countries and between periods, and these differences are usually so great as to outweigh any error in computing the statistics. The differences are obviously not significant in cases where the statistics are of the same order.

PREFACE

I SET out to write this book because I felt that it was necessary to bring together the dark and the bright side of the new power that science has given to mankind. People are well enough aware of each aspect by itself. The hydrogen bomb and the rocket dominate politics. Men, for the first time in their history, have to contemplate, as something that might happen any day, the horrible destruction of civilization and even of life itself. At the same time, they are made aware in hundreds of ways in their daily life, of the power of science to ease labour and increase enjoyments. The idea that we are in the opening stages of a new industrial revolution is gradually being accepted. But, it is also being realized that these new powers come none too soon, that the world is filling up with people and that the contrasts between the standards of life of Americans and Europeans and that of Asians and Africans is growing and becoming more unendurable. Only through a wise economic international policy and the full use of science can this disparity be removed.

Now on each of these two aspects of our times many books have been published, some of the greatest penetration and value, but most have dealt mainly with one or the other aspect—with the risk of atomic war or with the building of a prosperous world. What was needed, it seemed to me, was to bring these two aspects together, not just by putting them in contrast side by side, but rather by bringing out their interactions. For it is mainly the consequence of war preparation, the policy of the 'Cold War', that the peoples of the underdeveloped countries are deprived of the chance of securing a decent standard of life for themselves, while it is allegedly in defence of their own high standards of life that the protagonists of the 'Cold War' justify their policy of atomic deterrence.

I am not trying in this book to draw any simple blueprint of a world in which human knowledge is best used for human welfare. This has often been done with various degrees of probability and imagination. By themselves, however, such anticipations lack conviction because firstly, it is rarely clear whether such desirable states can be achieved with existing resources of materials and personnel and secondly, the way to achieve them is usually left vague and made to depend on general good will or good sense.

I have tried to remedy this by discussing the resources available for so raising the productive capacity of the world that it could afford to all a standard of living at least equal to that enjoyed in the older industrial countries to-day. Further, I have discussed by what stages and how fast

this transformation could be effected, taking into account the political realities of a divided world. While in the present conditions of the 'Cold War' it seems unlikely that for most of the underdeveloped parts of the world it could be achieved for centuries, once this was replaced by conditions of peaceful international economic competition or, still better, of co-operation, the process would only take a generation or two.

The conclusion is inescapable; the present preparation for war will produce at best economic stagnation and general impoverishment, at worst a destruction of human society.

While writing the book, I have become increasingly conscious that to deal with these great problems adequately would require a more profound and lengthy treatment than I had been able to give of the social and political aspects of the struggles of the day and the transformations of tomorrow. I could not embark on this without writing another and longer book, for which I am in any case not specially qualified.

What I have actually tried to bring out are the facts of the world situation, with its concrete dangers and possibilities. What I have not dealt with explicitly are the social forces that have brought this situation about and that can help to resolve it without recourse to suicidal war.

However, my readers should see that many of these questions are touched on implicitly in various parts of the book, and especially in Chapters XI and XII.

The basis of my analysis throughout is a socialist one. I believe that capitalist monopolies must by their very nature push the governments of the States in which they operate to war preparation and war itself, as has happened twice already in this century.

I do not, however, believe this tendency is necessarily bound to prevail. Against it are great, though up till now divided, popular forces which have already taken a third of humanity out of the orbit of capitalist economy. The example the socialist countries have given of the use of resources by the people and for the people is already inspiring hundreds of millions in the underdeveloped parts of the world to try to do the same. In the older industrial countries the lesson has rather been that of the value to be gained by the greater use of education and science.

I believe the forces of construction are the strongest, and that they will prevail. What is new in the situation since Hiroshima, is that we now know that this struggle cannot be resolved in the military field without the destruction of all civilization and most of humanity. Seeing this, more and more people are being brought to realize that the only short-term solution is a period of relaxation of tension, which will permit the first stages of disarmament, leading to the ultimate abolition of nuclear warfare. During this period countries with different social systems must learn to get on together in the same world.

Though I have tried to picture what such co-existence would be like, I have no illusion that it represents a final solution. This will mean a

recasting of economic, social, and political forms to bring them in harmony with the new powers gained through science.

I have written this book quickly and I know that it is in many respects imperfect, but I feel that such a book this year will be of much more use than a better documented work appearing two or three years hence. Every month of drift increases the dangers of humanity and diminishes hope in the future. This book will have served its purpose if it contributes in some small measure to raising interest and discussion in the vital issues of our time.

May, 1958 J. D. BERNAL.

ACKNOWLEDGEMENTS

THE production of this book in the short time there has been to prepare it has been made possible by the effort and skill of Mr. Francis Aprahamian. He has helped me in previous books and other publications but never before on such a scale or working with such intensity. On this occasion he has collected, sorted and put together the whole of the material for the tables and for the factual and statistical entries throughout the book. He has had to deal with the most heterogeneous sources, often biased and mutually contradictory, and it is almost entirely due to his labours that I have been able to present something like a balanced picture of the economies of the different parts of the world to-day.

I would like to thank particularly the secretaries of the Labour Research Department and the Society for Cultural Relations with the U.S.S.R. for their assistance in finding sources of information and, also, the Librarians and Staff of the Libraries of Birkbeck College, the Senate House, University of London, and of the United Nations Information Centre.

In the preparation of the book my thanks are due especially to my Secretary, Miss Anita Rimel, and to her Assistants Mrs. Joan Fergusson and Mrs Rowena Middle, as well as to Mr. D. Shukla for his help with the figures and Miss M. C. Black for preparing the maps.

I

INTRODUCTION

WAR has always been the curse of civilization: it is likely to bring it to an end unless we do something about it and that very soon. More and more people realize this, but at the same time so many feel that they can do nothing about it, that they are in the hands of forces too great for them, that science has now become an immense destructive force that nothing can halt. However the very realization of the danger may succeed in averting it in time. In these last years, with the knowledge of the destructive power of the hydrogen bomb and with the demonstration, in the launching of satellites into space, that there is no limit to the range of modern missiles, even generals and political leaders are beginning to realize that a critical stage has been reached. Defence, in any ordinary sense of the word, has lost its meaning. The only counter-move to annihilation of one side is annihilation of the other, and incidentally of all neutrals as well. The policy of piling up more and more destructive bombs, the multiplication of launching bases for rockets is not and is no longer even believed to be a solution. Even its supporters do not really believe in it but only continue the policy because they cannot think of another. The peoples of the world are beginning to see this too, beginning to feel that some other way must be found which will turn away from the logic of more and more destructive war to one of constructive peace.

Now it happens that the very advances of science which have made this possibility of destruction so absolute are just those that, if properly applied, could transform the whole economic situation of the human race: this situation certainly needs transforming, and the sooner the better. The crying evil of the present world is the great and ever growing gap between the standards of living of the rich and the poor, the few and the many.

There are certain privileged countries with a command of ample land and resources and who with it enjoy all the benefits of science and technology. There, not only the rich but a considerable section of the people are living better than have any comparable number of persons in all world history. Meanwhile three-quarters of the world are living in intolerable conditions of semi-starvation, disease and enforced ignorance. Further, the pressure of population on the resources of a primitive

agriculture, interfered with in many ways by the demands of the industrial countries, is leading to a steady worsening of their standard of living, which may become within the next few decades a catastrophic one, bringing a return to the ages of famine and pestilence.

Now what I hope to show in this book is that none of this need happen. We need not have the war, we need not have the famine. It is not only possible but practicable to raise the standard of living of all the world, within a generation, to that enjoyed by the people in the most favoured countries today. Now, as human misery has endured for centuries, indeed for millennia, this may seem a very large claim: but I hope to be able to make it good on the basis of known facts, with the one proviso, implied in my title of *World Without War*, that war is avoided. Not only must there be no fighting but something must be done to stop the present state of continuous war preparation and threats of war, a waste of human resources and human intelligence that is holding back the whole development of science itself and blocking its useful application.

The most important realization, and one which is not yet sufficiently widespread, is that the benefits of using science for welfare are so great as to make entirely pointless all the disputes about which wars have been fought in the past and for which countries enter into defensive and offensive alliances. The wealth that could be available to us now, through the application of the amount of science we know already, is far greater than anything that could be obtained from the conquest of the most fruitful territories or by winning the most exclusive controls of sources of raw materials, oil or coal. The material objectives about which nations have fought for centuries and for which they are prepared to fight are now completely trivial in comparison with what the same effort would win even more quickly in peace. If this were understood we might achieve a sudden realization of the advantages of peace which would lead to a complete switching over of the whole apparatus of science and industry to a planned, constructive task.

Here I am not imagining that such a reversal of policy will come about by any sudden spiritual conversion of humanity to the principles of non-violence. The old attitudes towards war as an instrument of policy will in the end be broken down because they have ceased to make sense and because more and more people will see that they lead to a suicidal absurdity. In the past sophisticated excuses have always been given for the destruction of other people's countries to preserve the interests or the lives of one's own people. Now it is known that, once a nuclear war begins, the population of both sides, the virtuous defenders or the wicked aggressors, are equally liable to destruction, so that the whole business of war becomes insanity as well as a crime.

The reason why people can still be persuaded to follow in the path which leads to war is largely because they have not been able to see any alternative. It is perhaps too much to expect those whose whole profes-

sion and interest is tied up with the preparation for war—the military commanders and those whose profits come from munitions production —to see this. However, if enough other people see it then there is some hope of bringing the change about.

What I am trying to do in this book is to set out, in as clear and orderly way as I can, the nature of the choice that faces humanity in its present crisis. I want to show first something of the character of modern nuclear war and the real meaning, in terms of certain human death and suffering, of its catch phrases, "the great deterrent", "massive retaliation" and "limited war with tactical atomic weapons". These horrors are not so well known as they should be, or people would not talk so lightly about preferring to be "atomized", or that the hydrogen bomb is just another weapon essentially no different from a blockbuster or a hand grenade.

It is not only the scale and character of nuclear warfare that we have to dread, but the acute danger of its outbreak at any moment whether it is intended or not. This threat in itself has a paralysing effect on human enterprise, except that of building up ever more and bigger weapons.

This is only one aspect of the condition of the Cold War that is using up precious resources of materials, men and knowledge, so badly needed for the relief of present miseries and the construction of a better world. It is perpetuating the division of the world and, almost worst of all, it is destroying any hope in the future, especially among the young. The danger indeed lies partly in the very situation itself, which may break down into war simply because the strain of awaiting it has become intolerable.

To put an end to this, to secure a relief before it is too late is the most urgent task of our time. The responsibility for carrying it out falls on everybody in so far as they understand the situation. But it is not sufficient to show the fatal dangers of modern war and of its preparation. The old path will not be abandoned until enough people see a hopeful and practical alternative to it. I believe such an alternative exists and most of this book is concerned with describing it and indicating how I think it is most likely to be achieved. Here the best and most logical solutions may well not be the most humanly acceptable and practical, and it may be necessary to proceed to the ultimate goal in a series of steps.

What I would like to see, and so would many scientists, is a world of socialist countries co-operating in a planned way to secure the best environment for all human beings, and to give them the chance of using their abilities to the utmost. But I do not expect this all at once, and much could be done in intermediate stages, when countries still with different economic systems can exist side by side in peaceful competition. The process of changing over from competition to co-operation, both internally in each country and in the relations between them, can become

the school to prepare mankind for a more consciously planned and beneficently directed human society.

The points I want to make clear are that science has put plenty within the reach of all: that through the production of abundant energy from atomic sources all natural resources can be released, and that there need be no shortages of any kind. At the same time scientific research and technical development can create ever-new machinery and automatic processes which will remove the necessity for all types of repetitive labour in office as well as factory.

Underlying this, and in the long run even more important, the increase of scientific knowledge itself will bring new and unlimited possibilities to mankind. It is unlimited because each step can always lead to another, but these advances are necessarily indescribable in detail, because if we knew the answers we would not need to do the research. It is possible to do so much with the amount of science we have now, despite its diversion to direct or indirect military purposes in the most advanced countries, that it is certain that its achievements would be many times as great once the threat of war was permanently removed. At the same time the potential scientific capacities of something like nine-tenths of the world population are not being used at all for lack of widespread elementary and advanced education in science.

I am not, however, proposing, in the first stages of the transformation, to draw on this very large potential of future scientific discovery, but rather to show what the science which exists today, and the technologies based on it, could do if this were applied immediately and thoroughly. I am not so much concerned with the long-distant future, as with what can be done for people alive now and their children within the next thirty years. This I hope to deal with in the first place technically; that is with what are the actual processes of development of industry, of agriculture and other methods of producing food, that are already known to be feasible or could be readily developed along existing lines. The technical limitations of the present can be overcome by future research, but resources and knowledge already available are so extensive that if they were used they would alone suffice to enable the transformation of the whole world to be achieved in a generation.

The "if", however, implies a very big proviso. To turn the possibilities into actualities requires men and money; that is, we have to face the problems of producing suitably trained personnel and the necessary capital. These are questions I shall also hope to deal with, particularly to point out that the capital available for the transformation is already there in the form of the capacity for the production of metals, machinery and power. But that capital is at the present moment locked up in the service partly of war and partly of purely wasteful expenditure in the most privileged countries. I am not suggesting, as many philanthropically-minded people do, that this should be put right by the people in those countries giving up a proportion of their standard of living in

order to help their underprivileged neighbours, though this would be a right and just action for such professedly Christian nations.

My thesis will rather be that it is perfectly feasible to utilize the capital resources of the most advanced industrial countries for the building up of the economy of the rest of the world without diminishing at all the capacity of their industries to satisfy the needs of their own peoples. Indeed it should increase that capacity, on account of the greater effective employment of capital that would result from the additional markets created.

Many of the troubles of the world today, as well as the strains that lead to war have been brought about by the extreme instability of the capitalist form of production, by the danger of slumps and unemployment, which can be met only by periodic wars or war scares justifying rearmament booms. If for that could be substituted an ever-increasing demand for capital constructions in other countries, the machinery of capitalism itself might for the time being be made to work more smoothly. I know that this is a difficult question because, although technically it may be possible, the profit motive makes it very difficult indeed to work out a scheme by which any benefit can be given to poor people either at home or abroad—those who in economic terms lack "effective demand". Here I shall say quite frankly that, if it is in fact true that it is impossible to improve the condition of the world by following the rigid patterns of capitalist economics, it is time those patterns were changed.

One difference between the present economic situation and all that have preceded it is that we can now measure the requirements, the productive capacities and the resources of the world as a whole. We now know from the scientific study of how people live in the more favoured countries what is required per person in the way of food, housing, goods and services to provide a standard of living which gives the best prospect of health and well-being. We can also measure the amount and kind of industrial production and raw materials necessary to provide for a population of known size and rate of growth. Though most of the world is very far from that standard it is not beyond our power to provide the necessary industrial and agricultural capital to reach it. As to the labour, that the peoples will provide for themselves once they get a chance of building up a suitable educational system which, as experience in China shows, can be done within a decade.

This knowledge is no longer confined to Western scientists and economists, it is increasingly permeating the peoples of the underdeveloped countries and is giving rise to insistent demands to be given the opportunity to be allowed to achieve for themselves what others have already achieved.

This opportunity can no longer be safely withheld. If those who were first in the race which started with the development of modern science consider that they have a God-given right to stick to all the advantages

that science provides and prevent anybody else having them, they will destroy themselves in the process. Not only that, they will miss opportunities which will be far greater for them in a world of mutual aid than it ever could be in a world of narrow class-selfishness.

This book, however, would be entirely unrealistic unless it examined just these political obstacles in the way of changes, which I hope to show are both economically and technically feasible. I am not proposing this book as a blue-print of the world of the future—that has been done often enough—nor am I going into details as to how science could be used for this or that aspect of industry or agriculture. There is now no shortage of good books in which this has been done.[1] Rather I want to examine the whole process of world rehabilitation as an operation: something actually to be carried out year by year according to a time-table which, however elastic, does not allow indefinite delay and in which the phases of the transformation are as important, if not more important, than the objectives themselves.

The ultimate aim is nothing less than a complete transformation of the material basis of human society, all over the world. Promoting such a transformation should not be seen as a matter of charity, but of justice and common advantage. The central problem is how to help people to help themselves, by making available to them just the amount of material capital and technical information as will enable the people of each country to make the best use of their human and natural resources, and rapidly build up a modern economy. This will require a close partnership between the old industrial countries and those building up their own industries for the first time.

In particular I will try to deal with the problem in relation to Britain as a typical industrial country of the old type. The future of British industry is now threatened by the far more rapid technical developments in the larger industrial countries of the United States and the Soviet Union. Nevertheless, on account of her historic position in the world, there are great possibilities for Britain to use her special industrial potential for the benefit of the underdeveloped countries. It will be a matter of thinking out and planning, with the full co-operation of the people of those countries, how to make a joint industrial and agricultural rehabilitation of their economies while helping forward the further industrialization of Britain itself on a rational and scientific basis.

This book is not, and cannot claim to be, an answer to the vast problem with which it deals. The most I can hope for is that by setting out the problems clearly it will encourage people to think about them, and possibly to produce alternative ways of reaching the same ends. Of the end there can be no ultimate doubt: it must be that of world co-operation in peace. The alternative, war, means the complete destruction of civilization, if not of the human race itself.

[1] See Bibliography, Parts, 1, 3 and 4.

II

NUCLEAR WARFARE

On 6th August, 1945 the first atomic bomb was dropped on Hiroshima. Though it seemed to mean immediate victory in a long war, when the news came through it was received far more in horror and apprehension than in triumph or relief. Just because at the time I was still working in the centre of the military machine, I was even more shocked than those who up till then had no idea that this terrible new method of warfare was being prepared. I had hoped that it would never be used—I certainly never thought that it would be used against a defeated enemy when the war was practically over. It seemed such pointless as well as callous brutality, an alarming portent of the limitless cruelty that can be inflicted by people in control who do not have to see and cannot imagine the results of the actions they order.

At the same time I also recognized that this was not just another bomb, but a new and final step in warfare—the destruction of men by men. It marked either the beginning of the end of war, or that of humanity. I looked around at the uniforms of the Allied army, navy and air force officers that surrounded me in Whitehall and thought "You are all finished—as out of date as the Yeomen of the Guard". The divisions, the fleets, the groups of aircraft, were even then, in principle, obsolete in face of the combination of the atom bomb and the rocket, of which we had had a foretaste in London with the V2's.

Now I was not at the time under the illusion that the mere horrible nature of nuclear weapons would prevent their use: in fact Hiroshima and Nagasaki had been a striking demonstration to the contrary. But it was clear that sooner or later the destructive power would strike back at those who temporarily had the mastery of it, and that then only insanity in its most violent sense could risk a war. That in itself seemed poor comfort, for we had only just witnessed the last acts of the suicidal drama of Hitler, in which millions of lives had been sacrificed to the insanity of one man and to the complicities and fears of his Marshals and Gauleiters (for on any military grounds the war was lost at least two years before it actually ended). With that lesson before us, however, it seemed for a time that if sane men could get together it might be possible to put an end to the new weapon and to war itself at the same time. That hope remains unfulfilled, but has not yet been lost.

The thirteen years that have passed since then have been years of

stress and danger. Wars have flared up and died away but they have stopped just short of being absolutely catastrophic. There have been tests, very dangerous tests, of nuclear weapons; radioactivity is accumulating in the atmosphere and on the ground; but no atomic bomb has been dropped since August 1945. The hydrogen bomb, more than a thousand times as powerful as the original atom bomb, has been developed independently in three countries. In 1957 we have seen the final limit to the power of destructiveness in the perfecting of the intercontinental ballistic missile. From now on no country is safe from direct hits on its most vital installations. It was evident even earlier, from the results of the tests of the hydrogen bombs, that any serious war, even without long-range missiles, would result in such contamination of the atmosphere, water, and earth of this world as to make the continuation of any kind of civilized life impracticable. All would suffer in some degree or other from radiation sickness, and even those who survived that—not only human beings but also the animals and plants they lived on—would be exposed to genetic damage of a degree never before found in the history of this earth.

I remember being told by one of the Chiefs of Staff that, at the beginning of the late war, strategy dictated weapons, but at its end it was weapons that determined strategy. But weapons themselves are not just pieces of magic; they are the end product of big technical-scientific developments, and therefore what ultimately determines whether countries can go to war is just their scientific and technical capacities; in other words the economic and social aspects are in the long run decisive. What governments and military staffs have sought are short-run solutions, in attempting to secure overwhelming superiority by some temporarily effective weapons that the other side has not got. However, except for wars between sides which were wildly unmatched, as when industrial nations attacked pre-industrial ones, the possession of superior weapons has not usually led to such easy victories. Hannibal's elephants, the British tanks or Hitler's various terror weapons did not in fact win the wars in which they were employed.

For some time since the last war, it is true, we have lived in the atmosphere of propaganda about the push-button war, a war in which the weapons held by one side would, we were told, in a matter of a few hours or even minutes, so paralyse the other side that no possible alternative to complete surrender could be conceived. This seemed to the military and to the politicians who took their cue from them to justify the use of these weapons. But that illusion has also gone, not because of any shortcoming in the damaging power of the weapons, but because both of the major states of the world today possess weapons that can annihilate and cannot be guarded against. What ensures inevitable destruction is the combination of a long-range missile, travelling at such speed that it cannot be intercepted, with a warhead capable of wreaking destruction over hundreds of square miles and spreading its

radioactive damage far wider still. For all but a few military fanatics these "ultimate weapons" appear no longer as means of winning wars, where all must lose, but as means of committing mass suicide. War, always a crime against humanity, is now an insanity as well. The undiscriminating destructive power of the hydrogen bomb makes it impossible, as long as it remains in reserve, to obtain decisions by more limited methods of warfare (pp. 13 ff.). But these logical conclusions do not impose themselves on governments or military staffs. The lesson that there must be no more war will have to be taught by the peoples themselves.

Now I do not want in this book, which is after all concerned with peace rather than war, to examine in any detail the character of all-out warfare. That has been done in many other books.[1] On the other hand something must be said in order to give a scientist's view of what such a war would mean to the continuation of civilized life or indeed of any kind of life on this earth. Most people know by now that one hydrogen bomb can wipe out a major city of several million inhabitants. There are, after all, only some thirty or forty such cities in the world, as against the thousands of hydrogen bombs lying ready to destroy them.

Realizing these horrifying facts, it is not surprising that many people accept the outbreak of all-out nuclear war as the end, and refuse to think about it at all. Actually, though it is unlikely to destroy all humanity, it will be quite bad enough. If we allow a single nuclear bomb of any size to be dropped, it will be very difficult to prevent at least half of the cities of the world from being destroyed. The other half may well escape because, after the first burst of bombing, the main combatants will be either totally destroyed or willing to come to terms. The radiation damage will be enormous and far more extensive; no part of the world will be spared, and the loss of life from that alone will certainly run into hundreds of millions. Perhaps a half or even three-quarters of the human race will perish according to the length of time the war goes on and the number of bombs that are dropped. If the outbreak of war occurs after underground, protected, rocket-firing bases are perfected, this might be even worse. An American General recently stated, in attempting to persuade the Greeks to install such a base, that forty hydrogen bombs might be dropped on it without being able to prevent it from firing. What these forty would do to Greece, when five suffice to knock out Britain, was a point he did not go into. It looks as if the only survivors of a properly conducted nuclear war would be the rocket artillery men in their bunkers.

The methods of total nuclear war are no longer those of combat, direct or indirect, as in all the wars of the past, but rather those of extermination that we humans use without any qualms of conscience against other species that have a common desire with us to enjoy the fruits of the earth, against locusts, for instance, or fungi. If we spray an area with

[1] See Bibliography, Part 2.

TABLE I

The Effects of Nuclear Weapons

BOMB TYPE		Power (Thousands of Tons of T.N.T.)	Direct Effects of Explosion (Distances in Miles)		Estimated Number Killed (Millions)			Average Area of Radio-Active Fall-Out with >500 millicuries/ sq. mile (sq. miles)	Estimated Additional Number Killed by Fall Out (Millions)	
			Total Destruction	Severe Damage —Many Dead	City Area (20,000 persons sq. mile)	Industrial Area (1000 persons sq. mile)	Agricultural Area (100 persons sq. mile)		Industrial country	Agricultural country
Nuclear Fission (Kiloton) Bombs	Hiroshima-Type A Bomb	20	1	2	0·2	0·01	0·001	—	—	—
	Maximum "Tactical" A Bomb	500	3	6	1·0	0·05	0·005	—	—	—
Nuclear Fusion (Megaton) Bombs	Bikini-type H Bomb	10,000	15	30	10	1·5	0·15	7,000	4	0·4
	Maximum "Useful" Strategic H Bomb	50,000	25	50	15	2·0	0·2	15,000	8	0·8

Note: The following symbols have been used in the tables throughout this book:
— = nil or negligible .. = not available [ ] = not applicable 1 billion = 1,000 million

a sufficient amount of poison we can check these plagues, we can kill half or three-quarters or seven-eighths or any other fraction of the invading hordes of enemies, but it is extremely difficult to kill the lot. Even the devastating disease of myxomatosis has not prevented pockets of the rabbit population surviving and in a few years re-populating the countries from which they were supposed to have been eliminated. The human race, then, has every chance of surviving, in this limited sense, at least its first nuclear war, but, even apart from the actual loss of human life, only at a cost of incredible suffering.

No one who has not read the detailed accounts of the Hiroshima bomb has any right to talk about the use of these bombs in war. Those killed outright will be the luckiest; far more will die in lingering agony from burns and radiation sickness. There will be little hope of help and it will be of little use when it comes. Overall there will be the general horror of the bursting, searing bombs, crushed and burnt bodies, greater than anything imagined in the hells of the Middle Ages, and the longer horror of recovering for a few of the immediate survivors. Thirteen years later there are men and women in Hiroshima who dare not go out in the streets for fear of the repulsion that their disfigurements will provoke in the passer-by, and they are still dying of leukaemia.

Nuclear war would not mean a simple, clean end to civilization, such indeed as could happen from an explosion of the sun, but rather a painful creeping back into some form of life of the maimed and crazed remnants of humanity in the least-affected areas such as Tristan da Cunha or Terra del Fuego, which will also be those least likely to retain the creative possibilities of civilization. It means a setback of hundreds or perhaps thousands of years. Yet I do not believe it means a complete destruction of civilization, because this has been sufficiently diffused, and enough will be kept of the principles of science, even in remote places, to start again without having to retrace all the steps from the Stone Age.

Nuclear war would be a tragedy beyond the range of mankind's experience of death and suffering. It is doubly tragic, with a pointless irony, because it may come just on the even of realizing in practice the enormous possibilities for security and happiness that the science which made the atom bomb can bring. Nor is there any avoiding these dire consequences once the die is cast for nuclear war. The possibilities

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Table I is intended to give a rough comparison of the effects of nuclear weapons of different sizes. The figures are estimates based on the known effects at Hiroshima and Nagasaki and the general law relating the radius of blast effect to the cube root of the effective charge. More accurate figures must exist but they are secret. For fall-out the estimates are based on the published reports of the Bikini explosion and only refer to the short-range fall-out. The effects both immediate and long-term of the fall-out from the upper atmosphere are not included.

(*SOURCES: Effect of Atom Bombs at Hiroshima and Nagasaki*, H.M.S.O. London, 1946.
U.S. Atomic Energy Commission Report, 15th February, 1955.)

of defence of a very limited kind did exist when the atomic weapons were to be carried by conventional aircraft, or even by hypersonic jet bombers because one of the major developments of military science, particularly dependent on that of electronic computers, has been the development of the homing principle, which has given the great advantage to the small interceptor rocket over any kind of air-supported bomb-carrier. It is the use of these interceptor rockets that now limits, if it does not entirely destroy, the potential destructive effectiveness of the U.S. Strategic Bomber Command.

There can, however, be no such simple defence against ballistic rockets coming from high altitudes. Now that the purely physical problems of securing the descent of such rockets through the atmosphere with some kind of anti-burning device in the nose have been solved, these have become the weapons to supersede all others. Interception by anti-ballistic rockets demands an accuracy of a different order from that needed to intercept airborne bombers. It is difficult enough, as we have seen recently, to get such long-range rockets into the air at all, but to get hundreds of them up at the precise fraction of a second required to intercept another rocket on its way to its target is stretching the imagination too far. This method has not even the merit of being new: there is a very detailed account in one of Baron Munchausen's tales when, during the siege of Gibraltar, he was able to destroy the enemy's battery by aiming his gun at the shot coming straight towards him and knocking it back to where it had come from. Despite this precedent, I think it would be most unwise to pin any hopes on ballistic interception for a long time to come, and by that time other and more destructive forms of long-range weapons will no doubt have been invented, if we continue along the crazy path which we have followed so far.

Nor is it practical to rely on the hope of destroying inter-continental ballistic rockets on the ground. It is true that the bases projected in Britain for the obsolescent but still untested American weapon would be easy targets, but better methods of launching from numerous small and interchangeable sites have already been perfected in the Soviet Union. The final stage of armoured, underground, launching sites offer, for reasons already given, even worse prospects for the civil population.

Passive defence remains as a technically possible alternative, though one hardly likely in fact to be followed. It would be possible to put a proportion of the key personnel of a few industrial countries underground in radiation-proof shelters, but there is no effective prospect of putting whole populations in them. The estimate of $63,000 million, which has already been made[1], for sheltering the 87 million U.S. city dwellers is almost certainly an underestimate. Even if this sum were to be spread, as suggested, over six years, it would represent an increase of 24 per cent on the present vast military budget of the United States.

[1] P. G. Steinbicker, "Shelter or Evacuation", *Bulletin of the Atomic Scientists*, Vol. 13, p. 168, 1957.

It is over 20 times the annual amount spent by the United States on all foreign non-military aid. It would be at least twenty years—that the shelters were being made, and would use up vast quantities of steel, concrete and contractors' plant, just what is needed for housing and useful public works. There would, of course, not be the slightest hope of people in other than the richest industrial countries being provided with such shelters. In the United States even such a plan would leave the 80 million people in the smaller towns and the countryside unprotected against widespread fall out.

Even if, by such a prolonged and costly effort, a substantial proportion of the world's population were accommodated in shelters, in the long run they would hardly be much better off, for, with this degree of protection, nuclear warfare could last very much longer. More rockets could be fired and more nuclear warheads exploded, so that the amount of radioactive material in the atmosphere could be many times greater than in a short and sharp nuclear war. The result would be to make an even smaller proportion of humanity ultimately viable, because even those in the shelters would have to come up some time. It is unlikely that they could keep more than two years' stores with them, if that, and when they had eaten them up they would have to come out into a world which was biologically as well as physically devastated; and for at least a generation it would be lethally radioactive. If they could find places free from gross contamination they would be very unlikely to find enough normal vegetation or animal life on them, and there would be a subsequent loss of life which, if less horrible, would be far more drawn-out than with an unprotected population where there would be more quick deaths and fewer lingering agonies from radiation sickness.

These considerations are necessarily somewhat academic in Britain, because it would be one of the first countries to be attacked, and we can be reasonably sure that for economic reasons no serious underground protection, except possibly for rocket base crews and other essential personnel, could be undertaken in this country. It would be difficult enough to find provisions for even such a limited shelter population.

I mention shelters, not just to make fun of them, but because they are being seriously advocated not only by generals but also by some scientists in the United States, and notably by Dr. Teller[1] who is more than any other scientist responsible for the whole hydrogen bomb policy. Their object is to make a nuclear warfare policy acceptable by lulling people into an entirely false sense of security.

The degree of destruction in all-out nuclear warfare is not now seriously disputed. However, its very extent is being used to provide an excuse for a supposedly milder version of "limited nuclear warfare". This has been the burden of Kissinger's book *Nuclear Weapons and*

[1] *Bulletin of the Atomic Scientists*, (1957), vol. 13, p. 162.

Foreign Policy, and the less well-known but more closely argued pamphlet expressing the views of British military experts issued by the Royal Institute of International Affairs *On Limiting Atomic War*. The theme of both of these is, effectively: "Let us go back to the practices of the eighteenth century, where war was carried out with limited means for limited ends." But where the authors have misunderstood the historic analogy is that such wars were limited, not so much because of any desire to spare humanity the damages of war, but from a realization that the means available were not sufficient to conduct any other kind of war. Napoleon was the first deliberately to break the rules and to come up against those sheer limitations of distance and supply that ultimately broke him.

But whatever our conclusions about the reasons for the limitation of war in the past, they have ceased to apply in the present. So long as the potential for total destruction is there, the tendency to use it to redress the balance of the side temporarily worsted in limited warfare is likely to be overwhelming. At any rate, no one is prepared to trust that this temptation will be resisted: even the staunchest advocates of limited warfare demand the maintenance simultaneously of the whole apparatus for all-out inter-continental warfare as well. In other words, they wish to reduce the ill-effects of war by duplicating the means required to carry it out.

The same ambivalence is shown at the highest level. At the United Nations General Assembly on 19th September, 1957, Mr. Dulles could advocate limited war in these words:

> "... We seek, by experiments now carefully controlled, to find how to eliminate the hazardous radioactive material now incident to the explosion of thermonuclear weapons. Also, we seek to make nuclear weapons into discriminating weapons, suitable for defence against attacking troops, submarines and bombers, and for interception of inter-continental missiles.
>
> "The Soviet Union seems not to want the character of nuclear weapons thus to be refined and changed. It seems to like it that nuclear weapons can be stigmatized as 'horror' weapons.
>
> "Does it calculate that, under these conditions, governments subject to moral and religious influences will not be apt to use them? And would the Soviet Government, not itself subject to moral and religious restraints, thereby gain a special freedom of action and initiative as regards such weapons?
>
> "And does the Soviet Union not want nuclear weapons to be refined into effective defensive weapons which could repel an aggressive attack by those who control the most manpower?"

A few weeks later he could threaten the bombing of the Soviet Union over a minor Turco-Syrian dispute.

Indeed, limited nuclear warfare is full of contradictions. The limits themselves are supposed to be set by conventions, not agreed as the laws of war of the past, but simply announced by one side. One has only to read the works of the advocates of limited warfare to see how absurd these conventions are. The nuclear bombs are to be limited to the half-megaton class, namely, anything up to fifty times as powerful as those used at Hiroshima and Nagasaki. They should be used exclusively against military targets, that is places where similar nuclear weapons might be launched by the other side, or against concentrations of troops. Other provisions are suggested for marking off open cities within a certain radius of which, say, thirty miles no such bomb is to be dropped. It is assumed that the civilian population will somehow be mysteriously wafted away when the military formations are occupying any other areas.

Those who wish to get the concept of limited nuclear war accepted are suspiciously silent when it comes to describing the effects of such a war on the civilian population, which is in vivid contrast to their description of the horrors of total nuclear war. However, the knowledge of the effects of tactical nuclear weapons of the Hiroshima type should make it clear to any that care to look that the horrors of limited nuclear war would differ only in extent and not in degree from those of total war, to which at any moment it might degenerate. Quite apart from the effects of direct hits, deaths from heat flash and radiation sickness would be counted in millions in any populated district.

Indeed, the advocates of limited nuclear war seem to admit as much, for they get themselves into extreme difficulties in discussing the actual territories over which a limited war might be fought, their opinions depending to a certain extent on which side of the Atlantic they are writing from. In view of the present N.A.T.O. proposals for the distribution of tactical nuclear weapons, particularly in Germany, it would appear that it is anticipated, at least by some high military authorities, that the limited warfare should take place in Central Europe. Others, however, do not entirely share this view, because they realize that if one takes a map of Federal Germany and draws circles of thirty miles around all the cities, there are precious few places in which a tactical atomic weapon could be dropped while sticking strictly to the rules. Even then the civilian losses would be great. A detailed estimate of the result of the N.A.T.O. exercise "Carte Blanche" in 1956, using only tactical nuclear weapons, was that 1·7 million civilians would be killed and another 3·5 million seriously wounded.

Nor can there be any assurance that the rules will in fact be adhered to, especially as both sides may be operating a different set. Remembering the bombing errors that have taken place in purely "conventional" wars, it is almost certain that even without their pilots intending it some bombs would be dropped in these prohibited areas, and these would in turn give rise to corresponding deliberate reprisals. In view of this, it

is not surprising that the German people, and even some of the German military authorities, do not look with favour on having any kind of nuclear warfare over their own territory. Even many of those who stand by the principle of "deterrence" would prefer to see Central Europe treated not as a theatre for limited warfare, but as a vital area, an attack on which would justify total nuclear war, so that the Russians and the Americans would also get their share of destruction, or that the fear of this might prevent such war breaking out at all.

Alternative areas for limited warfare have been suggested in the Middle East or on the fringes of Asia, but there, although in principle it should be easier to carry it out as there would be little opposition, there would be extraordinarily little reason for doing so. Mr. Dulles, it is true, was in favour of dropping atomic bombs to save Dien Bien Phu from the Vietnamese forces. If they had been dropped near that fortress where most of the attackers were massed, the position of the garrison might have been even worse than it was, while further away would have been of little use. As the fort was in the middle of an extensive jungle without any important military or industrial concentrations in the neighbourhood, it is difficult to see what advantage would have been gained. In the Middle East the only useful targets from a military point of view would be oil wells and refineries, but it would never do to bomb them, as the object of the exercise is to protect them.

Much of the force behind the argument for limited war stems from the belief that it would be possible for the Western Powers to use nuclear weapons in conditions when the other side had not got them or would not use them. Certainly this was behind the idea of using them in the Korean conflict and in Indo-China. But this supposition itself is very unrealistic in the present circumstances. If nuclear weapons were used by S.E.A.T.O., say, in any such outlying territory, a response, also with nuclear weapons, would be made to it from China on some S.E.A.T.O. country, and this would almost inevitably lead the Americans to do what Mr. Dulles has repeatedly said they should, attack the homeland of the Soviet Union.

Indeed, the whole very unconvincing propaganda for limited nuclear warfare is effectively a cover for the actual distribution of so-called tactical nuclear weapons to N.A.T.O., and possibly later to members of other military pacts, such as the Baghdad and S.E.A.T.O. pacts. The actual policy, whether acknowledged or not, of the Western allies is to base their whole strategy and tactics on nuclear weapons, and therefore to be unable to fight anything but a nuclear war, with the danger that wherever it starts it is not likely to remain limited for long.[1]

Recent events have still further emphasized both the stupidity and the danger of the policy of limited-unlimited nuclear war preparations. It is evident that the setting up of the intermediate range ballistic missiles

[1] A devastating criticism of limited nuclear warfare from the military point of view has been written by Professor Blackett (*New Statesman*, 17th May, 1958).

in various countries in Europe, and particularly in Britain, is incompatible with a limited war objective. It is rather a belated attempt to make up for the inability of the manned-aircraft to push home their attack on the strategic centres of the Soviet Union in the face of interceptor rocket opposition. The whole idea of this strategy is quite absurd, as Kissinger has pointed out, because the advantages of destroying the centres of industry and of transport only arise in a long-drawn-out war. In all-out nuclear warfare the destruction of these targets would have no effect on the immediate military capacity of the enemy to retaliate; in other words, attacks on them would be pointless slaughter.

For all the efforts to insist to the public that nuclear weapons are absolutely essential in modern war, and that any attempt to refer to them as "horror" weapons is propaganda, the advocates of the atom bomb either dare not think or dare not say what its effects will be or what objects it can hope to serve. Logically, an atom—and still more a hydrogen—bomb is simply a weapon with a large area of absolute destruction (and this applies to "clean" just as much as to "dirty" bombs). As such it can only be used economically against an equally large target and this is a city. The advocates of its use against troop concentrations must know that in any war in which they were used such concentrations would never be made, but highly mobile, dispersed units would take their place. Their object would be to get among enemy units in such a way that no bombs could be used.

The irresistible temptation of the strategists would be, as in the last world war, to bomb each other's principal cities, however pointless the exercise. Rocket nuclear warfare is indeed the last stage in evolution of impersonal war[1] where the separation between the button-pushing agent and the tens of millions of his victims becomes absolute. He does not see or know or care what he does. It is merely a duty automatically carried out. In itself this offers a horrible danger of the accidental outbreak of nuclear war. At the same time, however, it offers for the sane statesmen and strategists the possibility to put an end to the whole business. As war gets more scientific, the effects of weapons become more calculable and the human element disappears. If we know four figures giving the number, range, accuracy and destructive power of the weapons on each side, we can calculate the consequences of their being used. It is hardly worth firing them to find this out. If either side doubts the performance of the other's weapons, why not arrange a shooting match, as Mr. Khrushchev has suggested, in some corner of the Arctic Ocean or even on the moon. But if the answer should be, as most knowledgeable people already believe, that each could destroy the other and that between them they could destroy the rest of the world, why not accept the nuclear stalemate and dismantle the whole apparatus.

Indeed, with modern developments the very concept of nuclear warfare has become as illogical as it is terrible. It is maintained only

[1] J. U. Nef, *War and Human Progress*, London, 1951.

because it was thought in 1945 that the use of the ultimate weapon—the atomic bomb—would serve to compensate for the superiority of the Soviet Union in conventional arms and manpower. This supposed advantage of possessing the bomb had already disappeared eight years ago when the Soviets first made it, but the idea of the bomb as a guarantee of victory is still sustained, because without such a fiction it seems impossible to justify the continuation of the Cold War policy. To some extent, however, it has been replaced by an even more vague concept of "Deterrence", that is, of an increasingly intense preparation for all-out nuclear war in order not to have one.

The concept of deterrence is associated with another and older idea, that of "negotiation from strength". Now negotiation from strength is a nice, polite way of saying dictation. At the end of both the First and the Second World Wars, the victorious powers certainly negotiated from strength, but the prospects of doing so in the present Cold War situation are obviously becoming more and more remote as Soviet military technology advances. But the more remote they become, the more its protagonists insist on repeating their formulae—as is to be seen in that masterpiece of dull dishonesty, the statement of the N.A.T.O. powers at their Paris Conference in December, 1957, in which all the talk is of peace and disarmament, and all the action is on the setting up of nuclear rocket bases.

The continuation of this policy of deterrence and negotiation from strength can only lead to a continual wasting of human effort in the preparation and testing of weapons, and the maintenance of the present hair-trigger situation in which a mistake by an unskilful or overwrought pilot may precipitate an entirely unintended Third World War.

While we await this outcome, the war in one very real sense has already started, for the tests of nuclear weapons have already found their victims and will certainly find more, even if some means of stopping them is found through international agreement. So far, apart from the Japanese sailors and the Pacific islanders, there have been few direct casualties. The Australian natives who starved to death through the closing of their hunting grounds by the building of rocket ranges must be considered as indirect victims. However, the long-term effects of accumulating radioactive material, particularly strontium 90, in soil, plants, food, and human bones, will take an indirect but statistical toll in suffering, deformity, and death. It is estimated that the strontium 90 build-up in human bones due to the tests carried out up to the end of 1956 will eventually cause up to 100,000 extra cases of leukaemia and bone cancer. In addition to this, even if the fall-out produces only a 1 or 2 per cent increase in the effective background radiation, as the supporters of the tests maintain, this will give rise to a genetic hazard of unknown proportions. This amount of wanton suffering is caused solely to prepare for slaughter and suffering on a far greater scale. This is, indeed, why the advocates of nuclear warfare are so resolutely

opposed to the banning of tests, and why any success in getting them banned will mark the first stage in the abolition of nuclear war itself.

One particularly hypocritical defence of tests has been advanced by Mr. Dulles in the quotation given (p. 14) which is that these are necessary in order to perfect the "clean" bomb essential for limited nuclear war. This thesis paradoxically finds its chief advocate in Dr. Teller[1], the creator of the undiscriminating and superlatively dirty hydrogen fission-fusion-fission bomb. It is presumably with such clean bombs that an American writer estimated that the U.S. forces would manage to kill 100 million Russians at a loss of only 20 million U.S. citizens. The odd 200 million British and other Europeans who would be killed in the process are neither mentioned nor counted.

The repeated warnings of competent scientists against the tests[2] have by now thoroughly roused public opinion, and an increasing agitation against their continuance is growing up, notably in Britain and Japan. The first official step in stopping them, however, was taken by the Soviet government, which, after fruitlessly appealing for a joint cessation by the three nuclear powers, unilaterally suspended its own tests. This action has not yet been followed by Britain or the United States, who have both subsequently carried out tests. Public pressure, however, is beginning to tell, and the agreement of the Soviet Union to a United States' proposal of an expert examination of the means of checking whether tests have really been stopped may be a first step to an agreement on imminent abolition. But it will be already too late to avoid ill-effects on future generations, for the report of the United Nations Committee on Radiation Hazards shows that already the concentration of Strontium 90 in some regions has passed the danger point. At least it should come in time to prevent other nations such as France, Germany and Sweden from joining the race to nuclear suicide.

The present international disharmonies, the state of fear that the Cold War produces, the ever-present danger of an outbreak and the prospect of total destruction in full-scale nuclear warfare are only one part of the price that humanity has been paying and will pay for the division of the world into hostile military blocs. The other is the cost, actual and potential, of the preparation for such a war, a cost which is felt all over the world, in the Soviet Union no less than in the United States and Britain, and for that matter also in those countries that

[1] "Clean, flexible and easily delivered weapons of all sizes would make it possible to use these bombs as we want to use them: as tools of defence. When stopping an aggressor we would not let loose great quantities of radioactive atoms which would spread death where we wanted to defend freedom. Clean nuclear weapons would be the same as conveniently packaged high explosives. They would be nothing more." (E. Teller and A. L. Latter, *Our Nuclear Future*, New York, 1958, p. 172). The bombs at Hiroshima and Nagasaki were also clean bombs, and nothing more.

[2] A. Pitie (ed.), *Fall Out*, 2nd edn., London, 1958; *Current Digest on Atomic Danger*, International Institute for Peace, Vienna (in progress); *Scientific World* (Special issue on nuclear weapons), Vol. 2, Pt. 2., 1958.

appear to have no part in the war, in the underdeveloped regions of Asia, Africa, and South America.

The cost of the Cold War makes itself felt in many different ways, indeed it is far greater than would appear from a mere reckoning of the money invested by the various countries of the world in war preparations. This figure itself is vast enough both absolutely and seen in relation to other types of expenditure. Some estimates are shown in Table II. It can be seen that at least $90,000 million have been spent on the average every year since 1950. This sum, as we shall see later, is far greater than that required to provide for the most rapid practicable advance of all the underdeveloped countries.

To see the disparity we need only contrast the recent U.S. loan to India of $300 million with the $4,000 million additional expenditure on the development of rocket missiles sanctioned at the same time. Not only are the underdeveloped countries kept short of useful aid from countries that could well spare it, but they are also obliged by the prevailing state of international tension to maintain altogether excessive military forces of their own. Sixty per cent of the budget of India and seventy-five per cent of that of Pakistan is for military expenditure.

If the underdeveloped countries are the main sufferers from the present arms race, they are not the only ones. It cuts deeply into the possibilities of advance in the industrial countries as well, for the expenditure there on health and education and other aspects of life is being held back, and increasingly so, by the rising cost of the Cold War. Vast as is the total cost itself in dollars, that is, in men and materials, it is a very inadequate measure of what is being lost. Actually it is far more than it appears because of the quality of that cost. In industrial countries, the main concentration of research and development is in the electrical and aircraft industries. In Britain, for instance, the number of persons engaged in these fields are 26 and 32 per cent respectively of all those engaged in research and development. Now, in the two special fields of electronics—needed for radar and every kind of guided weapon, and aerodynamics—needed for both plane and rocket flight, the predominating interest is military, as is shown by the great contributions of the defence ministries to the electrical and aircraft firms. In the latter, in the United States, over 95 per cent of the production is of military planes. Planes which may be used for civil purposes may be produced incidentally, but the object of this great new industry is not principally to turn out such planes, but to produce increasingly effective military, bombers and fighters.

The figures in Table II, taken from official sources, show the mounting burden of military expenditure. Comparison of the expenditure of different countries, and any estimate of the total sum must be conjectural, to the extent of the uncertainty of exchange rates and price indices. For instance, the defence expenditure of the U.S.S.R. has been converted at a rate of 4 roubles to the U.S. dollar. At the low rates of exchange often quoted for the Soviet Union (10 roubles to the dollar), its contribution would be only $10·2 billion.

TABLE II

World Military Expenditure: 1950–1957

Country	*Unit (billions)*	*1950*	*1954*	*1957*	*Annual Average (1950–57)*		
					National Currency	*As percentage of National Income*	*In billion U.S. Dollars*
U.S.A.	Dollars	14·6	42·9	44·3	39·4	13	39·4
U.K.	Pounds	0·85	1·57	1·61	1·46	9	4·1
France	Francs	559	1171	1494	1164	10	2·9
Other N.A.T.O.							5·1
Total N.A.T.O.							51·5
U.S.S.R.	Roubles	82·9	100·0	96·7	101·8	9	25·5
China	Yuan	2·60	5·81	6·00	5·12	7	2·6
India	Rupees	1·64	1·94	2·31	1·92	2	0·4
Estimated Other							10·0

Estimated World Total of Annual Military Expenditure Average (1950–1957) — $90 billion

Sources: Statistical Year Book 1957, U.N., New York, 1958; NATO Press Statement, December, 1957; and national budgets of individual countries.

It is an irony, though we should be thankful for it, that all this effort has been thrown away, that most of the bombers and fighters alike are obsolete without having ever been used in war, and that all the careful thought and ingenuity, and man-hours of skilled scientists, that went into them have also been wasted, apart from some incidental research the results of which may leak into other sciences. This experience should have been enough to bring people to their senses and to get them to use all this ability for constructive purposes, but instead of that, the same scientists and technicians, or more of them if they can be found, will now be put to work on developing better and faster inter-continental ballistic missiles, or any other kind of devilry that the military will have thought of in the future.

It is in the field of nuclear science, however, that the military association is most damaging. All atomic energy research establishments are covered by security regulations; the nature of the research is keyed to its possible military uses, and as a result the development of peaceful uses of atomic energy has been held up, probably by at least a decade. Since the war the successes that have been gained, such as Calder Hall, or that are promised in the Harwell Zeta, together with similar advances in the Soviet Union, have been a record only of what could be spared from a much heavier military effort. In view of the world's need for power, this is in itself another crime against humanity. The effect of militarily-imposed secrecy has also been very serious in hindering international co-operation in science and has certainly slowed up advance even in the countries most concerned with nuclear research. This has, however, at least partially been overcome since the Geneva Conference on the Peaceful Uses of Atomic Energy in 1955; and in the more remote and purely scientific parts of the subject the ill-effects of military secrecy are largely neutralized. We are still, however, far from the condition of a free exchange of persons and ideas in the most vital field of modern physical advance, that of the atomic nucleus.

One other aspect of the Cold War, which has gone on for so long that it does not now call for very much comment, though in a pre-war situation it would have been considered a *casus belli* for active reprisals, is the existence of discriminations of the most absolute character in world trade. A list of forbidden goods which may not be sent either to the Soviet Union, China, or the People's Democracies of Eastern Europe, includes practically everything required for building up a modern industrial base. They are prohibited on the grounds that they could be of strategic use. Some of the items included have now become absurd, in view of the technical progress in electronics and machine building in the Soviet Union. To forbid the export of electronic valves or machine tools to these countries is very much like forbidding that of coal to Newcastle. But nevertheless in the aggregate, particularly in respect to China, the embargo puts a considerable strain on the development of

the economy of the world. There is no doubt that without it a much freer trade would ensue, leading to greater orders for industrial products from such countries as Britain, and a greater supply of other types of industrial goods as well as of primary materials from the Soviet Union and China. There is still much to be said for the soothing effect of a free trade on international relations.

The ever-present prospect of nuclear war, together with the burden of preparations for it, remain the major hindrances to the advance of mankind, just at the time when such advance is most needed and most possible. The first thing that must be done is to get out of this position, and quickly, for delay only means a further piling up of ever-more destructive weapons. By now, especially since the United States has come within range of inter-continental missiles, the governments of the Western Powers are beginning to appreciate the dangers of the situation. The difficulty is primarily that of finding an alternative to the policy of deterrence—how, in other words, to step down from the position adopted in the Cold War, without appearing to lose the advantages, even if illusory, that have been claimed for it.

The question of disarmament is one which has been treated with conspicuous dishonesty for the last ten years. Anyone who has studied in detail, as I have myself, the proceedings of the various disarmament committees and sub-committees, will see that they reveal one fundamental fact, namely that at no time did the Western Powers, particularly the leading nuclear powers, Britain and America, ever intend to give up their power to use nuclear weapons. Indeed, outside the conference they have never wavered in their adherence to the great deterrent. Their tactics at disarmament committees were essentially those of giving the appearance of wishing to abolish these weapons, at the same time as attaching to their offers such conditions as to be sure that they would be rejected. Occasionally this manœuvre conspicuously failed, as, for instance, when the Anglo-French plan for disarmament, put forward in 1954, was, they must have felt, very unsportingly accepted by the Soviet negotiators in 1955, which left the Western Powers in the rather unhappy position of having to say that they did not really mean it, at least not quite like that.

The latest failure of the Disarmament Sub-Committee in 1957, and the refusal of the Soviet Union to have any more part in such discussions, came about by just such an arrangement; the Western Powers insisted that already agreed proposals for the stopping of nuclear tests with progressive conventional disarmament, must be combined with other proposals which they knew in advance would be unacceptable to the Soviet Union, so as to be able to blame them for blocking the way to disarmament. Nevertheless, despite all this suspicion and bad faith, these discussions have charted a way to disarmament by stages which only requires signature to be put into operation. It would provide for the simultaneous lessening of conventional and nuclear forces with

adequate arrangements for inspection.[1] Some of its provisions—such as the Eisenhower open skies plan for aerial surveys—have been made obsolete by ballistic rocket developments. On the other hand a most promising plan of a nuclear weapon and rocket-free zone separating the contestants has been put forward by M. Rapaçki, the Polish Foreign Minister. This might well be the first move of a policy of *disengagement*, important not so much in itself as in marking the reversal of the whole trend of the Cold War.

Nevertheless, as long as it is left to governments, it will be extremely difficult to get out of the vicious circle of suspicions and threats. But by now ever-growing sections of public opinion in all countries are becoming aware of the dangers of nuclear war and are beginning to make themselves felt. In Britain, and even in the United States, a popular movement to end nuclear war, and indeed all war, is rapidly growing.

But to make that popular wish for peace effective it is essential to find some alternative which will enable the positions of mutual hostility of power blocs and the building up of opposing strength to be turned into a different direction: to see the constructive alternative which will not mean any admission of defeat on one side or the other. This concept of co-operative coexistence has been urged for years now in the Soviet Union. It has been resisted in the West for that very reason—on the stupid argument that if it is good for them is must be bad for us. It was, of course, always open to Western statesmen to put forward some such scheme of coexistence themselves. Perhaps they did not think of it; to judge from Mr. Dulles's utterances they did not want it: the Cold War must last until the Communist governments collapse or, failing that, for ever (p. 209).

It is now evident that the peoples of the world are increasingly disinclined to accept this gloomy prospect. The constructive alternative cannot be long evaded. The problem before us is to set it out in concrete terms as practical politics. This will be the burden of the rest of the book. It will be concerned in the first place with what is technically and humanly possible, given the full co-operation of mankind. However, as it is only too evident that this state will take long to achieve, it will also consider the best that can be expected from different degrees of relaxation of the Cold War and of an acceptance, even tacit, of the continued existence in peace of rival economic and political systems. What it will not consider any further, for reasons which this chapter should suffice to show, is the future of mankind if we are so stupid and so weak as to allow madmen to drive us to nuclear war.

[1] *Documents and Papers on Disarmament, 1945–1955*, World Council of Peace, Vienna, 1956; J. D. Bernal, "The Present State of the Disarmament Question", *Science for Peace Bulletin*, No. 17, 1957.

III

BUILDING A WORLD AT PEACE

ONLY in a world without war would there be, for the first time in human history, the possibility of using man's knowledge and labour to the full in order to satisfy human needs. It was never possible to do this in the past; even the great economic changes that occurred as a consequence of the scientific and technical revolutions of the seventeenth and eighteenth centuries were not undertaken primarily to satisfy human needs as a whole, but in the pursuit of private profit. Now, in the twentieth century, that same pursuit of profit, erected into the system of capitalism, still remains an obstacle, even in the absence of war, to any world-wide organization of human welfare. That obstacle, however, is already being removed in many parts of the world and may soon disappear. Here, we are not concerned primarily with how soon and in what way this will happen. Our concern is rather with the urgent task of how to secure at least the material basis of human welfare in a world in which this is the object consciously aimed at. We have seen and experienced enough in the last half century to realize that this is a problem which requires the full use of science, natural and social. Science will be needed not only to provide the answers, but also to set the questions, to determine what are the human needs in some kind of order of priority and how they can be met. This is no longer an optional task: the use of science has now become a necessity for human survival.

In this chapter I want to introduce these ideas in a general way, coming later to more particular examples. Here it will not be sufficient to treat the problems of individual countries, however large and self-sufficient; rather must we consider the problems of the world as a whole, taking into account the interdependence of its various areas, as well as the wide disparities of industrial development and standards of living between one country and another. This growing unevenness is a major symptom of a divided human society, which not only creates tensions but is responsible for the threat of war. At one extreme we have the United States with its highly mechanized industry and agriculture and the high average standard of living; at the other we have what are now politely called the underdeveloped countries, nearly all former colonies or dependencies of the older industrialized states of Europe, with little industry, primitive agriculture and a standard of living, for a great proportion of the population, only just above starvation level.

Relative Standards of Living*

Country	Infant Mortality Rate Per 1000 live births	Average Expectation of Life at 0 Years	Available Daily		Thousands of Inhabitants per Physician	% Illiteracy†	Annual Per Capita National Product (1952–54)
			Calories (hundreds)	Proteins (grams)			U.S. Dollars
U.S.A.	26	70	31	93	0·8	3	1,870
West Germany	39	61 (1933)	31	78	0·7	1	510
U.K.	25	70	33	84	0·9	1	780
France	36	66	28	99	1·0	3	740
Denmark	25	69	34	90	0·9	1	750
New Zealand	23	70	34	104	0·7	1	500
Italy	48	58 (1936)	26	75	0·8	10	310
U.S.S.R.	45	67	30	..	0·6	5	550
Mexico	83	39 (1940)	..	..	2·2	35	220
Brazil	..	53	24	57	2·5	50	230
Chile	112	52	25	77	1·9	20	360
Guatemala	89	44	..	..	6·3	70	160
Japan	41	66	23	64	0·9	2	190
India	113	32	19	51	5·5	80	60
Ceylon	67	60	19	47	5·1	35	110
Pakistan	..	..	20	47	15·0	80	70
Indonesia	..	..	..	..	71·0	80	..
Egypt	129	39 (1937)	26	73	3·5	75	120
Ghana	118	..	..	..	22·0	75	..

Sources: Statistical Yearbook, 1957, U.N., New York, 1958.
World Illiteracy at Mid-Century, U.N.E.S.C.O., Paris, 1957.
Per Capita National Product of 55 Countries: 1952–1954, U.N., New York, 1957.

* The figures in this table refer to the latest year available, and in all cases are 1950 or later unless otherwise stated.

† This is the minimum percentage of the population of 15 years and over estimated as illiterate in 1950 by U.N.E.S.C.O

Some idea of these differences in standard of living can be seen in Table III and Figure 1. See also Tables VI (p. 63), IX (p. 107), XXI (p. 246) and Figure 3 (p. 98).

The unevenness in development in the twentieth century, which has been more marked than in any other period in human history, is not confined to that between one country and another. As class distinction, it reaches right down into every aspect of life inside the different countries, primitive as well as advanced. In its technical aspects the disparities have become even more exaggerated owing to the stress of military preparations. We see on the one hand the development of weapons of incredible subtlety and accuracy while on the other we find that the amenities of life of the workers producing them remain far below what could be provided by present techniques. Military aircraft can travel at more than 1,000 miles per hour, but the great bulk of the population of the cities where these planes are produced are travelling in overcrowded buses and trams at average rates of nearer ten miles an hour. At a time when any military engine as much as two years old is obsolete, the people who make them are living as often as not in inconvenient and ill-repaired houses half a century old. Every rocket shot off today is the equivalent of homes for 500 families.

These contrasts could be removed today, and will be as soon as the concentration of technical advance on military objectives is relaxed. Then we can pay more attention to the problems of every-day life. The way to remove these intolerable disparities, by making it possible for the least favoured peoples and classes to raise their standard of life mainly through their own efforts, will be the theme of most of the rest of this book. It is not that we are demanding that the underprivileged should be given their right to *consume* a due share of goods of the world, but rather that they should be given a fair chance to *produce* what they need for themselves, so as to be treated no longer as either inferior or dependent. Here we can draw on the experience of the pioneer nations of our times, the United States, Japan, Russia and China, who have, in their very different ways, succeeded in industrializing their economies and providing at least the basis for a high standard of living.

This chapter will treat generally of the technical and scientific possibilities of transforming the world, leaving to later chapters the more detailed questions of its immediate economic and political possibility and of its phasing as an operation. The most important point to make at the outset is that the very growth of science and technology implies that man has from now on to be his own *providence*, to foresee and take

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All the figures quoted in Table III, though taken from standard sources, are probably inaccurate in detail. However, they are sufficiently accurate to bring out the larger discrepancies between developed and underdeveloped countries. Of the figures given, the infant mortality rate is the one which is changing most rapidly. Comparisons of per capita national product are somewhat speculative owing to uncertainties about exchange rates and different methods of estimating the national product. Here, unlike Table II (p. 21), 10 roubles—$1.

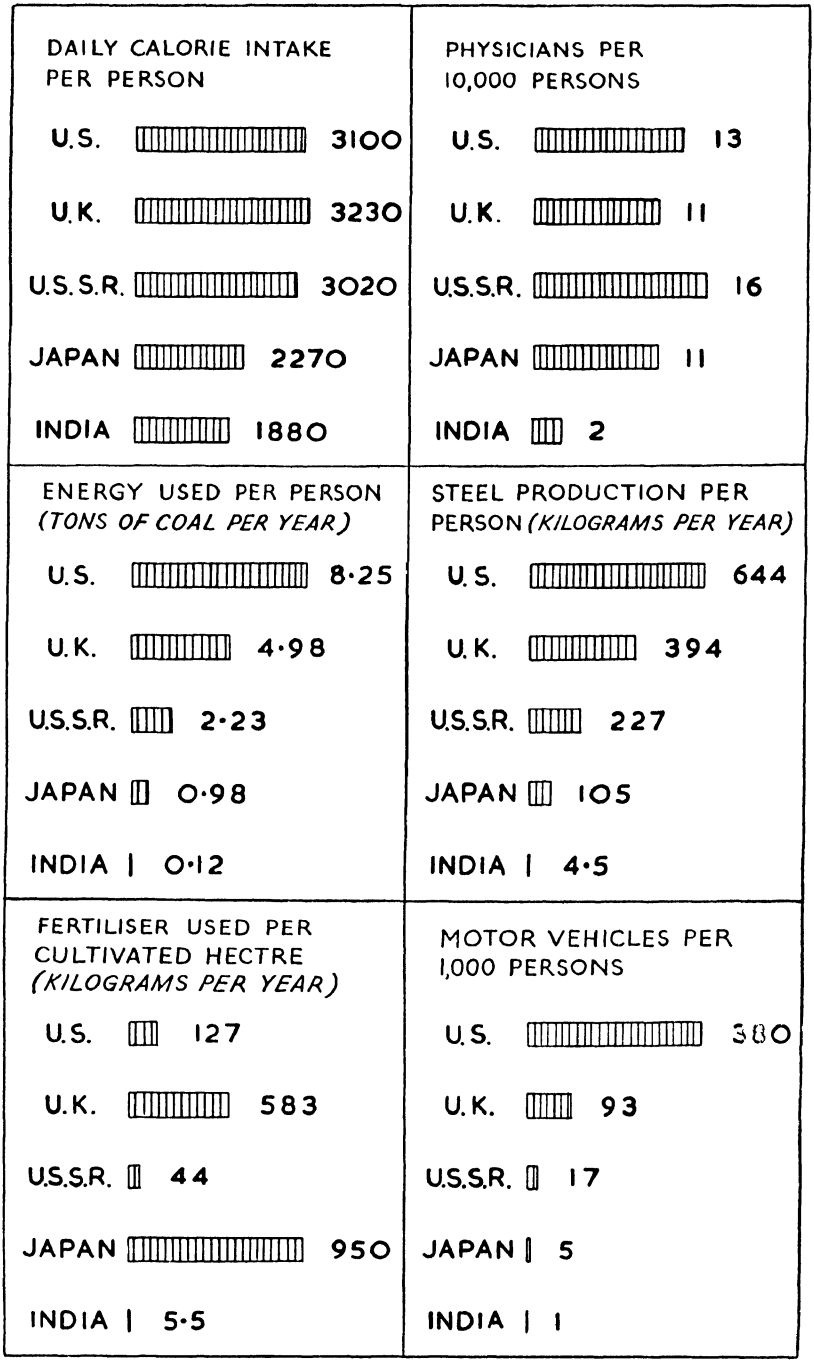


Fig. 1.—Some Contrasts of the Modern World (1955)

action for his own benefit. The external providence, the providence of the sun and the rain, of good hunting and rich crops, belongs to the past of humanity. It is true that for a long time we have tacitly accepted particular and general providences of human origin—we expect a family to look after itself and stigmatize it as improvident if it does not. But men have long attributed, and some still attribute, all the larger changes that bring good times and bad to the working of divine providence, to the acts of God or to blind fate. It is now becoming apparent that man is now having rather more to do with them, and can no longer avoid taking the full responsibility. The great troubles of our own century—a century in which so much of good was possible—the wars and slumps, can hardly be attributed to a divinity, even though it is extremely difficult to pin the blame on to individual men.

The essential requirement of human providence as a whole is one of looking forward—the literal meaning of the word—looking forward and taking care. But now that looking forward must be not only on a larger scale in area—for it must consider the conditions of men, women and children in all parts of the world—but it must stretch further also in time. For instance, one of the great tragedies of the late nineteenth and the twentieth century has been the improvident use of land by settlers driven on by the need to produce cash crops in ever-larger quantities for lower prices. They took the easiest way and exhausted the soil. If we do not look forward and estimate consequences, rather than look for quick profit, social loss will certainly result.

Plans must be made far ahead: the needs of human beings must be accurately forecast and provision made for their satisfaction, in many cases even before those human beings are born. The process is necessarily a complicated one, particularly in this era of rapid technical and scientific progress. Careful planning requires that, with techniques available or within sight, everything necessary is done in time to secure human well-being. Of course it may well be—though it cannot be counted on—that methods which are much more efficient and do not require the same extensive works will be invented in the years to come to achieve the same ends. To that extent a certain flexibility must be retained; but the basic principle—that one must insure against the demands of the foreseeable future—will remain, and even works which may have no permanent value will do well to serve their time.

It is quite likely that in a century or so the great railways and steamers, which were the triumph of nineteenth-century technology, will have proved completely obsolete, replaced for short distances by motor-transport and helicopter, and for long distances by sub-marine freighters and high-speed planes. Nevertheless, the building of the railways was a step which could not be skipped at the time, although in the future we should try to anticipate the technical changes as far ahead as possible.

In Fig. 1 different aspects of life are shown for five typical countries, only one of which, India, is an underdeveloped country.

Such anticipation is not necessarily extremely difficult; in fact, even today, the gap between the technical idea and its full-scale realization in practice, even in any part of the world, is still one of the order of a generation, about thirty to fifty years. It can be shortened, and I hope it will be shortened, but enough can be foreseen of the future to guide present planning of long-range efforts.

In discussing planning for the world, as a whole, I am not implying that this needs to be done for the world by any supra-national authority. The experiences of this century have shown well enough that great things are done only by people or groups who expect to benefit from them immediately or through their children. The thorough and rapid transformation which we now require in human affairs can in fact be carried out only as an exciting and voluntary effort. People must have the sense of doing things primarily for themselves in their own countries. This self-help cannot be replaced by help from outside, however benevolent in intention.

Countries and regions are, however, now so interdependent that in fact people cannot help themselves without helping each other. Some world-scale co-ordination is absolutely necessary to make the best of separate national efforts, while to further it we need the spread of what might be called rational unselfishness—some general consciousness of the needs of people in other countries, and the realization that the greater satisfaction of all is also the greater satisfaction of each.

Every country and every community has its own particular requirements and needs, of which, in the first place, it must be the judge. In solving its own problems it will, however, be able to contribute its best to the efforts of the other countries and communities. We want here a diversity, largely because we do not know the answers in advance, and only by trying out different methods can the best be selected. We want to avoid only the selfishness that has ruled the economic development of the world in past centuries, which seeks the advantage of some at the expense of others. In a world in which the limitations in the availability of materials and work were absolute, and where it seemed to follow that some could get more only if others got less, this unselfishness might seem merely idealistic preaching. It will be plain common sense in the kind of world in which ever-new possibilities of technique and science are opening up. For here there will be no limitations of a material kind; the only limitations will lie in what people actually choose to do with the virtually unlimited resources, both of materials and methods, that will lie before them. Here the more each person has, the more the others will have as well.

The first consideration is to provide for the actual biological needs of all mankind; for unless these are satisfied, there will be an almost insuperable block to the whole of humanity enjoying and contributing to social or intellectual life. Half-starved and diseased people can only produce philosophies of frustration and resignation, if not of blank

despair, and it is no accident that ignorance goes with poverty. The problem of providing an optimal biological environment for mankind is now fairly simple to state and well within the realm of actual possibility to solve. That we allow millions of people to live as we would not allow pigs is one of the major crimes that will be charged against the rulers of our time.[1] They know the need, and could have found, had they cared, how it could be met, but in fact were far too much concerned with other interests to attend to it.

In the course of the last thirty years medical science has been able to establish the minimal useful diet for human beings. Naturally, stated as an average, it overlooks individual differences, but our food supply works on averages, and the individual differences will sort themselves out inside the family and community. Something of the order of 2,700 calories a day is needed to maintain human life in its full working capacity; add to that the provision of the necessary amount of protein and vitamins in the diet and this will provide for as healthy a humanity as we know now how to feed. Now some 2,000 million people or over 70 per cent of the human race get less than this, and many of these are half-starved. We know, perhaps, a little more about what is not enough than what is too much. There is considerable evidence that some of the diets enjoyed by the allegedly most fortunate people in the world, in for instance such countries as the United States or New Zealand are excessive. With an average calorie intake of over 3,000, many are in fact overeating, and are producing diseases of superabundance where before there were only diseases of scarcity. But although continual refinement is needed to prescribe the best diet under different circumstances, the first and most obvious thing is to provide the basic diet for all, and to put an end to undernourishment and its consequences in ill-health and unhappiness. This is a straightforward agricultural and engineering problem (Chapter V).

Provision has to be made not for a static population, but for one which is increasing on the average by over one and a half per cent per annum, that is doubling every forty years. The rate of increase in food production must keep up with the needs of a growing population. However, that rate has in fact been exceeded in the last ten years, with an average increase of food production of about two and a half per cent per annum. In the world as it is this increase is deceptive, because most of it has occurred in regions where people have enough food anyhow, whereas in those countries with too little there has scarcely been any increase at all, and the growing populations there are consequently worse off. In a reasonably managed world the technical problem of producing the necessary rate of increase for the next few decades is certainly soluble, in ways which I will indicate later (Table V, p. 62).

[1] One farmer I visited after the war had installed central heating in his piggeries, but not in his labourers' cottages, because, as he pointed out with the logic of the Manchester school, he was not able to sell the labourers by the pound.

After food, the major necessity is for the comfort of people, for clothing and housing. The first of these is not any longer a very serious problem, partly due to the improvements of techniques with natural fibres, and behind them the development of artificial fibres, so that the possibility of providing adequate clothing for all already exists in most parts of the world.

It is far otherwise with housing: almost everywhere in the world it is inadequate and costly. The problem of housing is, however, not by any means an insoluble one; the failure to solve it up to date has been due to factors other than technical ones, largely economic, affecting socialist and capitalist countries in different ways. In capitalist countries the reason was simply that to build good houses for the people did not pay. For centuries they lived, rack-rented, in old cottages and tenements. Only the strongest popular pressure secured some measure of municipal housing. In Asia and Africa, in cities in which great profits are made, millions live in shanty towns or on the pavements, and even for that they have to pay rent. In socialist countries, where far more housing had been destroyed in wars, one reason for inadequate housing—though not dear housing, for rents are very low—was that the urgent needs for industrial construction were allowed, and wrongly so, as is now recognized, to take too much precedence over housing. As a result of this lack of incentive all over the world the techniques of building in general, and housing in particular, are still behind those of all other types of modern industry; but the successes achieved there, transferred to building methods, should enable the housing situation to be met easily as soon as its priority is effectively recognized (pp. 44 f.).

Food, clothing and housing represent the major material needs of mankind—the necessities, rather than the luxuries of life. But there is one other necessity which does not require material assistance so much as it does knowledge, and that is the preservation and improvement of health. Here the great advances made in the present century, particularly in dealing with varieties of infectious disease, especially those affecting infants and children, has produced a tragically paradoxical situation, in which keeping people alive has only made their food supplies even more inadequate. Pestilence has been avoided only to make way for famine.

Some of those who find the prospect of starving beggars sitting outside the rooms in which they are feasting a displeasing one think that the way out is to restore pestilence to its former power in reducing population, or, more humanely stated, simply not to provide medical help. This has found echoes even in scientific circles who should know better.[1] The more humane solution, and also the only one that will save the world in the long run, is to complete the improvement by providing

[1] A. V. Hill, "The Ethical Dilemma of the Scientist", Presidential Address to the British Association for the Advancement of Science, 1952, *The Advancement of Science*, September, 1952.

enough food to eat for those whose lives are saved by medicine. For centuries we have been so accustomed to disease as a normal part of life that we are still far from realizing how many people are dying today simply through lack of medical knowledge or medical treatment. We are absolutely unaware of the even larger number of people who are dying or suffering simply through lack of medical research necessary to find out the nature and cure of their diseases (pp. 97 ff.).

To provide men with optimal physical environment is a necessary objective. It is, or should be, a first charge on the productive mechanism, but it is not an end in itself. It is not a final objective, that is something much more difficult to achieve: it is how to enable men and women all over the world to make the fullest use of their capacities. That implies also training them so that they understand the world they are living in, and learn the skills by which they can be most useful. One of the most heartening discoveries of modern times is that there are no effectively innate limitations to human capacity. Not all people can express themselves in the same way, but each, given suitable opportunity, can learn to do something which both satisfies himself and is useful to the community.

The knowledge of this human potential reveals what is certainly the greatest waste in our present semi-civilized world: the waste of human capacity. At the same time it gives us the hope that, with the reserve we know we have of untrained talent, there should be no difficulty in finding the persons to run the more complicated and more demanding industrial processes that a scientific civilization will necessarily require (Chapter X).

Now already, in outlining the major needs of humanity, I have indicated something of how they can be provided for; the actual choice of the means to be used, however, poses problems of another kind. The multiplication of the means available to humanity is perhaps the most notable change that has occurred in the last centuries. We have now powers previously undreamt of, and devices more far-reaching than we are aware of ourselves, because they have either been left unused or grossly misused in the service of war. The development of science and technology—the characteristic feature of modern civilization—has now become something which has proved its value, and must be continued, not only to deal with specific problems, but also because its general advance promises the solution for problems of which perhaps today we are not even aware, or think of as insoluble, such as the prolongation of human life (pp. 279 f.).

Everywhere, up to the seventeenth century, and even now over most parts of the world, human existence had been maintained by a carefully elaborated productive system based on tradition, which had enabled a number of people, of the order of one to the acre, to be maintained on agricultural land, leaving a very small surplus for clergy, nobles, merchants and craftsmen. There are still some today who—admiring the

stability and antiquity of this system and the way in which it was built into cultures as different as that of China and medieval Europe—would like to return to it. But unfortunately this return, even if it were desirable, which I would most strongly dispute, is now impossible. If any serious attempt to return to this pattern of economy were made, or rather if we neglected the present services of a scientific-industrial state, it would lead to the death of something like 60 per cent of the present population, for more could not be maintained above starvation level by such traditional means. Even in the underdeveloped countries, the enormous population increase that has occurred in the last hundred years has been a by-product of industrial developments in the other countries, particularly in the production of efficient means of transport, which has prevented local famines cutting down the population.

If we are not to return to the medieval state of chronic semi-starvation through sheer growth of population, it is necessary to use and to develop industry far more rationally than we have up till now, and particularly far less wastefully. A fear which is often expressed by economists, especially in the advanced industrial countries, is that if all the countries of the world were to use up the natural resources—the fuels, the metals and other minerals—at the rate which they are using them in the most privileged countries today, the resources themselves would be exhausted in very little time, and the privileges of the industrial countries would be impossible to maintain. This, though a short-sighted view and a selfish one, follows from the thoughtless assumption that the present scale of wastefulness is an essential part of industrial civilization. So far this civilization has been developed under the influence of the profit motive, without regard to waste as such at all. If it pays to cut down forests to make paper for printing advertisements on, then it is worth doing, even if the penalty is floods and droughts and irrecoverably wasted land. With all the statistics indicating the increase in production per man hour in industrial countries goes another, the production per kilowatt hour, that is production per unit of energy employed. This has actually been going down rapidly in recent years. At present, it is calculated that in order to gain a 1 per cent increase in production, an additional 2·3 per cent of energy must be expended.[1] But this increased wastefulness is not at all necessary. It is possible to develop an industry that makes a rational and not a wasteful use of both material and human resources.

The whole scientific technological complex of modern civilization can be taken to include many of what were assumed previously to be a separate vocation such as those of the doctor, lawyer and clerk. It includes industry in the narrower sense, that is the engineering, metallurgical and chemical industries; it includes transport and distribution; it includes agriculture; it includes administration and other social

[1] *Nature* (1958), vol. 181, p. 1502. See also G. Hutton, *We too can prosper*, London and New York, 1953, p. 76.

services, the health services and medicine. All these have already been penetrated to a greater or less degree by science, and all will become intrinsically scientific as they develop. However, it will be convenient to treat them as separate units, as they still have their distinct traditions, and the way in which science is affecting them is different in each case.

The Industrial Revolution began in the engineering and manufacturing industries, and it is there that we still find the most thorough break with old traditions and the greatest possibility for the use of scientific methods. This is because the problems dealt with in the engineering industries are more mathematically specifiable and imply, on the whole, simpler physical ideas than those of the other sciences or occupations, particularly those in the biological field such as agriculture and medicine. As I have tried to show elsewhere,[1] science itself grew up largely as a by-product of this industrial transformation of the seventeenth and eighteenth centuries. The early manufacturers wanted to improve materials and processes for their immediate purposes, and in doing so found out the laws of their behaviour, particularly the laws of chemistry and physics. It is not until the present century that anything like the same process of analysis could be applied in agriculture or medicine, and there our understanding is still far behind our practices, that is, we do things which seem to work without knowing why or how they work.

The whole tendency of the evolution of mechanical industry has been the substitution by machines of human activities. The first stage of the Industrial Revolution consisted of finding mechanical substitutes for the power of muscular movement, as in the steam engine, and also for the skill of repetitive hand movements, as in the early spinning and weaving machines. Problems were then treated as they arose, or new ones were found by inventors. But now, after two hundred years of this process, people are seeing the substitution of human activities by machinery more as a general problem, the particular cases of which can be dealt with as examples of general principles.

The simplest breakdown of modern industry is into the categories of Energy and Skill. Energy is the currency of industry. All its forms—mechanical, electrical, chemical, and now nuclear—are economically as well as physically interconvertible. The crude raw materials of the earth can be extracted and processed into useful chemicals or materials —given sufficient energy. That energy was until recently limited to what could be drawn from coal or oil, plus a little water power. The limit is now removed through the discovery of how to extract energy from nuclear fission, and energy may become available in indefinite amounts from thermo-nuclear reactions. The removal of the limit to energy is equivalent to the accessibility of infinite material wealth, in a way that will be discussed in detail in Chapter IV.

[1] J. D. Bernal, *Science in History*, 2nd Edition, London, 1957.

That wealth, however, has still to be worked for and used in an intelligent way, and this is the function of the revolution in the operational control of industrial processes that has now acquired the name of *Automation.* Its possibilities will be discussed in detail in Chapter IV. Here it is enough to say that, in principle, automation, particularly with the use of electronic measuring and computing devices, makes production far quicker and more precise than does any humanly controlled machinery. It can lead to a new jump in productive capacity, with a consequent increase in real wealth. The Industrial Revolution substituted the machine for the craftsman. The automated unit now takes the place of teams of factory workers and co-ordinates and links the operations of individual machines into the unified output of the whole factory. At the same time, on the human level, it completes the transformation of the first Industrial Revolution by bringing all repetitive work, however complicated, into the orbit of the machine, just as that Revolution did with heavy manual work. From now on in principle there need be no more machine minders or routine clerks and accountants. Men and women can be liberated for creative tasks, which they can still perform better than any machine. It also implies, because of the speed of the new automatic machines, that intermediate production goods, such as machines as well as consumer goods, can be made increasingly abundant and cheap.

The combination of abundant power and automation increases the range and scale of man's control over Nature. It makes possible great works to speed transport and help agriculture, especially by irrigation, which can change the face of the earth and extend the area and fruitfulness of cultivation. Agriculture, as we shall see in Chapter V, armed with the new engineering as well as with scientific control of men and animals, will be ready to meet the demands of an ever-increasing population for a far better nutritional standard.

Greater than the contribution of abundant energy and automatized industry to human welfare, because both these actually derive from it, is the advance of science itself. Here in the pursuit of research, both fundamental and applied, lies an indefinite promise of further improvement of man's control over his environment, and over himself as well. Already, not only the progress of medicine, but its very day-to-day practice depends on the activity of scientific research (pp. 9 ff.). Further, a healthy industry and agriculture are equally dependent on it. We shall find with the decrease in the number of workers in routine tasks an increase of those occupied with pure science (pp. 182 ff.). Through this activity of science men will learn to overcome natural limitations to which humanity has been accustomed for millenia and which, as they were accepted as part of the order of nature, were not resented. At the same time radically new possibilities, hardly dreamed of before, are opening up in the conquest of outer space and in the control of living processes (Chapter XIII).

We shall need all the scientific effort we can find because of the greater needs and the increasing consciousness of those needs, that has been spreading all over the world. The overall problem of raising world productivity substantially and within a short time is one of the utmost urgency; unless and until it is solved in practice, and not just on paper, mankind cannot escape for long from pestilence and famine. Its solution has been dangerously delayed by the efforts wasted on wars and war preparations, but it cannot safely be delayed much longer.

The new scientific and technical revolution has already produced such an explosion in scientific productivity, especially in the countries where it first appeared, that the discrepancy between the standards of life of rich countries and the poor is widening, and we shall need all our intelligence and good will to remove it. As we shall see later (p. 149) the ever-increasing consumption of raw materials by the wealthier countries—particularly by the United States—will, unless modified by the use of less wasteful methods, greatly increase the difficulties of the rest of the world without in the long run improving the conditions in the wealthy countries themselves. Even in their own interests they cannot afford to be spendthrifts in a world of beggars.

We must not underestimate, nevertheless, the value of the American experiment of the late nineteenth and early twentieth centuries: it did set an example of mechanization and mass production of consumer goods which the rest of the world has done well to follow. But now that lesson has to be applied, no longer along the lines of rugged individualism—which in any case is obsolete even in the land of its origin—but rather along those of a rational, scientific development of resources on a world basis. Only thus will it raise the standard of living of all beyond the standard already reached in the most favoured countries.

The technical possibilities that I have here outlined in a preliminary way, and which will be considered more in detail in subsequent chapters, can be realized only within the limits of availability of natural and human resources. The question of natural resources is a straightforward material one. Natural resources are immediately available only in so far as they are discovered, though over most of the world they have not yet been for lack of sufficient survey. They will become available in the future only in the measure in which they can be utilized, that is, in the measure of the scientific knowledge of how to make the most of them. As scientific knowledge increases, so the capacity for extracting resources increases; accordingly there is no reason for any fears as to shortages of natural resources.

It is, however, a much more complicated thing when we come to the human resources. In actual numbers the human resources of active men and women are certainly adequate for any task, however large, provided, in the first place, that they are sufficiently trained for their tasks; and, in the second, that they are willing and indeed eager to undertake them. The problem of selection and training of specialized

personnel seemed at one time a formidable limitation to what could be expected, in view of the extremely small proportion of people who had the necessary qualifications, even among the very limited populations of the advanced industrial countries. But now experience in Russia, and later in China, has shown that this is not a serious objection, because the limitations that had existed in the past can be shown to be essentially relics of an earlier social system, which reserved the higher technical and learned occupations to a small section of the community. Once these taboos are overcome, the percentage of people of higher technical ability seems to be nearer 50 than the 4 previously accepted. This question will be examined in some detail in a later chapter (X).

Willingness to work, however, is a very different thing—it depends on the share which the people have and feel they have, not only in the produce of their work, but in its direction, and the choice of the general objective for which they are working. The capacity of human beings for arduous work is very much greater than everyday experience of industry or agriculture would indicate. However, in the varying episodes of this century we have had enough examples of work carried out in every range from heroic enterprise to surly acquiescence. We know that the tempo of heroic effort, which can achieve great things, cannot be maintained continuously for long periods. It has its function in specific enterprises, particularly in the early stages of building up an economy. What we want to achieve is a rate of doing work, both manual and intellectual, which can be indefinitely maintained with interest and keenness. This implies a close interplay between those carrying out the work and the general direction of it.

Here we shall have a great deal to learn from a careful study of actual experiences, rather than from a projection of theoretical and psychological analysis. In the post-war years in Britain, and to a certain extent in America, there has been a theory that by the use of psychology one could persuade workers to do more and produce more without the benefit of better equipment, and thus increase profits without expenditure of capital. It has, in fact, not proved a very satisfactory method, and the one that has taken its place, that is of steady pressure on the working class by means of continuous inflation, seems also to be breaking down. What will happen in the last and classical stage of a depression, with unemployment and wage cuts, still remains to be seen.

These considerations emphasize that any changes that take place will be firstly in the actual world as we know it, and we will then have to evaluate the real political and financial obstacles to pushing forward to a more productive and more equitable world (Chapter XI). I am convinced, from what has been achieved already in constructive enterprise, in the Capitalist as well as in the Socialist part of the world, that these obstacles can be overcome. Once this has happened, we shall liberate an enormous reserve of ability and human energy that can complete the transformation far quicker than most people think.

The old idea, especially prevalent in countries like Britain, was that in order to avoid trouble—interfering with vested interests or with established practices of work—the speed of advance must be cut down to an imperceptible minimum. This can no longer be done in a world in such violent transition as we have today, and an attempt to do so in any country risks letting it fall so far behind that its economy will no longer work effectively (pp. 160 ff.). And people are beginning to understand this: they are no longer willing to postpone till their grandchildren's or great-grandchildren's time the enjoyment of the fruit of their labours.

But is it possible to get these rewards sooner? This is, in the first place, a question of technical and scientific possibilities, and their examination will be the subject of the next three chapters.

IV

INDUSTRY

We have now reached a point from which it is possible to see man's industrial activities not, as in the past, as a set of interlocked crafts, but as one, many-streamed process for transforming the material world for man's benefit. The main flow sheet can be seen to begin with the *extractive* industries by which man wins from the ground, directly by mining or drilling, or indirectly through industrial agriculture and forestry, the fuels and crude raw materials needed for the rest of industry. These are first taken in hand by the *transformative* industries, those of the metallurgical or heavy chemical industries, to be turned into finished raw materials, bars or sheets of metal, cement, fertilizers, or purified chemicals. Here the stream divides, some going into the *construction* industries for buildings, roads and public works, the rest into machine, ship, aeroplane, and vehicle building, what is roughly called the *engineering* industry. Finally the machines are assembled into factories for the purpose of turning out consumer goods—textiles, food products, durables such as washing machines or television sets—this is the sector of *manufacture* proper. In parallel with it run the *service* industries of transport and communication. All this great complex of breaking up, transforming, and reassembling materials into usable goods can only operate by a continual and ever-increasing supply of *energy* resting on thermal, hydraulic, and now atomic power stations and the associated electric distribution network.

This brief account necessarily oversimplifies the picture and leaves out large sections, both useful and superfluous, such as the administrative, financial, and military sectors. It also does not allow for the extremely complex inter-relations between the different sectors of which the most evident is the link between the mining and oil industries and the generation of power. Nor can it be free from some ambiguity in placing, for instance, the production of motor-cars in the engineering industry, thus separating them from other consumer goods. It is, however, the best I can do in a few lines to present a picture in which it is possible to see the wood for the trees.[1]

[1] This classification is indeed a technical rather than an economic one, in which the industrial process would be divided between the generation of the means of production—fixed capital and raw materials—and the means of consumption—all other goods and services. Where, as in this chapter, we are concerned mainly with the effects of improvements in technical methods, the economic classification seems less appropriate.

Now this great productive system was never planned in the first place; it has grown, especially since the Industrial Revolution of the eighteenth century, by a process of simultaneous amalgamation and differentiation, from an assembly of handicrafts going back to the dawn of civilization.[1] It is now, however, acquiring a unity and at the same time beginning to undergo a new transformation which promises to be even more important than that which first brought it into being. This is now sometimes called the New Industrial Revolution, but I would prefer to call it the Scientific Industrial Revolution, for its leading characteristic is the change over from technical tradition to scientific analysis as exemplified in the two great advances of this century—atomic energy and automation.

Modern industry is reaching the stage when it can relate in a rational and scientific way the production problems it has to solve with the mechanical, chemical, or electrical means of solving them. It is just at the point of breaking away from the limitations of technical tradition, on which it was built in the past, and of approaching a higher stage in which the nature of the problems can be examined scientifically. Solutions can then be found by calculation or laboratory experiment and with the minimum of rule-of-thumb experience they can be incorporated into material objects and processes. We are just at the beginning of this transformation—it has certainly not been fully achieved. Over large parts of present-day industry the traditional technical mode still dominates.

The situation in industry at the present day is accordingly one of extreme confusion and contrast, where radically new methods depending on modern physics jostle with old methods depending on skill of eye and hand. Old industries are being transformed in detail by the application of such devices as electronic control, and they are also liable to be transformed almost out of existence by a radical approach to the whole question of the purpose and function of industry. For instance, the production of iron and steel is about due for such a radical revolution. The great giants of industry—the blast furnaces of our steel works—may well disappear. For all their apparent complexity and automation they are nothing but blown-up descendants of the original clay furnace in which the first iron workers produced their metal by blowing down reeds. In their place may come the reduction of iron from its ores at quite low temperatures using methods of the chemical or electrical industries.

Here, however, I do not want to look too far forward into the future, for I shall reserve some such speculations for Chapter XIII. Rather do I want to point out some of the possibilities of existing industry based on processes already tested out on a small scale, here and there, and capable of universal application. More particularly I want to stress

[1] See *Science in History, op. cit.*

the need for a rational appreciation of what industry is for, as well as how it can work, because it is here that the great new innovations are likely to lead to enormous waste of effort unless they are used wisely from the start.

I am referring especially, on the one hand, to the new available sources of energy derived from the discovery of atomic fission and the hope of virtually unlimited energy from thermonuclear reaction, and, on the other, to the new developments of electronics which have led to the possible automation of industry as well as of business and administration. These are great new forces which, when they are fully and wisely used, will make our industry unrecognisably different from what it is now. If, however, they are used, as they are now, under the stress of the preparations for war—as rather stop-gap methods to solve immediate problems—an enormous amount of time and effort are certain to be wasted. To avoid this a scientific approach not only to this industry or that but to the total industrial process is absolutely essential.

Before approaching the problems of atomic energy and automation I want to say something on the raw material resources on which all industry depends. Men have been using raw materials since before the dawn of civilization but usually on so small a scale that they ran no risk of depleting them. True, certain rare resources, such as gold, became increasingly difficult to find, but they were effectively always found to the degree to which they were really needed—in the case of gold even more so. But now we are reaching a stage when the old, easily exploitable resources have been extracted almost to the limit of what is known to exist on the planet. Warnings have been uttered in the past, and they are still valid, that, in such matters as iron, coal, water, certainly all the rarer metals such as copper and tin, the present rate of exploitation would use up all known resources in a relatively short time, varying, from about 35 years in the case of tin to perhaps 200 in that of iron. But such estimates, though right enough when they were made, have now little relevance to the limits of available resources. For we are no longer, as we were in the past, limited to using resources which were relatively easy to find or cheap to work. By using progressively poorer ores, there is hardly any limit to what can be extracted if we are prepared to spend enough capital and energy to do so. As the whole world contains something of the order of 5 per cent of iron, there need never be any shortage of steel. We could if we wanted to, cover the whole planet with a layer a mile or so thick without really diminishing the material still to be had. The normal surface rocks of the continents, the so-called granitic shell of the earth, contain between them all the insoluble elements in any quantities we may want them, and the soluble ones are all to be found in the waters of the oceans.

The practical point here, however, is that we are coming to the end of the easily won material—we do not pick up nuggets of gold in the streams any more. We have to work more for what we use. But this is

happening at a period when this limitation is not a very serious one. It is only a matter of putting more energy into the winning of the raw materials from poorer ores, and that energy will now be available from atomic sources in any quantity we choose to use. The difficulty of winning such metals as aluminium can be measured almost entirely in their energy cost. Aluminium is to be found in every clay and in most volcanic rocks all over the world, but it can only be made cheaply, at present, if electricity is to be had at a rate of a fraction of a penny per unit, and this will be quite a reasonable figure for atomic energy even in Britain within the next few years. This is an example of the fundamental equation of modern heavy industry: *Energy is now convertible into any kind of material we want.* This applies just as much to organic materials like polythene, rubber, or nylon, as to metals. This does not mean that one should necessarily want to convert energy into material at *any* rate of conversion, however low. We would still prefer to do it at the cheapest and most efficient rate and here is where science comes in. But the major fact is that we need not expect to be held up industrially by any shortages of raw materials, and they will be overcome as they arise. In the last resort, with the knowledge of nuclear fission and transmutation, we can actually make any elements we want out of others which are more abundant. The alchemist's dream has come true at a time when no one is really particularly interested in its achievement. We do not even know what to do with the gold we have already, indeed some of it is being turned into a more valuable mercury isotope.

In recognizing this new facility for producing materials, particularly metals, however, we may be led to overlook the fact that in our present civilization we use these materials in incredibly wasteful ways. We do not really deserve the luck of being able to get them as easily as we do. It would be perfectly possible for us, with a rational engineering practice, instead of making more and more massive machines and heavier and heavier buildings, to design them for the purpose for which they are really needed, and this will nearly always use less material.

A particularly glaring example is the use of steel for structural work —a piece of what is really financial sharp practice. It seems convenient for many firms to have expensive building accounts; it is convenient for steel firms to be able to dispose of their steel at high prices. Further, by counting on the engineers to allow generous factors of safety—an expression of deliberately maintained ignorance—and by retaining of out-of-date standard specifications, architects can be obliged to put into a building something between two and ten times the amount of steel that it really requires.[1] It was in the war, when we were short of steel, that this malpractice was discovered by Government research engineers; the knowledge is still, after nearly twenty years, only very

[1] J. F. Baker and B. G. Neal, "Economy of Steel", *Research* (1952), vol. 5, p. 412.

partially used. We are still deliberately wasting, for the profit of a few, resources which many worked hard to win.

What applies to iron also applies to a material used to an even greater extent in the modern world—cement. The use of *lime-silica* or Portland cement was the result of a purely technical development brought about by lime-burners using larger kilns and burning a clay-chalk mixture more thoroughly. Later more mechanical devices, such as rotary kilns, were made for producing the material continuously and more and more uses were found for it. But using cement and water still remains an extremely crude and enormously expensive way of joining sand and stones together into hard blocks and structures. Nature does it much more simply, and on the whole better. One does not reflect that in most countries of a non-volcanic character all the hard rock underneath has been produced by a natural cementing method from originally mud, sand, or shells. What Nature has done man should be able to do just as well and just as cheaply. Here scientific studies using pressure, heat, vibration and pre-stressing are already pointing the way to producing structural units cheaply and of desired strength and weight.

Far worse in its effect on the economy than the waste of building materials is the waste of fuel which is really on a gigantic scale. Here Britain, as the oldest coal user, is one of the worst offenders. Something like a third of the coal is burnt, mostly in primitive open fires, to warm inadequately insulated houses; much of the rest is burned in old-fashioned steam boilers. Even the part that is the most efficiently transformed into electricity is used for space heating in electric fires, while the waste hot water of the power stations, which would warm the houses just as well, is poured into the rivers. It is probable that the total of efficient use of the 210 million tons of coal mined every year is something of the order of 2 per cent, the final result being to warm, quite pointlessly, the atmosphere above our towns.

The battle against waste will have to be fought, if for no other reason, because the wastes of industry clutter up our whole way of living. It is not only the slag heaps and coal tips that have disfigured the older industrial countries, but also our smoky cities themselves, with their badly planned and badly constructed buildings, which are almost more expensive to pull down than they were to build. We want to build flexibly with the knowledge that things will change and change rapidly. We want to be able to rearrange what we have done instead of being blocked by the results of our former actions. This applies also to such enduring constructions as railways and road systems, which, designed to facilitate traffic, have effectively become choked with the additional vehicles they have encouraged.

Much of the inadequacy and confusion of our towns is a consequence of unplanned development in the pursuit of conflicting private interests, but it also stems from the backwardness of the building industry. It is only now that, in countries like Britain, the building industry is begin-

ning to catch up with the First, let alone the Second, Industrial Revolution. Though large-scale mechanization of building with mobile tower cranes has been used in the Soviet Union for some twenty years, it is still only making its way into Britain. This is largely due to the absurdly fragmented and tradition-bound state of the industry. It is this backwardness that is the root cause of the chronic housing shortage, which afflicts the whole world today. This will disappear and our children at least will have the chance of living in convenient, light, and cheaper houses once it is possible to get the scientific knowledge already accumulated on building materials and methods into practice on the building sites. Prefabricated parts and mechanization between them, can effect this revolution in construction.

For the last few decades man has no longer had to be totally dependent on Nature for fibrous and resinous materials. These are now being synthesized on an increasing scale from coal and oil. They are mostly what chemists call polymers, and we buy as plastics or artificial fibres. They are made by linking a large number of rather small molecules into a more or less regular chain. Now the development of plastics and artificial fibres has been one of the great achievements of the twentieth century chemical industry. However, as in many other cases of technical innovation, these materials were first conceived as imitations of those given us by Nature, as artificial silk, artificial wool, or artificial rubber.

But the search for such substitutes has actually led to the production of materials in some respects better than anything found in Nature. Nylon has now won its place into everyday life wherever strength for extreme thinness is required. And nylon is really only a beginning. We have elastic nylon already, as well as artificial fibres as warm as wool but unwettable and unshrinkable. In time the same rational, developmental process will lead to the direct manufacture of cloth or even of clothes without weaving or tailoring (p. 271). What we should here be more concerned about is the function which products serve, rather than seeking for an imitation of an older product that fitted this function only more or less well. The conservatism of the user or buyer has in the past done much to buttress the policy of invention masquerading as imitation. The first motor-cars were just what they were called—horseless carriages —and some of the characteristics of the carriage are still found in the most modern streamlined cars. But it is time that we took a measure of things and consciously broke away from this practice. What we should be doing is, irrespective of tradition, to think out clearly what we need and then set about using the full resources of modern science.

Certainly, modern chemistry can provide us with a range of possible materials that is probably already in excess of anything we now conceive of as needs. We could limit these products to those that did fulfil these needs, at least in the near future. And this would, incidentally, have a great effect on agriculture, because much of the land of this world is at present occupied in producing industrial crops when it could

produce food. In the past Egypt was a land which exported food; the corn of Egypt fed Rome. Though it exported linen cloth as well, the flax plant was also a source of food in the form of oil. Now it produces mainly cotton, almost all exported, and the Egyptian people's standard of living is distinctly worse than it was under the Pharaohs.

The greatest waste of all in this respect has not begun to be tackled — that is the destruction of forests for making pulp and paper, which is then utterly wasted and thrown away, although chemically it is simply solid sugar, the basic energy-giving food. It is time we devised some other methods for producing wrapping materials and bases for printing and pictures, or alternatively that we devised a way of making use of the food value of waste paper. The present world output of pulp would provide sufficient food, apart from nitrogenous food, for over 50 million people. Or, alternatively, it might be simpler to use it as nutrient for protein producing yeasts (pp. 80 f., 273 ff.).

As modern industry develops there will be an increasing call on materials, less for immediate consumption than for intermediate consumption in the process of industry itself, particularly in the chemical industry in the form, for instance, of solvents and finishes. But even in the greatest imaginable development of industry there does not seem to be any reason to fear that any serious shortage of raw materials will arise. As more needs appear, new means and new substances will be found to meet them, now that we know how to build from the very elements provided in the rocks any kind of chemical complex we need through the use of energy. The supply of energy is indeed a measure of the constructive capacity of human civilization.

Now, as we all know, the supply of energy need no longer be a limitation: we no longer need to feel anxious about the exhaustion of world supplies of oil and coal. Nor do we need, except for special purposes such as high temperature furnaces or cooking or refrigerating units in the tropics, to seek for a way of tapping the enormous supplies of solar energy continuously reaching the earth. For this source of energy is so diffused that the real difficulty is in finding any cheap way of concentrating it from large surfaces.[1]

All these sources of energy have now been short circuited by the discovery of how to produce and usefully direct the enormously concentrated energy from the breaking or fusing of atomic nuclei. We should be able to see, from the analogy of what has happened in the past, what this means to the general development of the world. By the end of the sixteenth century mankind was fairly diffused over all areas in the Old World where there were good crops to be grown and timber to be cut, that is over most of the temperate and tropical parts of the world. The power problem was that of providing food for animals and man. Later

[1] This may not always be so difficult. Indeed, by the use of cheap thermo-electric substances transforming the heat of sunlight directly into electricity, it may very soon be possible—at least in sunny climates—to rival atomic energy in cheapness and certainly in simplicity and safety.

on followed a slight drift to areas where there was good water-power for mills. But the real concentration came only with the development of the steam engine and the corresponding concentration of the new, mechanical, heavy industry in the areas of the coal fields, transportation being still a serious difficulty. In industrial countries today something like three-quarters of the population and nine-tenths of the industry are concentrated on coalfields or at large ports where cheap coal is readily available. Britain, the Ruhr, Belgium, the North French coalfields, the Pennsylvania coalfields in the United States, the Donbass, Ural and Altai coalfields of the Soviet Union, are still the main centres of world industry, and only in relatively few places, such as Southern California, has oil already taken the place of coal. With the extension of oilfields which is now going on, heavy industry will spread still farther but its localization will still be limited (Map I, p. 247).

With the full utilization of atomic energy which will certainly take place in another half-century, the need for this restriction will entirely vanish. All that needs to be done to set up an atomic plant is the importation of the fixed machinery—less than a lorry-load of fuel is sufficient for a whole year's operation. This does not mean that it would be possible or even desirable to break up existing concentrations and spread industry uniformly over the world. Quite apart from the resistance of vested interests, and they are extremely powerful—enough for instance to hold back the development of atomic energy in the United States by at least ten years—there is, so to speak, a natural lag in transferring machinery and skills to new places. It is easier to go on producing in places where people are accustomed to it and where all the necessary connections and trained labour are available. But this is not a permanent reason. Once the original advantage of available fuel has gone, nothing can prevent the gradual dissipation of the old centres of industry and the building up of a new, much more widely diffused, industry wherever people live. As we shall see (pp. 70 f.), that in itself will be further enlarged by the possibilities which atomic energy offers for increasing the area of agriculture.

I am not here going to discuss any of the details of production of atomic energy—the variety of piles, breeder piles, and various methods of transferring heat to turbines—or even of generating electricity by electronic methods directly from heated gases.[1] These are now becoming a regular branch of engineering and, if they had not been held back by the prior needs for military expenditure and experimentation, we would already be enjoying, instead of having to wait for another twenty-five years, an adequate supply of energy from fission sources. At the same time it would probably be a mistake to develop this particular source of nuclear energy on too large a scale as long as there is a serious hope that the other, fusion, process based on thermo-nuclear reaction—that is the forcing together of hydrogen nuclei at enormous temperatures to form

[1] "Turning heat into electricity", *New Scientist*, 16th January, 1958.

helium—will be practically solved in two or three decades.[1] Here, with water, or rather with heavy water, as the source of energy, the cost of the fuel will only be a negligible proportion of the production cost of energy. Whether thermo-nuclear energy can be economically produced will depend entirely on the prime cost of the equipment—some kind of large-scale Zeta—and its rate of depreciation. In view of the difficulties, even under modern conditions, of introducing radically new methods it will probably still pay to build as many fissile—uranium or thorium burning—stations as we conveniently can, and to keep them running throughout the early stages of thermo-nuclear energy production.

TABLE IV

NUCLEAR POWER PROGRAMMES OF THE U.K., FRANCE, U.S.A. AND U.S.S.R.

Country	*Year*	*Installed generating capacity from nuclear Power (millions of Kilowatts)*	*% of estimated total capacity derived from nuclear power*
U.K.*	1958	0·1	0·4
	1965	5–6	17–20
	1970	12–16	28–38
France	1959	0·1	0·5
	1965	0·9	2
	1975	c. 10	16
U.S.A.†	1970	c. 5	1·4
	1975	c. 30	6
U.S.S.R.‡	1956–1960	2–2·5	4

Notes:

*. The figures for 1958 and 1965 are part of the U.K. Atomic Energy Authority's programme. The 1970 figure is their estimate of the probable nuclear power generating capacity that year.

†. The U.S.A. has no federal programme for nuclear power. The figures given are estimates reported to a U.S. Congress Committee in January 1956.

‡. The period 1956–60 is being used in the U.S.S.R. to provide operating experience with a view to selecting the best installations to erect in the period 1961–65. No nuclear power generating capacity figures have been quoted for this period.

Source: Economic Applications of Atomic Energy, U.N., New York, 1957.

[1] Sir J. Cockcroft, *The Times*, 25th January, 1958.

The amount of energy that it is planned to draw from fission sources is already substantial. Table IV shows the present state of these plans, but it is apparent that, in the absence of a slump, they are more likely to be revised upwards that downwards. By the end of the century, atomic power will be running even with the older sources of coal and oil in power generation, and will probably have completely eliminated them in another century.

With the advent of abundant energy from uranium or even more so from hydrogen, the problem of energy supply will become quite a different one from what it has been in the whole past of humanity. It will no longer be a question of finding sources of energy, but rather of finding further uses for energy. Energy will be as freely available as air and light are today. Only one consideration will limit the extent to which it is used, and that will be the danger of warming up the surface of the world too much. An annual increase of five per cent in energy generation, which would be by no means difficult to obtain, would result, in a little over two centuries, in the production of almost as much heat as the earth's atmosphere retains from the sunlight that falls on it. The resulting heating would long before this have become intolerable, unless the earth could be fitted with a radiator to get rid of it.

Long before this will be necessary we will be finding what great things can be done in the world once energy is abundant and cheap. Man would truly become master of the world in the material sense. With gigantic, atom-powered machines he will be able to build on it, mould its surface and burrow into its depths at will (p. 74). This great power implies an equal responsibility to use it to improve and not to destroy irreparably the beauty of Nature and the past achievements of mankind.

The easy availability of energy should draw attention to two problems which, because they have not been solved, have always been pushed into the background and really remain a great disgrace to our scientific industry; namely, that we have no means of storing energy and no means of transmitting it without elaborate and expensive equipment. We want to use energy as we need it, that is by fits and starts, and here and there. But it is clear that it is much easier to produce it in an absolutely continuous way at fixed places, and this limitation will be even more severely felt when fission energy and thermo-nuclear energy come in, for the greater the proportion of capital to running cost the more necessary is continuous running. Perhaps half a dozen or twenty stations would, in principle, suffice the whole world. But as the load or requirement varies very much from hour to hour and day to day, something must be done with the energies produced all the time.

We may find some crude intermediate ways of doing this simply by pumping water up to higher levels and collecting the energy again as it goes down, or by using it for irrigation; but this is obviously a stop-gap method. We might also use energy to build up completely artificial fuels, artificial petrols for example, with which to run our cars when the supply

of natural oil is exhausted, as it certainly will be within a few decades once the whole world has reached the level of consumption of the United States.

Other possible methods will be touched on later; here it should be sufficient to assume that large quantities of energy will be available and to go on to ask how and where it can best be used. In the first place energy will be needed in as large amounts as we can produce in the next few decades for the great task of building up a world, on a modern industrial standard, with full provision of machinery, of public works, and of such immediate consumable goods as houses and clothes. With our present methods of food production, energy is also required for mechanized agriculture.

It is only in principle that the energy requirements of the world can now be met. They are very far from being met in practice, particularly over the continents of Asia, Africa and South America, where the energy consumption per head is equivalent to only a quarter of a ton of coal per annum. Even with the most rapid building of atomic energy plants, these needs are likely to take a long time to meet, especially if the procedure hitherto adopted is followed, of building plants only in the most industrial districts where the greatest profit can be reaped from the use of energy.

In the meanwhile, and for some time to come, we will also have to depend even more on a concealed source of energy, namely that which lies in the waste of energy produced in conventional ways, some forms of which have been already alluded to (pp. 43 f.). It is probable that an investigation of the best use of capital resources would discover that the production of fuel-saving and other energy-saving devices would cost less than making the atomic energy stations to produce the same power. We need absolutely to reverse the tendency of recent years to use more and more energy to produce the same units of production goods and consumer goods. This is partly a matter of research, but even more of political and administrative action. The most elementary way of introducing energy-saving would be to raise the cost of energy, to tax electric power very severely; only then would it begin to pay not to use it wastefully. At present energy costs represent about one-tenth of the total cost of production in most branches of industry, and even a 10 per cent saving in these therefore only effects a 1 per cent overall economy, which is not worth a big investment. On the other hand, what may not be in the interest of any individual or firm is of national and world interest and calls for administrative intervention. We want to develop the type of industry which makes the minimal and not the maximal demands on energy, and this in itself is good engineering. To use more force where less will do is to add in every way, in material as well as energy, to the cost of production. It implies the use of heavier and more expensive equipment. It produces more noise and wear and tear, and a shorter life.

The assistance, which has come only just in time, from atomic energy is an addition to an existing stock. Though it is drawn from a new source, once converted to energy it is no different from energy produced by hand, water power, or steam. New industries will have to be founded where none existed before and old industrial centres thinned out. Naturally it will take some time to adapt the users of power in different parts of the world to readily available sources of energy. The transition to nuclear energy presents no problems to engineering, apart from those intrinsic to the production of nuclear energy itself, which is already becoming the new industry of nuclear engineering.

On the other hand we are faced with a revolution in all forms of industry, through the advent of electronic automation. This is likely to be at least as big a revolution as that produced by the introduction of power-driven machinery in the eighteenth and nineteenth centuries. At present we are only in the early stages of this revolution and can barely perceive more than the direction in which it is moving, but one thing that is very evident is that it is moving extremely quickly. In less than a decade it is well on its way into the central regions of the most advanced industries, in the automobile production industry for instance, and into administration with automatic computers for running the routine business of large firms, banks and government offices.

It may well be said that there is nothing intrinsically new in automation. Automatic machines were operating in Egyptian temples in the third century B.C.; they represented the highest point in the ingenuity of Greek science. The centrifugal governor, which was adapted from watermill practice to the steam engine, was the first example in modern industry of the feed-back principle which is the basis of the new science of cybernetics. Nevertheless, we can treat these only as anticipations; they were not an essential feature of the earlier types of industry, which depended basically on continuous hand-control and adjustment. Mechanical devices which could do this were only applicable in rather limited cases of severely routine operations, such as the working of a reciprocating engine or the simple thermo-regulator.

In principle, once mass production was being used, many of the manufacturing operations were reduced to mere repetition and operatives could be simply replaced by suitably geared machinery. One step further was to link such individual machines on the assembly line by transfer machines to pass the work on. The real success of the new automation came when it was able to cope with non-uniform and not quite repetitive conditions, that is with various sizes and properties of the working material, or to allow for the gradual and unpredictable wear or breakage of working parts. This has been made possible only by the development of electronic control, which has a capacity for selecting and dealing with information far more rapidly than the most skilled operative. The fact that the ability of such control mechanisms to deal with altogether unexpected situations may be low does not alter

the fact that in the most ordinary run of industry the unexpected does not often happen. When it does it usually counts as an accident which is in any case outside the scope of the average machine minder. In principle, therefore, the new automatism does for the mental application of craftsmanship what the old mechanism did for the physical application. If one removes the need for sheer labour and strength, the other removes still further the need for skill and watchfulness.

There may be many things, even in the most elementary production, that a man can do much better than a machine but we know there are far more that a machine can do better than a man. The principle that we should be applying from now on is that wherever there is anything that can be done by a machine better than by a man it is worth while having the machine to do it, not only for the sake of production or profit as it is at present, but in order to liberate the man for something he can do better than the machine. And the things that people can do better than machines are necessarily the most interesting and amusing things to do. Machines can copy, a man can create.

At present capacity of automation exists only in principle, because it is only in its very first stages, and has been applied only in certain plants even in the favoured industries; but as surely as in the case of the steam engine, one can foresee its extension to cover all factory-type industry, and to go even beyond it. There are already two essentially different kinds of automation that between them cover most mechanical and chemical operations and that might be called the control and the executive types respectively. The first is a continuous control type, where any process, whether it is a chemical reaction or an engineering fabrication, is maintained within set limits of performance by some type of feed-back device. For instance in the handling of a piece of metal to shape it into some form, such as a cylinder block or a piston, the partly finished job passes from machine to machine by some automatic transfer mechanism, is treated in a prescribed way, and at the same time the product is regularly examined at each stage to see that the treatment is within the limits prescribed. An example of this is the ball-bearing factory which has been operating for the last three years in Moscow—it not only makes ball-bearings, but assembles them in races, and gauges them and matches them in a way which human operatives could hardly manage even at a speed far less than that of the automatic machinery. The logical end to this process is the completely automatic factory, though it may not be necessary to push it this far for some time to come. Though some operations are far better handled by automatic machines than by human beings, there are others, and particularly the interesting ones, where that is not the case, or rather where the automatic machinery would be in itself too complicated and require more attention than the process which it was carrying out.

It is evident that for preparing most chemicals and for fabricating all objects of a standardized type, such as motor-cars or watches, the auto-

matic factory will be *the* way of the future. The degradation of labour which mass production, and particularly the production line, has meant for nearly all machine minders will be brought to an end, but it does not mean that there will be any falling off of engineering workmanship, probably the reverse. Interest will shift from the production of consumer goods, machines, or even such things as clothes, to the production of the machinery for producing them, that is to capital or production goods.

Automatic machinery is necessarily more complicated than the older type of machinery. Further, for many years to come it will be in a state of active development, that is it will become obsolescent after two or three years of service. It will consequently require continuously working research and design departments which must extend into the shops themselves. This is because, though a machine of the complexity of an automatic production line can be left to run unattended, it would be most uneconomic just to let it do so. It needs watching, but for a different reason than did the old machines. Its operations must be scientifically studied in order to find some way of carrying out the task it has been set more simply and quickly, or perhaps even to discover that the task is unnecessary so that the whole process can be short circuited. Certainly, our present motor-cars with their 5,000 or more parts are quite unnecessarily complicated and have grown that way through the exigencies of old-fashioned production methods. Change of production methods will involve change of products, and all of this will involve a great deal of engineering and scientific thought.

It is here that the second or executive kind of automatic machinery will come in—that designed not for full-scale production of thousands or millions of one kind of component but rather to fabricate single elements or short runs. Here it is a question of automatic tools rather than the automatic factory. Their successful development shows that the operations of the hand and eye of skilled craftsmen together with a certain element of judgment can be taken over by machines which will be able to embody a simple idea, possibly not even expressed in a diagram or blueprint but in some mathematical expression, in the form of a working part or even of a whole machine. In principle the design of machines themselves is something that could be handed over to computers, which with proper instructions will be able to point out the effects of different kinds of construction and to choose between them the one which was cheapest and most economic to run. Machines of this sort already exist in the form of computer-controlled milling machines and lathes. Once their use is understood they will become universal in the engineering industry.

At present we are in a very early stage of this transformation. The electronic machinery that operates an electromagnetic switch gear or other control mechanism is simply used to replace the hand on the lever which the operator used to pull. But this is illogical procedure for

machinery in which the human being has no part; in the first place there is no need any longer for the machine to be at a handy height for the operator. A lathe instead of taking up a height of four or five feet could be run within a few inches of the floor or the rack on which it was placed, and the whole space requirements of factories would be drastically reduced. This might seem a backward step in one respect, as it would be much harder to service and maintain such equipment, for at present the workers in an automatic factory are largely occupied in maintenance and repair. But these tasks themselves are likely to diminish, because its need for repair would either be obviated by better design, or foreseen and provided for automatically, by the dropping out and replacing of the affected part. The tendency, already growing in engineering, to substitute a replacement of a readily and easily mass-produced object for the purely hand-operated, and consequently far more expensive detailed repair is winning its way. It may seem wasteful of material, but it certainly saves human labour which is the ultimate standard of value.

Automation, however, is not limited to manufacturing process, it may indeed find its most rapid application in the service industries—in transportation, distribution and communication, where it has already made great strides, and most of all in office work and administration. The railway was a pioneer of a mechanical type of automatic transport in the nineteenth century. It ensured the moving over of goods and passengers at a rate which the more primitive methods of horse transport could not cope with. But it is itself being superseded, and has largely been superseded, by the far greater flexibility given by the individual carrier in the form of the motor-car or lorry, for medium, and by the aeroplane, for longer distances. Now, in their turn, these methods are proving inadequate. Motor-cars and lorries, which were originally a cheap and convenient way of travel or transport, leaving the individual driver or individual shipper free to travel or send his goods from any place to any other, have provoked an enormous congestion just in the places where the traffic is heaviest. This has necessitated either an abandonment of rapid transport, which has occurred largely in the old-fashioned cities like those of London, or, in richer continental and transatlantic cities, in an altogether excessive expenditure in super roads, fly-overs, tunnels and other capital works, which almost tend to choke the cities themselves, and even there do not provide for effective and rapid transportation. Not only that, but a very large labour force is now required, one far larger than the railways ever needed, to move persons and goods.

It is high time that automation was applied here and, indeed, this would be an admirable field for it. The basic principles of automatic signalling have already been worked out on the railways. We now have the possibility of applying the same thing to roads, to unrestricted high-speed roads in the first place, and afterwards, gradually, to the

whole road system. It should be possible to dispatch automatically goods and people from any place to any other place, at a speed very much greater than that averaged at present, simply by arranging that the various vehicles travel at set relation to each other in what would be the equivalent of trains. The carriages in such trains would, however, be coupled by radar beams instead of chains. They would all move together at the same predetermined speeds, in such a way that they could never hold up the traffic or run into each other. This would help to avoid the necessity of rebuilding all our cities in order to enable us to move around in them.

A more logical step, as far as the transport of goods is concerned, is the control of what, in fact, is transferred. The very complicated and archaic methods of the present, in which goods of any kind can be sent from north to south while very similar goods are being sent from south to north, where the total amount of ton-miles is far in excess of that required to provide the same service, could be ironed out by adequate computing devices which would determine in advance how much would be required at any isolated depot of each character of goods at any time. This has in fact been done for the last three years in one very big concern in London, namely Lyons, operating some thousand branches, where, by the use of an electronic machine, the precise requirements of every store are determined and not only does this control the production of the various pieces of food and confectionery but also anticipates the amounts required by means of statistical studies. The machine at the same time carries out all the computations concerning the wages and accounts of the firm, and in the spare time is available for fundamental scientific researches.

The enormous army of clerks that has grown up in the course of the last century to represent an industry even larger than that of primary extracting—in Britain for instance there are 2½ million clerks and only 800,000 coalminers—could be drastically reduced without any injury to the clerks by transferring them to the other occupations requiring intelligence which the age of automation will certainly require. This reduction will not be affected only through replacing clerks by machines, in the first place those doing most repetitive tasks, such as operating adding machines and addressographs. The computing machines can also help in simplifying the whole process of distribution so that far less overall clerical work is necessary.

It is quite clear that this cannot be done as long as we operate the present archaic system of capitalist accounting and the corresponding taxation system, which by first allowing everybody to take what they can off the others and then letting the State take all it needs off them, in detail, manages to double and treble the amount of clerical labour necessary to satisfy at the same time individual and corporate needs. All this redundancy could be largely removed, and much of it is already unnecessary. From the point of view of the community as a whole

it would be very much cheaper, for instance, not to have any tickets on public transport of any kind. Small boys, it is true, might ride round all day on the underground, but they would soon get tired of it, and even if they did not, this would not upset the budget of London Transport seriously.

Indeed the very basis of the exchange economy represented by money has been effectively made obsolete by computing devices. We do not need any longer to reckon things in coin kept in bags or chests; we are prepared to trust the banks and even to effect considerable deductions automatically from pay cheques; but, with a fully automated system, exchange as such would not necessarily occur at all. Even as long as we retain the system of payment by results in which each person is entitled to get as much as he works for, it should be possible to keep a universal register of the amount standing to anyone's account from which he could draw and have debited automatically at any shop or place where he wished goods or services. The excessively burdensome method by which it is done now actually puts a large drain on the resources of the community, and there would be more goods and services available if this was completely simplified by automation.

One aspect of this problem that has grown beyond all bounds in recent times is that of communication and particularly of reproduction and written communication—shorthand, typing, duplication, print setting. Though all require skill, they are automatic, monotonous and uncreative occupations in themselves. True, they were a great improvement in speed and legibility on longhand writing, which they replaced, but they fall far short of the needs of rapid and accessible written communication which we really require today. For that purpose standard machines are already available for reading type, and a beginning has been made in codifying and putting down the sound of the human voice in the form of written words. The discussion of more far reaching proposals especially to eliminate the difficulties of international communication is referred to in Chapter XIII.

All the fields of application of automatic and electronic devices so far discussed cover only some of the various tactical aspects of modern life. If we pass to the overall strategic aspect there are even greater gains to be had. The scope of administration, both in its old legal and political sense and in its new economic sense, is continually increasing, and it is already being felt that the problems of dealing with its complexity are too great for the average officials. This indeed is at the back of much of the resentment felt in all quarters of the world against bureaucracy. In administration on any level, whether it be in a shop, a big firm, a nation, or a league of nations, decisions have constantly to be made on the basis of information which is usually fragmentary and almost always out of date. They also have to be made without the knowledge of the consequences of these decisions, and with the barest hope that, if they are wrong decisions, this will reveal itself and that they can be reversed be-

fore much damage is done. All this groping about is largely due to the inability to cope with large masses of information at the same time, and to extract very rapidly conclusions from it.

In the field of administration the advent of computing machines now makes it possible—just as in a comparably complicated subject such as meteorology in the forecasting of the weather—to be fully posted at any time of the relevant situation. Beyond that it offers the possibility to try out, as we say "on paper", a very large number of combinations of possible action and to obtain from the machine some idea of their probable results, in order to choose which course to follow. Indeed with complete automation, the choice in itself could be made by the computing machine, and higher policy, which has through the course of history nearly always been decided by extremely stupid people who have happened to get into a position of power, could perhaps become entirely automatic. This, however, requires such a psychological and political revolution that it may be one of the latest changes to be made. Nevertheless no one can object—at least one hopes not—to the administrator knowing where he is and what might be the results of his actions whenever he has to make important decisions. In any case the beginning of this change is already with us. Local authorities have started using such machines to carry out all their routine assessments and to forecast their requirements for different kinds of goods and services in the future, and it is only a matter of time before this will be done on a national and international scale as well.

The transition to automatism in industry and administration will not be an easy one. The most obvious problems are financial. For some time still automatized industry will have to grope its way by complicated, full-scale experimentation. In other words, the development side will be very large, and this goes with a very high obsolescence rate. We have the two contrasted systems of the introduction of automation in the United States and in the Soviet Union. In the first, the object, quite naturally, is to introduce automation only where and when it can be shown to pay immediately. This means making and remaking tools and assembly lines continually, so that in some cases machinery is used for only two years, in other words it can only be profitably undertaken when it can produce at least 50 per cent profit on the new investment per annum.

In the Soviet Union they have followed a different principle, that of large-scale experimentation in limited fields in order to get round all the essential difficulties before launching a complete transformation in the industry. This they can do far more easily than in capitalist countries because they are not tied to immediate profitability. The first completely automatic factory, the Moscow Piston Factory, was operating in 1952, and there are only about four or five such factories in similar fields, such as ball-bearings, in the Soviet Union. However, the lessons of these factories will be applied over the whole field of industry, and already for two years there has been a Department of Automation, studying the

whole question and deciding where and when automation should be introduced in different industries.

Difficulties which will probably be far more serious arise from the effect of automation on the industrial and administrative workers. Already two major difficulties have appeared, or rather have been foreseen, as, effectively they have not yet had time to operate. The first is the question of redundancy. The whole object of the automatic running of factories and offices is to save labour, or in other words to save wage costs, and this, at least in capitalist society, means a degree of unemployment. So far this has not been very seriously felt, because in an expanding economy those displaced by the automatic machines have found other employment relatively quickly, but if the transfer comes on a much larger scale and comes more quickly, especially if it comes in a time of recession, not to say slump, it might be a serious matter. It can only be dealt with, as indeed the unions are already demanding it should be, by foreseeing what the redundancy will be and by arranging for industrial development to take over the power of the men displaced, not necessarily, however, at the same job, but at least at a job which brings equivalent pay.

By and large automation will not substitute for the skilled worker; indeed, he should be even more in demand to deal with the ever-more complicated machinery in the automatic factories and offices themselves. Not only that, but we may find that as automation advances into manufacturing industry and effectively cheapens the production of standardized goods—kitchen equipment, television sets, motor-cars—the effective demand for quality individual goods will increase. As their production will require, even if partially automatized, the services of more skilled workers, there is in fact little risk of unemployment for them. But it will replace the occupations of the machine minder and the clerk, and here it is not so easy to see in advance what the alternative occupations will be. One tendency will certainly be in the direction of jobs involving personal contact and personal service which automation cannot replace. There will be more and more opportunity, especially in a community where, as we shall see later, most people will still be studying until the age of 25 or so, for personal service in the educational system itself—that is dealing with people.

We must also remember that one of the objectives of automation is to decrease the hours of work. It may very well be that the present 40-hour week in most of Europe, which has already been replaced by a 35-hour week and even a 30-hour week in the United States, may shrink even further. Whether it will shrink in this way is an awkward question: people might prefer to work, let us say, a 40-hour week for six months a year and have the rest for holiday. Or they might like to work like that for five years and have five years holiday. In that case, in my opinion, the dangers of leisure and the question of what to do with it are not serious ones. They are only serious in a very corrupted society, where the

moment anyone has money to spend and time to spend it in, he is immediately assailed by high-pressure salesmanship trying to get it off him.

The other human aspect of automatism is the obvious need for higher qualifications for industrial and administrative workers. This will be the subject of a later chapter, but I want to make this point here in that, to a certain extent, this counteracts the dangers already mentioned of unemployment due to automation. Not only will more trained people be required, but in the process of training them, the numbers required to train them will also go up. Thus, generally speaking, we may find, when things settle down to a new stage in human social economy, that nearly half the population are engaged in the forward looking parts of human activities, namely scientific research, the arts and education (pp. 182 ff.).

The whole tenor of the preceding chapter has been that of an industry in a state of rapid transformation due to the availability of new and large sources of energy, and to the alteration of working process by electronic automation. It would seem, therefore, very difficult to make any precise estimate as to what this industry could do in remaking the world and raising the standards of production and life in all countries to those at present reached in the most fortunate ones. But it is precisely this pioneer and flexible character of the new industry that should make such a task possible even without any accurate forecast. An established industry is necessarily geared to certain types of production; the new type of industry has not set itself in such lines and will be available to produce almost antyhing in the way of goods and services, and to do so very rapidly.

Moreover, in so far as we can break away from the stranglehold of military considerations and the arms race, the openings for these products will be greater than they have ever been before in history. It is possible that the beginning of this has already been felt, that the absence of any serious recession in the capitalist world, for instance, in the last fifteen years has been very largely due to this great transformation and opening up of the world both intrinsically, in the industrial countries, with the changeover of industrial methods, and in the developing of the underdeveloped countries. We are in a situation not unlike that of the great railway boom in the middle of the nineteenth century which temporarily suspended, though it did nothing to end, the instabilities of the capitalist system. However that may be, the demands of the new countries coming into the industrial system will be so great as to force the introduction of the new methods of production, which are now shown to be technically possible.

In a later chapter we will consider how this process can take place, in what kind of order this productive mechanism should come into action. What is available already will, as we shall see, be just suited to the first stages of the transformation. There can be no question that the new kind of industry will be capable of very rapid expansion. It will be able to provide far more quickly than was thought possible only a few years ago,

for the needs of industrializing the whole of the world. Even before that its present capacity should be sufficient for the first major task of the building up of the new world—that of the transformation of agriculture and the provision of food—we can feel assured that there will be available enough machinery, fertilizer, transport, administration and other primary requirements for a new type of agriculture. What this type is likely to be we will examine in the next chapter.

V

AGRICULTURE, FOOD, AND POPULATION

THE task of getting enough food has been with man and his animal ancestors ever since the beginning of life, and it still remains the major task of humanity even in this scientific age. Three-quarters of the people in the world today are occupied in agriculture, and most of them depend on the produce they raise themselves. This has been the pattern of life ever since the agricultural revolution, some six thousand years ago. The old basic pattern of peasant subsistence farming is still the predominant one, as far as numbers are concerned. However, in a few, but highly productive, parts of the world it has been replaced by another in which the actual food-raising is largely separated from the food consumption, where highly mechanized farming, using a very small number of people to the acre, provides food for many times that number situated in distant cities (Fig. 6, p. 183).

In subsistence agriculture it is roughly estimated that nineteen farm workers can, as well as keeping themselves and their families, maintain one family in a city or in a country house. Already by the middle of the last century in industrialized countries and their dependent lands, the situation was reversed, and one agricultural worker could keep four people in a city. Now, in the most advanced areas, it is possible for one agricultural worker, fully provided with machines and oil, to keep twenty people supplied with food.

Nevertheless, although there has been an enormous improvement in the yield per agricultural worker, the yield per acre over most regions of the world has shown no such improvement. In fact the major problem of agriculture in the world today—the question of finding ample food for all, now and in the near future—is as yet unsolved in practice; and all the advances made in industrial science, as related in the last chapter, have not as yet enabled the production of food on the land to advance to anything like the same extent. Table V shows some of the figures for the production of the main food items for selected countries. It shows that for the fortunate countries of North America and Western Europe an annual increase of the order of 2·5 per cent per annum has been maintained for the last twenty years, which is well above the rates of population increase. For the Soviet Union, Japan, India and China, much lower rates of the order of 1 to 2 per cent per annum are recorded. Except for the Soviet Union, these are less than the rates of population increase (but see p. 295).

TABLE V

AGRICULTURAL PRODUCTION: PRE- AND POST-WAR

A. TOTAL PRODUCTION IN HUNDREDS OF THOUSANDS OF METRIC TONS. B. MEAN ANNUAL % INCREASE.

Country	Year	*Wheat*		*Rice*		*Maize*		*All Cereals*		**Potatoes*		*Sugar (refined)*		*Meat*	
		A	B	A	B	A	B	A	B	A	B	A	B	A	B
U.S.A. . . .	1934–8	195		10		551		951		100		19		73	
	1956	264	1·7	25	4·7	825	2·2	1501	2·6	104	0·2	22	0·7	121	2·5
CANADA . .	1934–8	72		—		2		144		19		1		6	
	1956	121	2·7	—	—	7	7·2	245	2·7	17	−0·5	1	2·7	11	4·5
U.K. . . .	1934–8	17		—		—		45		50		5		12	
	1956	28	2·5	—	—	—	—	81	3·0	72	2·0	7	1·7	16	1·5
FRANCE . .	1934–8	81		—		5		151		172		10		17	
	1956	121	2·3	—	—	13	4·3	217	2·4	167	−0·1	14	1·7	24	1·8
U.S.S.R.† . .	1934–8	381		—		..		958		739		21		..	
	1956	528	1·8	—	—	..	..	1190	1·1	960	1·4	44	3·8	118	..
JAPAN . . .	1934–8	139		115		..		148		16		2		1	
	1956	145	0·7	131	0·7	1	..	171	0·8	28	2·8	1	−3·5	2	3·0
INDIA . . .	1934–8	74		323		22		442		18		12		..	..
	1956	85	0·8	404	1·2	29	1·5	547	1·1	17	−0·1	18	2·3	..	..
CHINA† . .	1934–8	228		505		85		909		..		4		..	..
	1956	237	0·2	771	2·4	..	..	1240	1·6	204	..	5	1·2	..	..

Source: Statistical Yearbook, 1957, U.N., New York, 1958.

Notes: * Potatoes and other root crops.
† Estimates based on various sources.

TABLE VI

NET FOOD SUPPLIES PER CAPITA

(Kilogrammes per year)

Country	*Year*	*Cereals (as flour)*	*Potatoes and other starch food*	*Sugar (refined)*	*Pulses and nuts*	*Meat*	*Milk*		*Fats and oils*
							Fat	*Protein*	
U.S.A.	1935–9	90	64	44	4	71	9	9	20
	1955	70	46	40	4	92	9	9	20
U.K.	1934–8	95	82	42	3	68	5	5	21
	1956–7	87	95	49	4	69	7	7	22
U.S.S.R.*	1934–8	220	..	11	..	..	..	..	..
	1956–7	320	..	20	..	..	..	..	..
France	1934–8	124	143	24	4	61	4	5	14
	1955–6	112	124	26	3	78	5	5	12
W. Germany	1935–8	113	185	26	2	53	6	7	21
	1956–7	95	156	28	2	49	6	7	25
Japan	1934–8	162	63	14	7	4	—	—	2
	1955	150	67	12	9	3	—	—	3
India	1934–8†	143	8	13	18	3	4	2	2
	1954–5	129	12	15	22	1	2	2	4
China*	1934–8	172	30	1	25	13	—	—	6
	1956–7	213	..	1	..	14	—	—	10

Source: Statistical Yearbook 1957, U.N., New York, 1958.

Notes: * Estimates based on various sources. † Including Pakistan.

It is clear that it is in just such countries, where there is already a shortage, that food production is falling behind. Most of the inhabitants of Asia and Africa, and many in South America, are at present below the minimum standard of nutrition of 2,700 calories per day, and on present showing they are likely to be worse off in future, except for occasional good years. Many of these people are living on a margin depending on the chance vagaries of the weather. Any ordinary drought or flood may cause the deaths of millions.

The same picture of marginal existence is shown in the data on *per capita* consumption of various foodstuffs, shown in Table VI. Here, the decline in nutritional standards of the poorer countries is only too sadly evident. Richer countries are eating less cereal, but more meat.

How can this situation be altered in time to prevent further great disasters? This is the most serious and immediate problem of mankind. But it is a strictly short-term problem, because as we shall see, once the present difficulties have been overcome, the prospects for many years to come are extremely favourable. The Malthusian danger of population out-running supplies is theoretically always there, although in the last 150 years it has been successively pushed back by opening new land and improving agricultural methods. Human beings require a certain minimum of food, whereas the land available to produce this food will always be limited; so that if a population does not limit itself there is bound to be, as long as present agricultural methods are used, some time—not too remote, perhaps two or three centuries from now—when the population of the whole world seriously presses on its total available food supply.

The problem of food production can therefore be considered in three stages: the immediate stage, covering the next twenty years; the intermediate stage, say for another century; and the distant future. We can leave this last stage for a moment to a few speculations about scientific food production (pp. 273 ff.), in the confidence that, if we can avoid destruction by war, the men of a century or two hence will also find the answer to that problem, either along the lines of achieving a static population at what they consider to be a good level, or by providing alternative methods of food production, not depending on present-day agriculture.

Many estimates have been made in recent years of the probable growth of population (Fig. 2). The more serious of these estimates agree on the general thesis that the world population is bound to

In Fig. 2 is shown, on a logarithmic scale, the growth of world population, from 1850 to 1956, together with estimates of future population. Those derived from the U.N. World Population Conference 1954 postulate steady rates of increase, ranging from 0·8 to 1·6 per cent per annum. As the rate of growth is increasing, it would appear that, unless there are calamities or some measure of birth control is practised, the high estimate of 13 billion persons will be reached in a century. My own estimate implies a slow increase in birth control, so that the world population will in 2050 be 7 billion, still growing at 0·5 per cent per annum, just below the present rate.

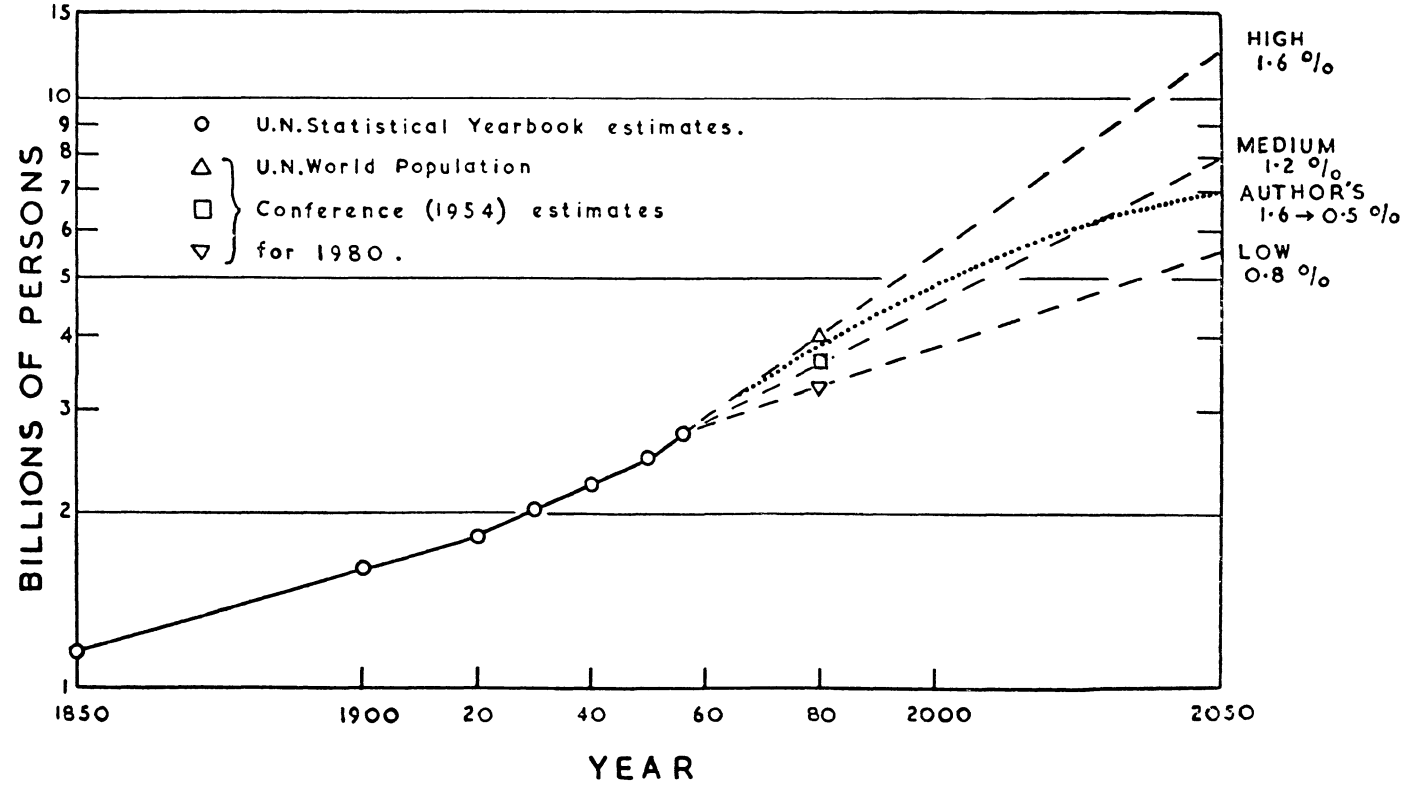


Fig. 2.—World Population Trends

increase for the next few decades at the present rate or slightly over it. Thus in about a century from now it will be some two or three times its present numbers, that is, estimates range from six thousand to twelve thousand million souls in the second part of the twenty-first century. Now it is also estimated that without unduly straining present agricultural methods, that is, by employing everywhere the kind of agricultural methods suitable to the region but on the same technical level as those employed in the under-industrialized countries, it should be possible to provide adequate food for such a population. In other words, there is no intrinsic need of famine in the next century, and if famine comes it will be due entirely to some people's stupidity or greediness (p. 595).

Indeed, the problem of food and population is not essentially a technical or even a biological problem but a social and political one (pp. 244 ff.). As the world is developing today, at least in the two-thirds of it that is often referred to as the "free" world, the strict, capitalist system of economy would seem to doom the majority to starvation, simply because it would not pay to invest in those countries for better food production. Much greater returns could be always got by investing in the highly-industrialized countries themselves where the greatest purchasing power already resides. At the present moment the United States, with less than one-twentieth of the population of the world, has an annual income which is nearly half that of the rest of the world, and this disparity is growing (Table XXI, p. 246).

Nevertheless what is happening in the world, and particularly in countries such as China, which have been as poor as any in the past, indicates that it may not be necessary to wait for the assumption by the citizens of the United States of their moral responsibilities, in order to start building up an adequate agriculture and food supply from the resources of those countries themselves, even though without help from outside it is certain that it will take them longer to do so. In that case, and only in that case, it may also be desirable in the intermediate period to practice some limitation of population growth. Why this should be so and how it can be managed will be discussed in a later chapter. Here we are concerned rather with the primary task of providing enough food for all the peoples of the world and providing it soon.

In approaching this problem it is necessary in the first place to realize how partial has been man's cultivation of the earth he nominally occupies. Of the land surface of the globe only 10 per cent is cultivated in any way and most of this is rough grazing, hardly better than desert or moorland. Only $6\frac{1}{2}$ per cent is intensively cultivated (Table VIII, p. 68). This is largely because, with the means available to man up to now, there has been no possibility of getting a reasonable return from any land that was either too hot, too cold, too dry, too wet, too rugged, or generally inaccessible. And this, as the figures indicate, represents most of the world which is presented, as it were, raw for the utilization of mankind (Map II, p. 249).

TABLE VII

Land Use, Agricultural Mechanization and Productivity in Various Countries

Country	*Total Area*	*Land (Millions of hectares)*				*Hectares of Arable Land per Tractor (1956)*	*Wheat yield per hectare in Metric tons (1956)*
		Agricultural		*Forest and Woodland*	*Other*		
		Arable	*Pasture*				
U.S.A.	770	188	256	259	79	41	1·35
U.K.	24	7	12	2	3	16	3·12
France	55	21	12	11	10	50	2·07
Denmark	4·2	2·7	0·4	0·4	0·7	41	4 ·03
India	329	158	11	50	109	8600	0·71

Source: Yearbook of Food and Agricultural Statistics, 1956, 1957, Part 1, F.A.O., Rome 1957, 1958.

The first and most obvious way of getting more food is to cultivate more land, and this of course was the method which staved off the Malthusian prediction in the nineteenth century. Malthus himself got the first wind of it when he wrote:

"In the wildness of speculation it has been suggested that Europe ought to grow its corn in America and devote itself solely to the manufactures and commerce. But even on the extravagant supposition that the natural course of things might lead to such a division of labour, for a time, and by that means Europe could raise a population greater than its lands could possibly support, the consequences ought justly to be dreaded."

Curiously enough the evils Malthus foresaw of a Europe with a swollen population which might be forced to depend on its own resources are by no means the most serious problem of food production today. In the Europe he was talking of, particularly the advanced industrial countries, especially England, knowledge and equipment for agriculture has so advanced that it would by no means be impossible, though difficult, to feed the whole population on a reasonable standard of nutrition off the land in those countries themselves.

The real problem, however, still remains that of providing sufficient food in the other countries that lack those material and industrial resources. Once these are made available, the process which went on in the nineteenth century of turning the prairies into cornfields can be repeated and indeed is already beginning to be repeated in the central plains of Asia, both in the Soviet Union and in China. There is also much land to be reclaimed in South America and Africa (Table VIII). To work new land, however, requires men and machines, and agricultural machinery is the first call of the underdeveloped countries on the industrial countries, pending the building up of their own industries. Nor is there any reason why that call could not immediately be answered. There is now a capacity in the industrial countries for producing vehicles, tractors, and contractors' plant in quantities far greater than the requirements of the countries themselves. And for the first stages of opening up a new country, of building roads, of developing public works, power stations and irrigation, it is just this kind of thing that is most useful. For instance, the agriculture of China could give an increased yield of some 50 per cent if there were adequate tractors to operate in the country: the total number would be of the order of one to two million, and this is well within the capacity of the U.S. motor industry alone.

In the first stages of the agricultural industrial transformation of an underdeveloped country it may sometimes be necessary to supply food

The first part of Table VIII is a digest of existing statistics on land use. The second part is an estimate of my own, and necessarily an extremely rough one, of what could be done by various more or less difficult and costly ways to increase the land under cultivation, along the lines indicated in this chapter (pp. 67–78) and Chapter XII (p. 258). It is intended to correspond to Map II of possible land use shown on pp. 249 f.

TABLE VIII

Present and Potential Land Use
(Millions of Sq. Km.)

Region	*Estimated Population 1956 (millions)*	*Total Area*	*Land at Present Cultivated*		*Cultivated Area Per Person (hectares)*	*Additional Land Available With*						*Total Cultivable Land*		*No. of Times Present Cultivated Land*
						Existing Methods		*Capital Expenditure*		*New Methods*				
			Area	*% of Total Area*		*Area*	*% of Total Area*	*Area*	*% of Total Area*	*Area*	*% of Total Area*	*Area*	*% of Total Area*	
Europe (Excluding U.S.S.R.)	412	4·9	1·5	31	0·36	0·5	10	0·9	18	1·5	31	4·4	90	2·9
U.S.S.R.	200	22·4	2·2	10	1·10	1·8	8	4·1	18	6·9	31	15·0	67	6·8
Asia (Excluding U.S.S.R.)	1,514	27·0	4·1	15	0·27	2·9	11	6·1	23	7·1	26	20·2	75	4·9
Africa	220	30·2	2·4	8	1·10	2·6	9	7·4	24	9·5	31	21·9	72	9·1
United States and Canada	184	18·5	2·3	12	1·26	2·2	11	2·9	15	4·4	23	11·8	61	5·1
Central and South America	191	20·4	1·0	5	0·52	3·0	15	5·1	25	6·0	29	15·1	73	15·1
Oceania	15	8·6	0·3	3	2·00	0·5	6	1·7	20	3·0	35	5·5	64	18·3
World	2,737	135·0	13·2	10	0·48	13·5	10	28·2	21	38·4	28	93·9	70	7·1

Sources: Yearbook of Food and Agricultural Statistics, 1956, Part 1, F.A.O., Rome, 1957.

itself. This has been done to a small extent in the days of UNRRA and more recently by U.S. wheat loans to India, and Chinese rice–rubber barter agreement with Ceylon. It could, however, be done to a much larger extent by using the agricultural surpluses that are at present stored till they rot. Food production could even be accelerated where it is most easily achieved—in the United States—for the benefit, the immediate benefit, of the undernourished peoples of the rest of the world. This is not suggested as a charitable act; in fact such an act as a set policy would be self-defeating, because by pauperizing these people it would remove their incentive to better their own condition. But it still remains a fact that over many parts of the world, inability to work, or to do heavy work, depends on sheer malnutrition. I remember some years ago, in the days of the ill-fated British experiment in Central Africa, a responsible minister remarking to me "the natives don't seem to have enough food to work properly on the scheme: I'm afraid we may have to give them some of *our* groundnuts". Nor is this situation confined to the tropics. The inhabitants of Britain's oldest colony, Nova Scotia, were deemed incapable of heavy work until an American airfield contractor thought of shipping in an adequate supply of beefsteaks.

Within four or five years of intensive, mechanized agriculture, in suitable areas and making use of transport facilities, it should be possible to remove the need for any additional food supplies from other countries, or at any rate for more than could be paid for in other agricultural or mineral products. The serious business of extending the agricultural area could then begin with much heavier investment in large-scale reclamation schemes, either by the development of irrigation combined with water-power production and navigational schemes, or by drainage and grass-land improvement in the colder districts or those in the mountains. Such schemes, as experience in various parts of the world has already shown, notably in the Soviet Union, in India in the last century, and in certain parts of the United States, could increase the available agricultural area by some 38 million square kilometers or by twice the existing cultivated areas (Table VIII, p. 69).

Behind that there would be in reserve even larger schemes which could be used if required, though for reasons which I shall come on to, they may not be needed. If, for instance, it is decided that the population of the world should be limited to some figure not much greater than four thousand million, or that it is worth going in for micro-biological or chemical food production, something like the present cultivated area would be sufficient. However, we know that the climatic conditions over most of the central desert belt of the world which stretches all the way from Morocco to the coast of Manchuria, and of the smaller deserts of America, South Africa, and Australia, would respond at once to water. With water there is no reason why most of the Sahara should not be at least as fertile as Egypt. And here the advent of cheap power, and even more of the unlimited power we may obtain from thermonuclear re-

actions, should provide a very much larger amount of potential new land, enough to supply the needs of many times the present population of the world even by existing agricultural methods.

It may be necessary to distil sea-water and pump it over the land[1]; this would be a somewhat extravagant proposal in energy, considering that the water would in its turn evaporate and less than one part in 10,000 would be incorporated in the food grown. If some method of enclosed or greenhouse agriculture, using light plastic coverings, were developed a very small amount of water would do the same thing; and therefore the power requirement might not be so extravagant after all (p. 276).

Similar large-scale efforts could be made to recover for cultivation the great rain-forest areas in South-East Asia, in the Congo and Brazil. Here the problem is not to keep water in but to keep it out, especially to prevent it leaching the salts out of the soil. This may involve some way of using the tropical forest itself by directly cropping the leaves of quick-growing trees.

The putting of more land under the plough is simply a crude way of ensuring enough food, which it is worth noting exists, but may not be necessary to follow up. At the same time science is offering other methods by which the food supply can be increased without necessarily increasing the area at all: by more intensive cultivation; by better breeding of crops and stock; and by fighting the pests and diseases which destroy so much of the crop already gathered. It will be a matter of economic calculation to decide whether a given instalment of capital be put into making a fertilizer or into irrigating fresh land. One may be more suitable for a short-term project and the other for a long-term one.

Professor Mahalanobis, one of the inspirers of India's five-year plans, has put forward the following time preference balance sheet for the different stages of developing agriculture.[2] He considers the question of providing the 700,000 tons of extra grain needed for the five million annual increase of the Indian population. The alternative ways of getting it would be: (a) to purchase it outright from abroad which could be done within a few months and would cost £340 million; (b) to purchase enough fertilizer to raise the extra crop. This would cost £100 million and would take the best part of a year to collect and distribute; (c) to set up a new fertilizer plant each year which would use local materials and labour. It would cost £75 millions but would have to be planned four or five years in advance of the crop season concerned; or (d) to build engineering plant capable of making the equipment for one such fertilizer plant a year. This would cost only some £10 million but it would have to be planned eight or ten years in advance of the season in

[1] The island of Guernsey is installing an electrical fresh-water-from-the-sea plant at a cost of £250,000 as a business proposition for its tomato crop. It is cheaper than to construct reservoirs to hold the same amount of rain water.

[2] P. C. Mahalanobis, "Science and National Planning", *Vijnan Karmee*, Calcutta, January 1958.

which fertilizer would be used. As usual it is those in most immediate need who fare the worst.

This should make it clear that fertilizer provides the ultimate rather than the immediate solution. For this the best first step should be wherever possible to open up new land, which might afterwards be allowed to go back to pasture if it proved not worth manuring. This was the essence of Mr. Khrushchev's plan for opening up the Kazakhstan virgin steppe.

At present only a small fraction, about one-sixth, of cultivated land gets any fertilizer at all; and it is only in countries like China, where intensive agriculture is practised, in which human excreta are used for manure, that it is possible to raise the productivity above the bare, unmanured minimum. This is why the conservative agriculturists have pointed out it is safest to rely on Nature: to grow crops at their minimum yield in which state they exhaust the soil less and to have all the population living on the land, when no material of value as fertilizer is taken away from it. In this way it is possible to maintain a very small density population, ranging from 10 to 100 to the square mile, indefinitely at a low standard of living in most areas of the world.

This situation is not only unacceptable today, but impracticable, because already some 20 per cent of the world's population is living in large towns and needs to be fed off the country districts which have also to supply their own resident population. If for no other reason, it would be necessary to return to the land the amount of mineral substances taken off it and sent to the towns.

The use of fertilizers, nitrogen from the air, rock phosphate, potassium, is probably the most economic way of transferring industrial into food potential. One ton of nitrogen, as manure, produces about ten tons equivalent of extra sugar. Phosphate and potash have variable and generally smaller return ratios. In many parts of the world it would even pay to grow a certain portion of the crops simply for fuel and to use the power thus generated to produce fertilizers. This, however, is not likely to be done if energy from atomic sources becomes available. It will be in fact convertible most directly into food by first transforming it into fertilizers. Nor is there any reason to suppose that adequate supplies of mineral fertilizers are not available from widely-dispersed rocks or from the sea.

The use of fertilizer would, however, be extremely wasteful if it were not combined with all types of soil conservation methods, such as preserving the soil from erosion, from excessive leaching, and from the formation of salt in the more arid regions. All of this implies a considerable application of capital to the land. If intelligently done this can mostly be combined with the off-season work of the farmers themselves. The great curse of erosion, which has done so much damage, that though not irreparable, costs a lot to repair, could be ended once and for all. It is not so terribly difficult: it has in fact been ended in many areas of

the world, for instance in Japan, and now on a far larger scale in China and, indeed, wherever the land is owned by a population with an interest in preserving the soil rather than by speculators in land whose main object is to exploit it and leave it when they have got everything they can out of it.

The problem of the preservation and the improvement of the soil itself to suit the growth of various kinds of plants is one which, despite the attention given to it in the last hundred years, has hardly begun to be studied scientifically. Modern science offers possibilities for soil research which are only partially taken up. We do not know, for instance, the real basis for the age-old agricultural practices of ploughing, harrowing, rotation of crops, or leaving land fallow. In fact practically none of the things that the farmer does are scientifically understood. They are clung to empirically on the grounds that they have worked in the past and that when applied over a large number of years, they have not notably made the land any worse. That is very far from saying that we are doing the best that could be done for the soil or that we are doing it most economically. The new practice in the Soviet Union of very deep ploughing every four years instead of every year, which seems to work on certain soils, indicates that there is great room for research and improvement in soil management.

We have read a great deal in recent years about the disastrous effects of erosion, mostly a by-product of greed and exploitation of the land either directly for cash-crops or indirectly through the destruction of forests, or of over-grazing due to the crowding of native peoples on inadequate and unproductive land through the occupation of good land by foreign planters[1]. It has been assumed that this erosive process results in permanent destruction of the soil. It is probably correct, in the short run and with the means available to primitive farmers, to say that eroded soil is useless. But this need not be so in the long run since, with greater research on soil, we could restore or even create new soil, given a region flat enough to make it worth doing. Furthermore, much of the poor soil of the world could undoubtedly be improved so as to yield the greatest amount available under the particular climate. Nor would improvement be limited to level ground. Mechanical terracing of hills, together with the new Chinese system of running irrigation canals along the tops of ridges[2], would make enormous areas of dry, hilly country fertile, while on the more rugged slopes fruit trees and tiber could be planted.

In particular there are great areas covered at present with bare limestone rocks in a region otherwise very suitable for agriculture but where the rain as it falls goes straight into underground channels. Reclamations of such so-called karstic soils would not offer a serious engineering problem, though whether it would always be worth doing, if other less

[1] J. de Castro, *Geography of Hunger*, London, 1953.

[2] Pao Hai-chen, "Irrigation comes to a mountain region", *China Pictorial*, (1958), No. 92.

difficult land is available in the same area, is a question that has to be decided on the spot after adequate research.

The climate itself is not a fixed thing. Already it is possible to induce rainfall artificially, though unfortunately this cannot yet be done with certainty in the regions where it is most needed. For centuries men have made use of various water-raising and storage systems to cope with viable rainfall. These smaller scale efforts are being replaced by large irrigation works covering whole valley systems, but there may be other methods which research will discover for conserving moisture, short of the radical enclosed agriculture which I have mentioned elsewhere (p. 71).

The preservation of the soil in detail can now be supplemented by the large-scale transformation of the face of the globe by the use of heavy earth-shifting machinery and an ample supply of power. Even in its present pre-atomic stage, such machinery can level mountains, drive rivers backward to make them flow into regions hitherto drought-stricken. Most important of all, it can be used to build reservoirs and irrigation systems which should provide in the near future just that extra secure food supply for the world's growing population in order to win time for the elaboration of even more productive methods of agriculture.

Still further advantages can be got by the application of breeding methods, by a skilful adaptation of plants and animals to the particular soil and climate of a locality. Wherever plant breeding has been intensively practised, yields have been increased as well as desired qualities. Naturally this has been used under the capitalist system mostly for cash crops, but as these include the major cereals, wheat, rice, and maize, there is no reason why it should not be applied to all human food crops. Indeed attempts to do this in a variety of climates are being made to a large extent in the Soviet Union and in China.

As long as we continue with agriculture as the main if not the only source of food, it is obviously best to grow suitable and high-yielding plants, and to keep the effective yield per acre and per man employed as high as possible. But new possibilities are becoming available through breeding. Heavier yielding and more resistant varieties are continually being produced. Most recently there has been a successful attempt to breed a variety of grass that does not go to seed, but rather produces leaves much richer in protein than the usual varieties.[1] It should now be possible to breed for specific chemical products, for instance to provide plant protein which more resembles that of animals, and thus become less and less dependent on the need for the wasteful production of animal food, which rarely has a conversion factor of more than one-thirtieth. That is, only one thirtieth of the food value of the fodder consumed by the animal is available in the meat.

Except in countries like China, where for centuries animals, other than the pig, have formed a very small part of the diet, the greatest

[1] M. L. Peterson *et al.*, "Non-flowering Strains of Herbage Grass", *Nature* (1958), vol. 181, p. 591.

amount of agricultural products is still fed to animals. In Britain, for example, animals consume some six times the amount human beings do of the home-produced food and more than two-thirds of the total of home and imported food. For nutritional reasons there is at present a great deal to be said for a mixed animal and vegetable diet, particularly through the use of milk; and we are beginning to understand the reason for this in terms of the variability of certain amino-acids and vitamins. There is nothing particularly magical about animal protein as such except that, wherever men have been wealthy enough to get it, they have preferred a meat to a vegetable diet, and that it will be hard to wean them from it.

The continual improvement of crops and stock on the land would be of little use if it were not accompanied by a growing battle against pests of various kinds—insects, and fungi and diseases, particularly virus diseases. This is not merely a matter of applying existing knowledge, but rather one which calls for increasing research combined with the continuous application of new knowledge. At the present moment, even in the more favoured countries where protective methods have been tried, we lose something like one-quarter to one-third of the crops from various kinds of pests. In the parts of the world where pests are relatively uncontrolled, whole crops may be lost by locusts and there are whole areas in which cattle cannot be kept at all on account of the nagana disease carried by the tsetse fly. There is probably no field in which a smaller investment of capital could yield bigger returns than in combating plant and animal diseases.

The problem of the agriculturalist is usually supposed to end when he has produced his crop and handed it on, in an acceptable way, to the market, whether it be grain in bags or vegetable or fruit for the cannery. But we have been using all kinds of new methods of producing crops without giving anything like the same amount of thought to the utilization of them. Most of our domesticated plants have been used by man or by animals for fodder for some thousands of years, and they have eaten those parts they could eat with or without some very crude preparation, such as soaking in water, fermenting, drying, or salting. Much of the crop has been rejected as unsuitable either as food or fodder and simply ploughed back into the ground or burnt.

The kind of intensive agriculture which will be needed to supply a much greater population at a higher standard of living implies a very much more thorough use of plant materials. In principle all material contained in plants are suitable for food, if not for animals, at least for fungi and bacteria which can be subsequently used for food. That they are not so, is sometimes due to their physical consistency—they are too hard to digest—or sometimes to the presence of a poisonous constituent. Ways of bettering these can be found either by breeding or by subsequent chemical treatment.

Still more radical methods will be needed if we are to make anything

like full use of the products of the soil. Primitive man was content to pick up vegetable products which were highly concentrated foods, such as varieties of seeds and nuts. Herbivorous animals would eat juicy leaves in the good season and for the other part of the year had to be content with very dry and poor herbage. They could not at the same time manage to make the best of fresh leaves and of hay or straw, and the latter had to be their food for the greater part of the year. Their internal economy was more adapted to the relatively dry and unnutritious diet.

With our modern knowledge of food values we can see that very much more could be extracted from the plant than merely the seeds, roots or straw. An economical way would be mainly based on the leaves which are particularly rich in protein and sugar. Moreover, the effect of fertilizers, particularly nitrogen fertilizers, is to increase the growth of vegative parts in comparison with seed. If we could find a means of economically extracting the protein and sugar from the three-quarters of the plant that we normally throw away, we would effectively have doubled the available food in the world today. Some research is being done on this, notably by N. W. Pirie at Rothamsted, who has produced leaf protein in hundredweight quantities, enough to show the enormous returns which might be expected from large-scale development.[1] In fact, in many ways, this would seem the most immediate method of solving the world's food problem.

To sum up, the problem of improving agriculture is made up of six elements, all of which can be put into action simultaneously—more land under cultivation, better cultivation, wider use of fertilizers, better breeds of plants and animals, fighting pests and increasing the amount of the crop actually used. Between them they offer, as serious experts have already recognized, "ample possibilities to provide for a population two or three times as large as the present one".[2] Whether this nutrition could be on the level at present enjoyed in such countries as the United States and New Zealand, that is largely based on meat, is much more doubtful, because of the high degree of inefficiency of conversion of plant materials to human food by the process of feeding it to animals and eating the meat.

Most of the largest population group of the world, the people of south and eastern Asia, are not normally meat eaters—they either eat no meat or only eat small amounts on special occasions. It does not seem desirable, even if it were possible, to change these habits. The major object of eating meat—for those who have already formed the habit and cannot imagine life without it—is to provide what is called first-class protein, and that is protein containing an adequate supply of some particular amino acids. Some of these, namely methionine, tryptophane and lysine, are rare in vegetable protein.

[1] N. W. Pirie, "Enexploited technological possibilities of making food for man and animals", *Proceedings of the Nutrition Society* (1956), vol. 15, p. 154.

[2] H. Brown, *et al.*, *The Next Hundred Years*, London, 1957.

These are formed in certain plants, notably those of the leguminous or pea family, but even there it is in proportions less than that required by the human frame. The problem therefore is not a matter of substituting an animal by a vegetarian diet, but of adding the necessary protein or even the necessary amino acids, which in the last resort might be produced microbiologically or even chemically, as we shall see later.

The major immediate problem of food production is how to realize the technical and biological possibilities which are already inherent in agricultural methods. This is essentially an economic and political problem, to which we will return (p. 119). In the fortunate countries of the world, in Western Europe, in much of North America, as well as in parts of South America and Australasia, the problem of food production is to improve an already high level with the object in the first place of providing an agricultural surplus which can be used for the kind of pump-priming operation of giving adequate nutrition all over the world for the first stages of a new agricultural revolution. In these countries capital is abundant, there is considerable, but by no means adequate, research and what is lacking essentially is economic incentive to produce food for export.

In the vast and very varied areas included in the Soviet Union, there are other agricultural problems which are now being energetically tackled, although it was necessary to wait until a sufficient degree of industrialization was achieved before an adequate break could be made with the old, small-yielding, methods. Agricultural productivity in plants and even more so in animals has lagged, and only now is a large effort being made to catch up and even improve on the standards of nutrition in Western Europe. In neither of these regions is the problem of food in itself a vital one—it is only a matter of improving a diet already basically sufficient.

This is not the case in the rest of the world, particularly in Asia and Africa. Even in the next few decades there is the serious problem of providing food from regions where the amount of cultivated land per person is 0·7 acre, less than a quarter of that in Western Europe and America combined, and where fertilizers and mechanical assistance are almost absent. In the largest of these areas—China—the problem is being tackled in a conscious and planned way, but with a full realization of the difficulties.

Chinese agriculture had, hundreds of years ago, reached such a level of conservation and self-sufficiency that only marginal improvements can be made until artificial fertilizers are available in quantity, as well means of transport and mechanization. New land available, though large absolutely, is relatively limited, not more than 50 per cent of the present cultivated territory, and of inferior quality or it would have been occupied long ago. However, by getting rid of the obstructions of ancient, feudal land tenure and by rural collectivization, together with an ever-increasing application of science in the form of better varieties of plants

and soil conservation methods, it is certain that the immediate problems will be solved. The twelve-year plan for Chinese agriculture is aiming at a doubling of the food supply, mostly by securing better yields of crops. This is a planned increase of some six per cent per annum, well above the present two per cent increase in the population. Nevertheless, the Chinese authorities consider that the first claim is in improving the standard of nutrition for a more limited population. They are accordingly carrying out a birth-control campaign with a provisional aim of a static population of some 800 million.

The rate of improvement of Chinese agriculture could be greater still, if the limited, though well-planned, Soviet aid could be supplemented by capital from other countries in the form of vehicles and fertilizers, and also of the machinery and plant to make these in China itself (p. 294).

Much more serious immediate problems are to be found in the already overpopulated Japan, as well as in Java and a number of other tropical islands which have in the past been developed as colonies for the production of single crops, such as rubber or sugar. Here the land available is fully used up; it is cultivated intensively with yields that can hardly be bettered, and either emigration or of a policy of food imports balanced by the export of manufactured goods is indicated. This problem, however, is essentially an economic rather than an agricultural one. The presence of large populations accustomed to intensive agriculture is ultimately an asset rather than a liability.

Probably the greatest problem of all is that of India, where the natural agricultural resources are severely limited and the population is being forced to lower and lower standards of living, hardly, in many cases, above mere subsistence level. India is outside the socialist orbit and its government is attempting to repair the damage of centuries of colonial rule, without entirely breaking with capitalist economic and political limitations. Nevertheless it is advancing by means of Five-Year Plans of industrialization and agricultural improvement. This should ultimately supply the means of effective self-help. However, its advance is being hampered by lack of capital, which in the immediate instance can only come from outside the country. Indian agriculture suffers from a large accumulation of disabilities. Except for favoured areas in the valleys, the land is exposed to violent climatic fluctuations of drought and flood, the soil is poor and is used largely to maintain an animal economy at such a low level that it becomes a drag rather than a help. Dung, for instance, is burnt for lack of other fuel and this leads to continuous impoverishment of the soil. In the long run the Indian problem is certainly soluble, and the country could provide decently for even a larger population than it at present holds. But whether it will be in fact possible to reach this condition without disastrous crises on the way is a matter which will test the conscience of the world, particularly of the capitalist world, in the next few decades.

It is hardly necessary to continue the catalogue of poverty and land

mismanagement that occurs in the rest of the world from Africa to South America.[1] Everywhere it can now be seen that the problems involved are easily soluble in principle, but their solution depends on the achievement of a peaceful world in which the resources of the more fortunate countries can be used, not in any way as charity for the less fortunate, but rather as investment for the future welfare of the world as a whole.

I have talked of agriculture as if it were the only and not just the main method of gaining food for men, but we also have, in the form of fisheries, a method, though so far a very limited one, of tapping the food of the seas and rivers. This is all that survives in the present world of the once universal living by chasing animals and fish. We know now that the sun's energy produces more living matter in the sea than on the land, but that its harvesting is excessively inefficient. We may make use of as much as a twentieth of what grows on the land, but certainly not more than a millionth of what grows in the sea. The yield from fishing can be much enlarged by covering all the suitable fishing areas, many of which are now in such remote regions that they are not profitably fished, and more particularly by arranging for the preservation and the processing of fish on the spot in a suitably designed fishing fleet mother vessel or floating factory. This would be a kind of immediate development which would help to solve the problem of the protein shortage until the other methods, based on the better utilization of vegetable and animal products, can come fully into action.

Beyond that there is the possibility of fish farming, already existing on a considerable scale in Japan but capable of being extended to the wider seas particularly in the coastal belts. Much of the tropical continental coastline is fringed with a lagoon strip admirably suited for fish farming, but this requires the production of sufficient fertilizer for the plankton to feed the fish.

The conversion of plankton into fish, however, is an excessively inefficient process going through a number of stages—microscopic algae plankton is eaten by microcrustacea which are eaten by larger crustacea, then by smaller fish and then by larger fish. The whales effect the process slightly more directly by eating the crustacea and do this by means which we might indeed copy. One of the advantages of atomically-powered ships, and particularly atomically-powered submarines, is that it would be possible to convert them into what would be virtually artificial whales, taking in and processing plankton, mainly crustacean plankton, directly for animal and even for human food. The amount taken in being a function of the distance covered, it would therefore increase with the speed of the vessels.

All the methods mentioned for the improvement of food production from agriculture and fishery are immediately available from existing knowledge and practice. It can suffice to deal with the food problems of

[1] De Castro, *ibid.*

the world for the next twenty years or so, in which time the population would have increased by about a third. But we ought to be thinking already of the stage beyond, because the requirements of populations from thirty to a hundred years ahead depend on basic scientific and technological research carried out now. It will be difficult to carry it out in time if we wait for new sets of food shortages to show themselves before starting such researches. Indeed, some of them might prove so useful in the short run that they could be used within the next two decades at crucial points in the food production process.

We can divide these into what might be called semi-agricultural methods, that is, the more rational use of what grows on the land today or could be made to grow on it; micro-agricultural methods, using the smaller organisms rather than the green plant as the basic energy producer; and the straightforward chemical production of food. These are not exclusive methods, but actually could be used very much more efficiently in conjunction with each other. Of semi-agricultural methods, one has already been touched on, that is the extraction of protein and sugar from plant leaves (p. 26).

A more radical and far larger-scale operation would be the complete recovery, for food uses, by man or animals of all the cellulose produced in the vegetative process. By and large the residuum of plant growth is cellulose, that is polymerized sugar, sometimes simply as such, as for instance in the case of cotton, and sometimes mixed with various types of binding agent such as the lignin of wood or the silica of grasses and straws. All cellulose itself can be broken down with bacteria, firstly into sugars, and then through various intermediaries to acetic acid or vinegar. Indeed this is the way in which ruminants like cattle extract their food, using the bacteria growing in their stomachs. No higher organism seems to be able to digest cellulose directly, though some snails can do this. The first stage, therefore, is the provision of relatively purified cellulose for basic cattle fodder, and particularly that from indigestible materials such as wood.

There is, as already mentioned (p. 46), a quite ample supply of cellulose for all needs of human consumption in the forest woods already cut for pulp and probably in the pulp wastage which is not made into paper, which would provide a very acceptable addition of some millions of tons of sugar. Our economy, however, is run in such a peculiar way that the best that can be done with this waste cellulose is to convert it into alcohol, and that not even to drink but to burn. The northern forests, however, are not the regions where food scarcity is greatest; this occurs more in the arid districts in low latitudes and here the conversion of brushwood and straw into suitable cattle food would make an enormous and immediate difference. It could, of course, only be effected if there were no longer a need for brushwood and straw as fuel, which is about the most wasteful use that could be devised for it. But here, partly by distribution of mineral fuels and partly by the use of solar energy for

cooking, it might be possible to get this material saved and transferred or transformed into fodder for animals. Certainly it is an enormous waste to use such products as rice straw, maize stalks and bagasse (pressed out sugar cane) simply for fuel or at best for building material.

The problem of such conversions of waste materials is only partly, however, one of technological research, another is that of the economy of the process and particularly the economy of collection. The problem here is that the raw material is produced over a large area and has to be taken to some kind of medium or large size factory and then redistributed as fodder or raw sugar for human consumption. But these are practical problems which will find their solution only as part of the general question of where best and most economically to find the necessary fuel or fodder. At any rate we should strive to avoid the present situation in which those countries which are poorest are also those countries where the very small existing resources are most thoroughly wasted.

What has been said already indicates that viewed as a technical problem the question of providing food on an adequate scale for the existing population is immediately soluble. That of providing for an increasing population at least up to say ten thousand million or four times the present world population, a figure which will be reached at the present rate of increase in less than a hundred years, is certainly much more difficult but experts realize that this too offers no insuperable technical difficulties. It must be recognized, however, that much of what I have written represents technical or scientific possibility and is practised, if at all, only in specially favoured regions. Before these things can be realized a great deal has to be done, particularly in the provision of capital in the form of machinery and chemicals, especially fertilizers. Even, therefore, if we could look forward confidently to feeding such large populations say in fifty or a hundred years, we might have to face serious problems in feeding a much smaller one within the next thirty. These problems will, however, be essentially political and economic rather than scientific and technical, and I will return to them later (p. 119). I will also in another section deal with the more speculative and long-term problem of providing for a far larger population in the distant future by invoking the aid of chemistry (pp. 273 ff.).

The Malthusian limitation to human population can, even with our present knowledge, be pushed back to an indefinite future. It is not and it has never been the actual limitation to human population. Lack of knowledge in primitive times, economic greed in the recent past and the present, have been far more potent factors. In any case what happens in a hundred years' time is not our immediate concern. Our responsibility is limited to seeing that the people of that time are in a position to choose for themselves how to arrange their lives. The only reason we need now to consider these future possibilities is to counter the views of those who think that the present situation of the world, with its half starved

population, is something that is in the course of Nature, and cannot be altered without impiety and challenging even worse disasters. Actually, far from being in the course of Nature, the large population of the world today is one of the first products of the Industrial Revolution. World population grew very slowly from some 20 million at the beginning of civilization, about 5000 B.C., to 700 million in the middle of the eighteenth century. From then on the growth was increasingly rapid, doubling in the hundred and thirty years to 1880, and then doubling again in less than eighty years to the present population of nearly 2,800 million. At the present rate of growth it should double again in forty years by the year 2000 (Fig. 2, p. 65) (p. 295).

We could not restore the previous balance of peasant population without starving or killing in some other way about nine-tenths of the present world population. Even then the survivors would, with the knowledge they had, reproduce very much the same situation within a few hundred years. The story of the Garden of Eden, which dealt mythically with the discovery of agriculture, applies here once again. Knowledge once gained or stolen cannot be taken back. What we have to do is to find out how to use the knowledge, and not to complain of how much happier we were when we did not know.

The immediate troubles of the world population, with its increasing poverty and semi-starvation, are largely due to the persistence of the restrictive and exploitative practices of the last two hundred years, particularly the development of land tenure based on the production of cash crops by poor peasants most of whose produce is exacted by the government as taxes or as rents, or by landlords anxious to buy foreign luxury goods. But, as we have seen in many countries, and particularly India, the mere removing of the landlord system does not solve the problem, but simply leaves the impoverished peasant without the means or implements and fertilizer to produce any more from his land than he did under the old system. Nor are the charges on him necessarily reduced, for what he used to pay to the landlord as rent he may now have to pay to the state as taxes or instalments for purchase of his land. Only the wealthier peasants are likely to benefit by the change.

The solution, already adopted in the Soviet Union and in China, and now seen to be necessary even in India, is some form of co-operation or collective use of land; but even here the advantages are unlikely to accrue unless the cultivating co-operative can be assisted with fertilizers and farm machinery and pumps for irrigation in the more arid countries. We cannot hope for any serious improvement in agricultural productivity in the underdeveloped countries unless in the first place all forms of exploitation, including plantation agriculture and cash crops extracted and sold at prices that do not allow enough to the peasant, are abolished. In addition it will be necessary, in return for many years of such exploitation, to put sufficient back into the land. How this can be done will be discussed in later chapters (VII and XII).

VI

THE ADVANCEMENT OF SCIENCE

It should be already apparent from the last two chapters that the technical problems of the world can find their solutions only through an increasing and ever more intensive application of scientific knowledge. The present population of the world could not in fact be maintained, even at the low standard of life which they endure at present, without a continued application of the new knowledge won through scientific research in the last few years. Its continued growth will certainly lead to famine unless there is far more research in the future than there has been in the past. Indeed, today any efficient industrial and agricultural system depends on the continual maintenance of research. This applies even more in the biological field than in the mechanical, because, although things may continue to work in the same way in inert systems where we have only the crude laws of inanimate nature to deal with, in living systems our very interference creates biological reactions requiring new means to deal with them. This is shown, for example, in the failure of the older antibiotics to kill strains of bacteria which have evolved in such a way as to circumvent their action.

We are now beginning to understand the place of scientific research and development in the evolution of technology. In the past, science has been very much an almost optional extra, coming into techniques either as a way of improving them here and there or as a source of radically new techniques, for instance such as those of electricity and synthetic chemistry. By now, however, science is no longer a dispensable element for, if nothing else had shown it, the dependence of modern weapons on scientific research demonstrates how indispensable it is becoming to advancing industry.

The general picture of the industrial-scientific set-up of the future is one which does not accept any fixed ways of doing or making things but, from the very beginning, conceives of the process of production as one which is continually growing and changing under the guiding direction of scientific research. If we take the complex process of production, distribution, consumption, as the main running variable in human economic life, then the measure of the change of this variable, what we can call mathematically, the *first differential*, is what is called *technical progress*. Usually this does not occur in very big steps, but in thousands of little alterations here and there, so that technique has been continually improving since it first started in the Old Stone Age.

Such a complicated construction as a ship, for instance, has grown to its present perfection very largely as the accumulation of an enormous number of small technical improvements. The first log gave rise to the dugout, the dugout had sides which built it up into a canoe, the original dugout shrank to the keel and the ribs and straking were added to it. Even the transition from wood to steel retained these features, long after they had lost any structural utility. Every boatbuilder or ship designer has in fact followed the traditions of other ship designers, and so on backwards to the builders of the Ark and probably far beyond that. We can count, therefore, on technical progress; it is a sure method, because each new departure is tested against the older one from which it was derived, and is rejected unless it is better or cheaper by a kind of industrial natural selection. Accordingly, no disasters of an unexpected kind are to be feared, because there is no likelihood of any great departure from previous practice.

Now we have a better way of advancing production methods by speeding up the trial-and-error processes of technology through an understanding of their underlying principles, and thus influencing directly the rate of advance of techniques. This provides what is mathematically equivalent to the *second differential* of production—though the analogy is weakened by the appearance of discontinuous jumps or inventions. This rational process is sometimes called *applied science* or sometimes *research and development*. Its major features are that the aim of such research is to find out what needs to be made or done and how best to make or do it without being tied in any way to existing practice. The idea is, as far as possible, to bring in fundamental principles and to find out how to clothe them in a practical form.

It is beginning to be recognized that this kind of research has a logic of its own. We used to talk in the late war of *objective* research; though the word has other connotations, it is reasonable enough to say research for an object—research to make something that will fly faster, to stay underwater longer, or produce things more quickly. For such research we need to bring together all the kinds of knowledge in the different fields of science that might bear on our particular problem. In practice it meant bringing together a kind of assorted research team or commando to attack the problem. Instead of objective, I would like to call it *telonic* research—simply from the Greek *telos*, purpose or objective, a word we are most acquainted with in its philosophic association as teleology—the idea of a purpose in Nature. A human purpose can quite properly be identified with its achievement in this kind of directed research. A very good example of it in recent times has been the successful development and launching of the artificial earth satellites, both from the Soviet Union and the United States, involving not only all the physics and engineering of rocket propulsion, but extremely delicate, electronic controls of the flight of the rockets, knowledge of astronomy, knowledge of meteorology of the upper atmosphere, and, in the pre-

liminary animal experiments at least, a great deal of physiology as well. It is clear that in the future all projects sufficiently definite to be tackled as a single problem will best be coped with by such research teams—not necessarily permanent ones, but assembled for the purpose and afterwards, if there is nothing immediate to follow up, broken down and reassembled as other teams.

This, however, is not the only kind, or even perhaps the main kind, of applied research. Another is finding out the possibilities of individual substances or process, what used to be known as *subjective research* and what I would call in comparison with the first, *thematic* research—research on a subject or theme. To take a very lowly example from my own experience in the war, there was the question of mud, the universal accompaniment of all wars, but so far it had been cursed at rather than studied. I was able to organize an Inter-services Mud Committee which did some useful work on what mud was and how to deal with it. The study of mud in the war has been followed up in the peace by an extremely extensive, even world-wide, study of clay minerals and their associations; something which, although it is extremely limited in its subject, has a very large number of divergent applications, for instance in pottery, in agriculture, in the oil industry and in transport.

Behind that again, comes what we are now beginning to call *fundamental research* but used to be known as *pure science*—the study of aspects of Nature and of human constructions that tries to bring out underlying structure rather than particular aspects. The general body of fundamental science is the fount from which will flow radically new understanding of existing techniques and radically new techniques. In this sense fundamental science is the *third differential* of the production process. By another more biological analogy, fundamental science is responsible for the *growing points* of the whole of the social organism. A growing point of a plant consists of the small and delicate groups of actively dividing cells that are responsible for the throwing out of new leaves, branches and flowers. If the growing points are destroyed the organism is not killed but cannot do more than continue with the living parts that it already has, it can neither grow nor reproduce. It is not necessary to follow this analogy to the end to appreciate the need to guard the essential self-renewing character of science as a social institution.

The overall *strategic* problem of the use of science, consists in finding the best way of combining all these aspects: production itself, its technological improvement, research and development, and fundamental research. All have to be pursued in the appropriate strengths, not supporting one to the extent of starving another, not producing pure science in such a refined atmosphere that it never gets applied, or rushing ahead with an application without supporting the fundamental research which is needed to establish its basic principles.

In the past all these adjustments have been left to the normal

operations of chance, personal contacts, influence of a profit motive and other secondary factors which have resulted in an extremely rich development of science, but, as we can now see if we look backwards, at an enormous cost in wasted human ingenuity. And it was achieved far more slowly than the abilities and resources available would have made possible if they had been wisely directed. This idea of holding back some human effort from the immediate human needs in order to prepare for needs in the future is as old as civilization itself, and indeed older, for it is exemplified in the Old Stone Age by the men who sat chipping flints instead of hunting with raw stones, or later by those who kept back some of the seed corn even in times of famine to ensure future harvests.

That practical wisdom can now be realized on an even far longer time-scale, but it still remains a problem of how much to invest of human ingenuity in serving the distant future and how much in serving the immediate present. These proportions cannot in any event be expected to be constant. We are at the moment in a stage of accelerated development, not only because new possibilities are being continuously opened by rapid developments in science, but because of the increased needs and increased consciousness of those needs that have been spreading all over the world.

In this chapter it should suffice to attempt to indicate in the barest outline what are the requirements of a modern society for science. For although we can reasonably say that we know enough already to assure the livelihood of mankind for an indefinite future, we know also that the infinitely greater knowledge we do not have, but could reach by methods already established and tested, would go far further than that. In the measure that new knowledge is gained we could fulfil the tasks already indicated more simply and quickly and deal as well with other problems which our present knowledge does not equip us to deal with at all. Some of these, indeed, are still so remote that we cannot even imagine them. Others are of perennial interest to humanity, such as the preservation of health and vigour and the prolongation of human life (pp. 278 f.).[1]

Now one of the early lessons of the history of science which I have discussed elsewhere[2] is that in dealing with the unknown one can only rarely proceed directly towards a prescribed goal, but must move along a number of intrinsically promising paths of advance on the edge of the

[1] Francis Bacon's list *Magnalia Naturae* (1626) included the following:
The prolongation of life; the restitution of youth in some degree; the retardation of age; the curing of diseases counted incurable; the mitigation of pain; the increasing of strength and activity; the altering of complexions, and fatness and leanness; the altering of statures; the altering of features; the increasing and exalting of the intellectual parts; making rich composts for the earth; drawing of new foods out of substances not now in use; making new threads for apparel; and new stuffs, such as paper, glass, etc.; greater pleasures of the senses; artificial minerals and cements.

[2] *Science in History, op. cit.*

unknown until an appropriate opportunity for breaking through to new knowledge and new power actually occurs. Few of the great discoveries in the past were made in direct pursuit of an industrial, agricultural or even medical aim, though they resulted in enormous changes in industry, agriculture and medicine. Magnetism, electricity, and the knowledge of the physical or the chemical atom were not found by direct economic enquiries.

However, this is only half the story. The development of technology and economy generally does furnish to science both new problems and the material means to solve them. Nearly all scientific apparatus are modified forms of domestic or industrial equipment. New technical developments may be derived from purely scientific research, but they become in their turn the source of further scientific study in which new fundamental principles are often discovered. The key principle of the conservation of energy was in fact discovered from a study of the steam engine, where already the question of the economy of the transformation of coal into power was a question of practical interest. There is indeed a continual interplay between the intrinsic developments of science and their practical applications.

We need to maintain and even to understand and direct this healthy interaction between theory and practice. We must give ever greater proportions of effort towards the advancement of fundamental science in the full knowledge that while no particular piece of fundamental work can be attached in advance to any particular utilization, the total of this fundamental work is essential for the transformation of the economy itself.

It is sometimes said that the needs of the world at the present time are so urgent that we should not so much proceed with fundamental science as use the science we already have. This criticism is applied with even greater force to those advances in fundamental knowledge gained by large and expensive equipment, such as proton phasotrons or satellite launching devices. It would be better, the critics assert, to spend the money on the development of better plant varieties or methods of dealing with diseases. This whole attitude springs quite naturally from the experience of scientists in dealing with excessively limited resources, which is all that most of them have ever had to dispose of. Even if the advice was good it would be hard to follow, for in actual practice it is extremely difficult to switch from physics to applied biology. But a study of the history of science would show that it would be a mistaken policy even for the ends for which it is desired. If "useless" nuclear physics, for instance, had not been studied the possibilities of atomic fission and atomic energy generation would never have become available. Although we may regret and try to limit the ill-effects of this in the military field, it is abundantly clear that without atomic sources of energy the situation of mankind on this globe would become extremely difficult within a relatively short time owing to the exhaustion of our mineral fuels, and

it is only the discovery of atomic energy that permits the unlimited prospects of which I have already given some indication.

The arguments against slowing up or shutting down fundamental research altogether are even stronger, because it is so difficult as to become almost impossible in most cases to apply existing knowledge without doing very much more research. In fact, the proof of the validity of existing knowledge can only be judged in practice, and then it is nearly always found that the fundamental knowledge is not as perfect as its propounders thought and more research work has to be done to perfect it. Further, though much of this work may be of the nature of applied science, fundamental science also comes in, as I have already indicated, because it is in the dealing with the unsolved problems of practice that scientists come across aspects of Nature that call for new theoretical approaches.

So far the discussion of science has touched only on its functions and activity in relation to production. But the developments of our century have brought into existence a whole world of science with an internal life and growing organization of its own. Indeed, as the productive process itself becomes easier and makes less demands on unintelligent labour, applied science may become equivalent to a major industry and fundamental science cannot be allowed to lag far behind.

Already in Britain there are some 10,000 people devoting themselves to research in fundamental science in comparison with some 80,000 in the Soviet Union and 40,000 in the United States.[1] Altogether over all the world there are probably less than 200,000 fundamental research scientists, or one hundredth of one per cent of the world's population. But these numbers are growing fast. In the industrial countries, in which the great majority of scientists are employed, the rate of increase is about 7 per cent per annum or a doubling every 10 years. This is a faster rate of increase than any other category of worker and it is still growing. We must also consider that with the levelling up of world productivity a corresponding contingent, much larger in total numbers, will come from the at present under-developed countries. This growth of science cannot of course go on indefinitely or in a mere 250 years 100 per cent of the population will be engaged in science, but it will settle down to some steady figure which may amount within a century or so to 20 per cent of the population directly or indirectly involved in scientific tasks (p. 184). Not all of these will be expected to make major contributions to knowledge but all will help in an essential way to the extension and application of science.

This is not the place to discuss the nature of the organization of science (p. 203) but only to draw attention to the need for it, and to look briefly at the various methods of organization that are used in different

[1] *Annual Report of the Advisory Council on Scientific Policy 1956–1957*, H.M.S.O., London 1957. *Scientific Manpower—1956*, National Science Foundation, Washington, 1957.

parts of the world. By and large, in all countries in which active research is carried out on a large scale, this is done in one of three types of institution; a first covering fundamental scientific research which is usually connected directly with teaching in the universities as well; a second in the form of industrial research, either directly by private industrial firms or, in Socialist countries, under government industrial ministries; and a third, under direct government control in central laboratories, and, nowadays in what is undoubtedly the largest sector of science, in military research establishments.

Where there is any formal organization of science at all it usually takes the form of some kind of academy, normally the descendant of the original scientific academies of the seventeenth and eighteenth centuries, more or less closely connected with government. In Britain and the United States most fundamental research is carried out in universities but is increasingly financed by the government and, in the United States, very largely by the military departments. Another source of finance there, are the great semi-autonomous foundations supported by big business firms.

The power of the organizations is very varied; some of the older academies are merely honorific bodies, useful to belong to for prestige purposes, but not occupying themselves directly with the planning of science. At the other extreme of scientific organization we find bodies such as the Academy of Sciences in the Soviet Union and those of China and the Eastern European democracies. These were originally of the same character as the Academies of Western Europe, but they have now become effectively the general staffs of science, concerned with the planning of the whole of science and carrying out not only of the fundamental research, but also of its application in a large number of fields though much applied and some fundamental scientific research is carried out by the various government establishments which control industries.

At the moment the two tendencies in the capitalist and socialist worlds are to some extent converging. In the capitalist world it is seen that it is necessary to have more organization of science, in the socialist world it is seen that it is necessary to make the organization they already have more flexible. Major differences, however, remain. The importance of science in the socialist world is very much greater, measured in quantity, in amount of funds available, and in the prestige and esteem of the scientists in the general community. The figures shown in Table XV (p. 185) should be sufficient indication of this, and it is now being reflected in the technical and scientific achievements of the Soviet Union.

The actual financial provision for science determines only an upper limit to its fruitful activity. Without adequate financial resources for laboratories, equipment and technical assistance, research is inevitably slowed down and may be brought to a stop. This has indeed already happened to a number of institutions in the poorer countries of Western Europe. But lack of funds is by no means the only limitation. Science

as a whole cannot advance as it should without some degree of organization and adequate provision for exchange of information. Both are largely lacking today even in countries as active in science as Britain and the United States.

The idea of any organization or strategy of science is, however, anathema to many scientists in those countries. To them it seems to go against the old tradition of the academic freedom of science, and this belief is often reinforced by their experiences of obstructive or merely stupid interference with research by non-scientific or even by scientific bureacrats. Actually, no experimental scientist in the present age can be anarchically free. His possibilities for work depend on what facilities he can get for apparatus and assistance. The best he can hope for to further his work is to take his place in an organization of scientists all of whom understand the conditions of freedom in which a scientist can do his best work and support each other to secure it. With an organization of this kind the elaboration of a strategy of science is no hindrance but a positive help to every active scientist.

However, before considering how it can work, I want to allude briefly to another necessary condition for the advance of science, namely, the provision of an efficient information service designed to secure that the results of research everywhere in the world can be brought to bear on particular problems. Over most of the scientific world such a service is still very imperfect and though efforts are being made to create one, particularly in the United States, it is only in the Soviet Union that a reasonably adequate service exists. It is now recognized that for lack of information services, for example, many of the results of scientific research are completely lost. This results in the same discovery having to be made over and over again. More than that, it prevents very useful pieces of information which are not in themselves decisive in an early stage, being completed later by adding other bits of information not originally available.

The efficiency of scientific research considered as means of finding out facts and setting them forth plainly is extremely low.[1] This is only partly for lack of organization, much also arises from policies of industrial and military secrecy. In the physical sciences in Britain and America probably about two-thirds of newly won information is never published at all, but kept on the records of firms and very carefully guarded from their rivals, who are very often discovering the same kinds of things and also sitting on them. This secrecy, bad as it is in the industrial field, is of course far worse in the military. This would not have mattered much twenty years ago, but now that much of the most exciting and interesting parts of science, those concerned with atomic energy and particularly with thermo-nuclear research, are guarded as military secrets, it means that large sections of science are not open to the kind of mutual com-

[1] J. D. Bernal, *The Social Function of Science*, London, 1939, Chapter V.

petition and information that has been the main source of new ideas in the past[1].

The discussion of these hindrances to the advance of science should serve to bring out its immense vitality and promise, for all its great triumphs have been achieved in spite of them. The reason for bringing them up at all and stressing the enforced inefficiency of scientific research is to show the enormous additional advances that will occur in the measure that these hindrances are removed.

Now I want to turn from the negative to the positive aspects of scientific research and show how these difficulties can be and have been overcome. The advance of science is not a completely blind proliferation of knowledge on all fronts. In studying its history it is possible to discern a pattern revealing an unconscious strategy[2] in which one break through is followed by a rapid advance and where the junction of two lines of research can suddenly open whole new fields to knowledge. The problem here is as to whether this unconscious strategy can be turned into a conscious one. At first sight it might seem that this was absolutely impossible. Almost by definition, fundamental discoveries cannot be predicted in advance.

The solution is perhaps not to try to do so, but to be prepared to make full and immediate use of all discoveries that do occur and to continue pressing on those places in science where discoveries seem most likely. Lord Rutherford, the greatest experimental physicist of our century, used to say "Never attempt a difficult problem". Now there are very few people who are so clever that they can spot the easy problems, and he was certainly one of them, so that this advice is easier to give than to take; all the same the idea is worth thinking over. It is the adaptation to the field of science of the military maxim of "reinforcing success".

At any given time there are certain regions in science where advances are easy and abundantly rewarding. There are break-throughs on the front of ignorance, and at these break-throughs or growing points of science it is worth putting in a great deal of effort. Actually, there is little difficulty in mobilizing scientific effort at these points because these are inevitably also the most interesting parts of the science of the day and those that draw into them the keenest young minds coming into science for the first time. The difficulty is rather on the administrative and financial side, where certain sums are regularly attributed to certain disciplines in accordance with the imagined needs of some distant past, and a distant past in modern science is a matter of five years and sometimes less. A greater availability of funds and equipment for science would go far to solve the problem as to how best to develop it. The principle once enunciated by Professor Blackett is really the key to the situation. He maintained that if any young scientist had a clear enough idea of what

[1] *Science in History*, *op. cit.*

[2] J. D. Bernal, *The Freedom of Necessity*, *op. cit.*, p. 285 and "Strategy of Research," *Research* (1955), vol. 8, p. 456.

he wanted to do and how he wanted to do it, he should be given adequate means. "The difficult question", as Mr. Chesterton's Father Brown once remarked "is not to find the solutions but to find the problems."

As examples of such break-throughs I will discuss some of the fields of science about which I know something of the prospects in the very short time that we can reasonably predict; because the more rapid the advance of science the shorter is the time scale of prevision. It is most clearly worth backing up the study of the nucleus and the fundamental particles in physics. There we may hope to find quicker ways towards realizing thermo-nuclear energy on one hand and also altogether unpredictable knowledge of the fundamental properties of matter, such as was revealed last year in the discovery of the failure of the principle of parity, or of the equivalence of right-and left-handedness in fundamental particles[1].

The production of nuclear energy has now become a new branch of engineering and as such involves more of technology than of science, but in the process there are certain to be many scientific problems which call for more basic research. It has also many applications to other fields, particularly to chemistry: here already nuclear reactions are utilized for the production and modification of plastics.

What is from the point of view of nuclear energy production a very small by-product, the production of radioactive atoms or tracers, has had already an enormous effect on the understanding of chemical and even more of biochemical processes, and this is certain to be a major tool for research in the future.

The development of electronics is an application of modern physics second in importance, if that, only to atomic energy; particularly as its new basic components are no longer limited to thermionic valves, but include various types of transistor devices based on the properties of semi-conductors, that is by controlling the movements of electrons inside specially prepared crystals. The general study of solid state physics and crystals is fascinating from the theoretical point of view. This is because it deals with a set of complexities of inorganic solid matter far greater than that of the gases which were the main object of study in the last century.

The realization that a few special kinds of substances can have quite exceptional properties which lie outside the range of behaviour of all other substances is only a recent one, though examples of them have been known and wondered at for thousands of years. One of the earliest was the magnet or lodestone, the properties of which are still not fully

[1] It had always been assumed that in basic reactions such as the disintegration of nuclei or of mesonic particles the probability of right-handed and left-handed spins were exactly equal, and now it is shown that, especially in weak reactions, there is a basic right-handedness about the physical constitutions of at least this part of our universe which is similar to, but possibly completely unconnected with, the predominant right-handedness of the arrangement of atoms in the molecules in living organisms.

explained. But now in addition we have a variety of ferro-electrics, piezo-electric and super-conducting and semi-conducting crystals which are furnishing the basis for what might be called a second and more intelligent application of physics to human affairs. The first application, typified by the steam engine, was that of brute force and energy; the second, initiated by the electromagnetic telegraph, lay in the conveying of information.

It is this capacity for recording and playing back information through such electronic components that has given rise to the computing devices already mentioned in connection with automation. Great, however, as the importance of these is already and is likely to be in practice, they also open a new field to science. The assembly of unit devices of this kind in different varieties of circuits furnishes a possibility of a creative use of physical science in doing with electric systems what had previously been a purely mental exercise in the development of mathematics. But although it will be a long time before it is possible to use the same quality of intelligence in the mathematical forms of computing machine as has been the practice of the great mathematicians of the past, the very speed of these machines furnishes opportunities for mathematics which the older direct computations could never reach. In effect we are at the beginning of an era of mathematics based on the possibilities of computing machines.

The analogies between the methods of working of electronic computing machines and of our own brains, or the rather simpler brains of other organisms right down to the cuttlefish, give us another weapon in understanding biology. It goes further to link all the sciences together. Thanks to this development we are coming to the end of the phase of science which consisted of an examination of the natural world and of its laws. This is now no longer the whole but only part of science. In the new phase now opening, the laws of possible combinations of mental or material entities have also to be discovered. We need to study combinations which never occur in Nature but are of purely human construction. This new, completely artificial field of study is now becoming more and more important, and may in the course of time become the most important part of science, or at least of physical sciences. In the biological sciences we have a long way to go yet before we understand the complexity of even the simplest organisms, but even here the building of electronic models has already helped to unravel some of it. This advance changes the whole aspect of science by adding an element of *creativity* to those of analysis and observation. The world of the future will inevitably be a more man-made world not only in the material, but also in the intellectual sphere. This creative aspect means that science will, in its own nature, become closer to art and become, what mathematics has always been but in a rather restricted field, a field of human activity in which new combinations are being continuously created and not merely discovered by the study of Nature (p. 266).

The prospects of further developments in chemistry, though possibly not so intrinsically important as physics, are likely to be just as immediate in their practical consequences. Synthetic chemistry can now be used to make organic compounds out of their elements by simple and reliable processes, and not just a few odd molecules like alcohol, but complex plastics like nylon and polythene. We may expect further advances in the direction of going beyond the original models, beyond trying to produce artificial silk or artificial rubber. What will be aimed at will be entirely new substances having desired properties not necessarily ever found in Nature; not only passive but possibly even active properties, such as spontaneous and controlled contraction imitating the action of muscle.

Indeed the tendency of chemistry will be to invade and transform all the material-producing industries. As I have already indicated, the metallurgical industry which grew up largely technologically is already being penetrated by chemistry, and may soon be operated almost entirely by the methods of chemical engineering. We can envisage a situation in which the flow-sheet of all of the elements, of the atoms of different kinds that occur in Nature with the addition of other new kinds that can now be made by nuclear energy, will be part of one universal, organized, chemically-directed flow-sheet, in which various combinations will be formed, broken and re-formed in different ways according to an increasing knowledge of the methods of chemical synthesis.

Here, not only in substances but also in methods, chemistry may come first to learn from and then to surpass the action of those marvellous chemists, the living cells. We call them marvellous because they are able to produce the most complicated substances, working under conditions where present-day chemists would hardly produce anything at all, that is at normal temperatures in dilute water solutions, without the use of any strong agents such as acids. This mastery of chemical synthesis is also the answer to the food problem already mentioned; and the guarantee of the independence and security of the lives of a much more numerous human race of the future.

More and more the attention of the chemists of today is being drawn towards the understanding of the problems of biochemistry. This has first to provide the picture of the operation of the unit cogs and levers of the living machine, such as the carbohydrates, amino acids, and fats. Now it is approaching an interpretation of that living machine itself so rapidly indeed as to produce a revolution in fundamental biology, one which already makes it one of the most exciting parts of science. Biology has borrowed from physics some of its new tools, like tracers and nuclear resonance, the electron microscope; others like chromatography were derived from chemistry.

In the light of the information thus revealed we are beginning to realize that what we had previously thought of as an extremely simple single-celled animal is in fact a complexity of a kind that would have

confounded all those who argued against design in the past. Yet at the time it is being discovered we can also see, if still only dimly, the reasons why the various parts should be constituted and act as they do. That the very fact of this complexity has been discovered is a proof that man is at last in the measure of understanding it, and in that understanding is likely to make enormous advances, not only theoretically but also in the practical applications to the control of living organisms, in health and in disease. But the complexity in detail depends on principles which are extremely simple and relatively few. Indeed we would never have understood biochemistry unless this had been the case.

The operation of the enzymes, each of which is responsible for a single chemical transformation, the co-enzymes which deal with energy transfer, the nucleic acids which preserve the pattern and form the basis of heredity, all are common features of existing life. However, it is evident that they must have been preceded by simpler and cruder mechanisms, for these themselves depend on the existence of quite complicated molecules, such as sugars. The establishment of the sequence of synthesis of these simpler biological units will go far to explain the origin of life on an inanimate earth.[1]

At the moment an active search is going on to elucidate the ways by which the type of activity of the enzymes is linked with the memory and pattern character of the nucleic acids; and already these give us hints which may provide within a measurable time a solution to problems such as those of degenerative diseases like cancer.

Already the knowledge of metabolic cycles of changes, such as the fourteen steps which fermentation requires to turn a molecule of sugar into alcohol and carbon dioxide, enables one to see something of the mechanism of the drugs which have been used for centuries with more or less effect in medicine, and more particularly of the new drugs, the antibiotics, which are coming into action. We are still at a somewhat primitive stage; we find almost by accident that a drug has a certain effect; and by playing around with drugs of similar constitution we may improve this effect or even produce some other one. But we are only just approaching the stage when it will be possible to design *a priori* the kind of drug that is required to have any given effect, from a knowledge of how it works in producing that effect, that is from a very deep understanding of the chemical processes of the cell.

If all this elaborate chemical machinery is to be found in a simple single-celled organism, it is evident that the complex organisms of the type of our own bodies require a much deeper understanding of the inter-relations of their various parts, in their development and in their normal functioning. And here the ideas of communication, which are already developed in connection with the purely physical and technical tasks of various types of telecommunication, are beginning to be applied to whole organisms. Here we find a slow-speed communication through

[1] A. I. Oparin, *The Origin of Life on the Earth*, 3rd. edn., Edinburgh, 1957.

the passage and diffusion of chemical substances, such as the hormones, and a high-speed communication system through the various nervous links of the central, sympathetic and para-sympathetic nervous systems in the human body. This is more than a matter of detecting the actual means of communication, the reactions which occur at nerve endings or in nerve cells in sending out or receiving messages. The really difficult problem is to understand the total connected communication that goes on inside a higher organism, a matter in which reaction and inhibition is as important as action, a matter in which memory plays a very large part and in which we need to understand complexities of a degree of which until recently we could form no idea.

Fortunately, it is just this kind of complexity that we are already creating for our own purposes in the new electronic computing machines. Comparative studies of the nervous system and the computing machine are increasing our knowledge of the one and our control over the other (p. 000). The human brain itself is a computing machine far more complex than anything anyone has yet attempted to construct, though it is not beyond the possibility that we may be doing so before long. But even then we are a long way from making a computing machine which will go by itself and itself learn how to work, not to mention the difficulty of building itself up from simple elements. However the mechanisms of learning and of judgment, deemed in the past to be incomprehensible faculties of the mind or of the soul, are now coming within the reach of understanding through the applications of the new mechanical mathematics. It is evident that the linking of the psychological with the engineering side in development of such machines is essential for the proper growth of both. This is another argument for maintaining fundamental science and even strengthening it in such regions.

We have now, for instance, a direct way of registering much that happens inside the brain through the electroencephalograph, but this is at the moment rather in the stage of hieroglyphics before they were interpreted. We do not know what the marks on the chart mean, although we can under certain circumstances alter them or notice how they are altered in disease and particularly in insanity. Through such understanding the communication possibilities between human beings will also inevitably be increased, and we may be able to solve the fairly elementary problem of how to communicate with each other without the rather tedious mechanisms of speech and writing (p. 279).

To go further into the field of psychology is beyond the purpose of this book. It is in psychology that we meet the boundary between the knowledge of the body as an organic mechanism, and that of the mind which has been formed largely in human society. The former aspect is something which can be studied profitably in parallel in animals and human beings. The latter involves the study of the complex effects of society in which another kind of memory, that of social memory or tradition, is bound to play an ever-increasing part as civilization becomes

more complex. For this reason the maintenance and increase of social studies is also of vital importance. At the present time, as I have argued elsewhere[1], much of this study has been perverted by the needs of such trivial objects as industrial psychology to persuade workers to do more for the same pay, or advertisement. Nevertheless the possibilities of further development of the social sciences, both observational and experimental, will be enormous and deserve far fuller support than they have ever received up till now.

The applications of science that have the most direct bearing on the lives and happiness of people remain those of medicine. One may say that it is only in recent times, certainly only in the last eighty years or so, that medicine can claim to be based on science. Whatever was good in older medicine depended on practice and chance discoveries, usually by unlettered and primitive people. But ever since the time of Pasteur and the dawn of biochemical science with Claude Bernard, medicine is becoming more and more an attempt to use our knowledge of biological processes to control those of our own bodies, to check and prevent disease, and to prolong active and healthy life.

The really great break through came only with the advent of effective antibiotics just before the Second World War. Penicillin and its multiple successors did establish a mastery, even if only a precarious one, over all diseases caused by bacteria and protozoa, that is over most of the diseases killing children and young adults. The remainder are largely virus diseases like measles and poliomyelitis that are not as yet open to chemical attack, as they operate actually inside the cells of the body. So far they can only be dealt with by the limited means of vaccines.

Overall, however, there can be no doubt that the victory over infectious disease has been won, at least in principle. This has already led to great changes in the death-rate all over the world and has become one of the major factors causing rapid population increases, especially in countries where previously a high birth-rate had been balanced by a high death-rate.

Nevertheless, the victory over infection and disease has still to be consolidated. It is true that under the impetus of a new and democratic government in China enormous changes can be made in the incidence of disease by quite elementary sanitary methods, removal of rubbish, killing of insects and so forth. What happened there in the years after 1949 was equivalent to what happened in the decades in the middle of the nineteenth century in countries such as Britain, France and Germany, where the introduction of sanitation ended epidemics of cholera, typhus and similar dirt-borne diseases. But it is only a small proportion of the world today who are enjoying adequate medical care. There is one doctor for every 610 persons in the Soviet Union, one for every 770 in the United States, one for every 950 in Britain; whereas there is only one for every 56,000 in Nigeria and one for every 71,000 in

[1] *Science in History, op. cit.*

Indonesia. We cannot be said to be caring for our fellow men until we have raised this ratio to the optimum in every country of the world (Table III, p. 26).

A look at the comparative death-rate curves of a country such as the United States and of India will show that at all ages of life, particularly in childhood, but continuing right the way through seventy odd years of life, people are dying who could have been kept alive with adequate sanitation and medical care. Once we know the reasons for this, it is difficult to escape the charge that these people are being murdered, perhaps inadvertently murdered, but those who know how they could be saved and are not saving them have a certain responsibility for their deaths (Fig. 3).

In the long run the burden of medical care, the training of doctors, the provision of drugs, is one which can be easily borne by any community, even the poorest, granted the know-how and the training. India today, for instance, is proposing, with Soviet assistance, to build up its own factories of drug production, thereby among other things economizing

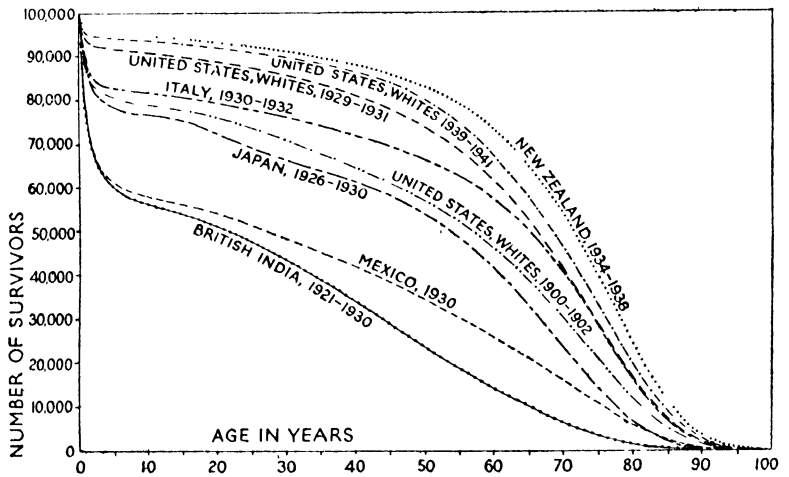


Fig. 3.—Survival Curves for Various Countries.

These curves show the number of survivors out of 100,000 persons in each case, for different countries at different times. It shows the effect of good nutrition and reasonable medical care on human life spans. It shows first the heavy losses that occur under bad conditions from infant mortality, and then the toll taken all through life, mainly by infectious diseases. The curve for New Zealand and U.S. (whites) shows how, within the limits of present medical knowledge, little can be done to prolong life beyond 75. The successive curves for the United States show the improvement, mostly in the range of infant mortality, brought about by better medical care and general knowledge of hygiene. Curves based on more recent figures might show the effects of antibiotics, even above this age. (From A. Comfort, *Biology of Senescence*, London, 1956; based on T. N. E. Greville, *U.S. Life Tables and Actuarial Tables, 1939–41*, Bureau of the Census, Washington, 1946).

quite considerably on many expensive foreign drugs and providing for more drugs than it could afford before for its own population. Similarly there is no difficulty in training an adequate number of doctors; in fact many of the industrial countries have, or believe they have, a surplus of doctors already, who could help to spread the knowledge of medicine in other countries until these were ready to take over with their own nationals.

The logical end of this process would be to wipe out all infectious diseases—a not impossible task—for this has already been done in respect to old killing diseases such as tuberculosis in countries like Denmark. When this has been done, and only when this has been done, can we say that we are no longer murdering through our indifference hundreds of millions of our fellow men.

Nor is it sufficient to say that once we have provided the doctors and the drugs we have done everything necessary. Medicine lives by further research. Without that, as we are beginning to find, old remedies fail to work and diseases begin to catch up on us. Nor can that research be done today without considerable expense and organization. We should not be blinded by the impressive effects of a very little research in a crucial field, such as that of Pasteur in the nineteenth century, to thinking that all medical research can be as cheap. What was done then and what has been done since, in the almost equally chance discovery of antibiotics, is to tackle the most obvious and vulnerable aspects of disease, those caused by detectable micro-organisms that can be killed directly by biological or chemical agents, or whose spread can be stopped by noting the track of the infection.

In the past, death and disease were considered to be either agents of blind fate, or punishment for sin of one's own or one's ancestors. Now we know that this is not so, it implies a responsibility everywhere to provide for all mankind the knowledge and medical service to cure all the diseases that we can cure, and to pursue researches in order to cure the remainder. There are still many diseases, the most of the killing diseases of the middle and late years of life, that we do not yet know how to deal with. Of these, cancer and heart disease stand out, accounting between them for more than half the deaths of those over fifty. What we do know, however, is that we shall never get anywhere towards curing those diseases without research, research undertaken in a way and on a scale quite different and far greater than anything that has been attempted heretofore.

The history of science shows very clearly that direct attack on such complex problems is not likely to yield the best or quickest results. Much more could be gained on the clinical side by trying to isolate from the study of disease what are fundamental physiological characteristics, and then to combine this knowledge with research into the behaviour of biological systems in general, particularly so with microbiology, till we find how to prevent the crucial stages of these diseases, often perhaps

before the appearance of any symptoms, by a suitable regulation of the metabolism. The statistical knowledge of the incidence of these diseases shows already that they are related to social conditions almost inversely to those diseases which have already yielded to medical science, that is it is the wealthiest countries and the wealthiest individuals who are more affected.

If we call the deaths from diseases based on poverty and ignorance murders, we must qualify the deaths from the diseases of superfluity as suicides; but again suicides of indifference. Very few people would in fact eat and drink what they knew would cut ten to forty years off their lives; but they do not know. It is true that when they do find out they are not over-anxious to take action. It is now some five years since the close association between cigarette smoking and lung cancer has been established beyond a doubt statistically, but that knowledge has not yet been able to counteract the enormous social tradition of smoking and the advertisement pressure of the cigarette companies.

Together with the killing diseases there are those that merely disable and cause invalidism for long periods, such as the rheumatic and bronchitic infections of which we know effectively very little for lack of adequately financed scientific research. I know that to judge from public statements there would appear to be a great deal of medical research going on. But this impression is largely created by the publicity of the drug firms. What research there is suffers from two cardinal defects: first of all most of it is clinical rather than fundamental, and therefore, except when here and there a specific remedy is found, it is very difficult to generalize and extend from the researches carried out; and secondly because it is so little co-ordinated and planned. If we had throughout the world a really adequate system of medical statistics, one which could quite easily be coped with by our modern computing machines, we should have some measure of the problems and the effectiveness of various preventive or remedial medical measures. Until that happens we must consider the medical profession as essentially a technical one: a qualification of which there is nothing to be ashamed of because it was taken by Hippocrates in his famous apostrophe of life being short and the art (*tekhne*) long; but it is one incompatible with the modern move to transform technology through the use of science.

In so far as medicine is successful and saves lives, we will be faced with the problem of what to do with the lives that are saved. With a healthy population there are more people to feed; more children survive infancy and not so many young people die of tuberculosis. And being healthy all of them want to eat more. It is indeed much easier to kill malaria mosquitoes, or to cure patients of yaws, than to provide the number of people saved with enough food to eat. This has given rise to the proposals by people who ought to know better of holding up the application of medicine in order that the check of disease should prevent the operation of the check of famine, when in fact both go together.

The humane alternative is to insist that the operation of maintaining life should go with saving it, and if people cannot be kept alive on the existing economic system it is time to change it. This problem indeed is already with us in some small and densely populated places where medical research has already produced marked effects, for instance in the Caribbean Islands, Costa Rica, and the Mauritius. There the population is increasing at a rate of from 3 to 4 per cent per annum without any corresponding increase in the food supply. However, by analogy with the history of the older industrialized countries, it would appear that this excessive population increase—excessive that is not absolutely but in relation to the means immediately available—will taper off as a knowledge of birth control spreads and people see that it is to their own advantage to limit their families to two or three children.

But it will take some time for this to happen, especially in those countries where medical action has stopped disease, while nothing has been done in other directions such as industrialization to improve the situation of education and general economic well-being. In many countries even today children are the only form of social insurance. If a man does not produce at least one son who will survive him, then he is more than likely to have to beg in his old age. However, as indicated earlier, there is no reason why there should not be some measure of birth control in these intermediate stages pending the development of agriculture to provide the necessary amount of food for the greater population.

In any case the effective increase in population cannot be maintained for long, if only because the age composition of the population will change as lives are saved, and the smaller number of women in the reproductive period will automatically reduce the birth-rate; whereas the survival of the children saved from early death to the age of fifty or more will equally automatically increase the death-rate. This, however, is a relatively slow process and cannot at all be operative under fifty years. The immediate problem, which is essentially one of nutrition, still has to be faced (pp. 271 ff).

This concludes the discussion of the contribution which a rapidly advancing science is making to industry, agriculture, and medicine, and tells something of its intrinsic promise in deepening our understanding of the universe. It should serve to bring out the enormous potential fruitfulness of science and the degree to which this is still not being realized. What stands in the way above all at this time is the militarization of science which has gone with its enormous expansion in the last two decades, itself a consequence of the Cold War. This great effort is actually being either wasted or turned to ends which may destroy the world. Indirectly through the secrecy, the security checks, and the interference with international scientific exchanges, it severely hampers science and turns it from its original international, generally beneficent character into almost a weapon of war in itself. However, the

actual scale of the science for war in itself shows what is available for science without noticeable strain on the economy in the service of peace.

It is clear that much more thought will have to be given to the position of science in a world without war, one which will combine the freedom of the individual to think and experiment creatively, with the provision of adequate material support and adequate information. In the scope of this book, however, this subject cannot be pursued any further, except to emphasize once more that an enhanced scientific activity will be absolutely essential for the general realization of the transformation of human society.

To sum up, as to the place of scientific research in the building of a world without war, the essential point is that science has proved its capacity to deal with already recognized problems, to tackle any new ones as they occur, and to generate problems of its own whose solution illumines new aspects of Nature and gives men new powers. With an adequate scientific foundation well linked with practice, it is not necessary in the first place to know the problems or the answers to them: all we need know is that if we have sufficient trained scientific personnel and set them to work they will soon enough find what has to be done and how to do it.

Now whether we can find this personnel in sufficient numbers is a question which we will return to in Chapter X; but to anticipate the answer we may say that in practice it has never been difficult to find enough people providing the community is willing to pay for them. And this is what the rulers of the Western world are for the moment unwilling to do on an adequate scale. They are only beginning to be scared into it by the plain evidence, from technical successes such as that of the earth satellites, that in Socialist countries this restriction does not hold. There far more support is given to science and enough is done to see that the scientific results come back in practical form. It is, however, at last beginning to be recognized that the status of science in a community is a measure of its potential strength and promise. Here is a competition as strenuous as war, but one that can only bring good to the contenders.

So far we have dealt essentially with the possibilities inherent in the technology and science of the world today. Once the burden of war preparations, both military and economic, has been removed, most of the things I have written about so far could be done straight away. Where more knowledge is necessary, the answers could be found by research. However, there is an enormous difference between what could be done in detail and what will be done overall. Even with the best will in the world it would be impossible to do all the things I have mentioned at once.

The material and human resources to carry out such a scientific and technical programme have first to be built up, and this is a problem which is not in itself technical, although it implies a complete knowledge

of the possibilities of techniques. It is in the first instance an economic problem, that is it is a matter of finding out how far the available resources, limited as they are, can go at any given time, and how from those initial resources to build up further resources to carry the process to higher levels. It should be evident from what has happened already this century in certain countries that we can advance in developing a modern industrial system: the questions are really how far and how fast we advance and over how wide a front, whether it is possible only for a few favoured nations or even favoured classes within those nations to advance, or whether the whole of humanity can advance together. This requires some quantitative estimation of the possibilities before mankind today, and will be the subject of the next chapter.

VII

THE ECONOMY OF A WORLD IN TRANSITION

This next section of the book is one dealing with the realization on a world scale of the technical and scientific possibilities already sketched in earlier chapters. Though nearly all of them are based on actual achievements, these have been realized only in certain places, largely in the most advanced countries, and are still far from having affected the world as a whole. The problem that must now be examined is to what degree and how fast can they be extended to cover the whole world. We must try to find the answer at the outset, in terms of the actual available resources, material and human, of the world and for later stages in terms of its potential resources. The political difficulties of such a utilization of resources are deferred to Chapter XI and some of the ways of overcoming them to Chapter XIV. Here, I am making a hardly realistic assumption that we are operating, if not in a benevolent, at least in a rational world where countries see the advantage to themselves in helping each other. The value of such an assumption at this stage of the argument is that it should help to bring out the upper limits to rates of advance. In practice things would not be as good as this, but it would be impossible to make them better.

I call the limits I have in mind *economic*, but this word has not here the narrow academic sense of pertaining to exchange and to profit and loss. I am not considering in this chapter, though I do in Chapter VIII, the profitability or unprofitability of the various courses I discuss. I am fully aware that if an evenly balanced economic development of the world as a whole would have yielded a maximum profit to financial concerns, it would have been undertaken years ago. Unprofitability rather than lack of resources has been the major factor responsible for the very slow development of the major part of the "free world". This is a question to which I will return later (p. 139 f.). For this, discussion I want to make it quite clear that the economic limit I talk about is that which concerns itself with the maximum amount of useful work which can be done with the men and equipment available—the kind of manpower budgeting or "real economics" we used in the war. The economic problem then reduces itself to finding the best disposition in place and time of the available means. It is evident

that the kind of economic laws that have been operated in the "free world", by which the rich countries have been getting richer and the poor poorer—an ample confirmation of Marx's predictions—would be of little help in finding the best and equitable use of world resources.

We have to keep in mind from the outset the major economic change of our time, which can be viewed in two aspects: the general economic transformation of the scientific industrial revolution, and the removal of the gross inequalities between peoples and classes.

The scientific industrial revolution is a transformation leading on not only from the state that immediately preceded it—that of machine-based civilization of nineteenth-century Europe and America—but also simultaneously from all the even earlier forms of economy which still subsist together in different parts of the world: from primitive tribal economy, from peasant economy, from the economy of the exploited colonial territory. It is concerned with the transformation of all these into an economy based on a scientifically directed heavy industry with a full utilization of power and of increasingly automatic machinery. Now, as will be evident from what has already been written; I am not here arguing whether this transformation is desirable or not, I am only stating that it is necessary if more than a small fraction of the present world population is to survive. In fact, however, it is going forward in many parts of the world, despite the resistance of capitalists, mainly because the people want it, for they see in it a condition not merely of survival but of any possibility of achieving a better life.

There is no longer any hope of blocking off even a part of the world to preserve a less developed economy or the modes of life that go with it. There can be no repetition of the attempts made in China and Japan from the seventeenth century to the nineteenth to preserve their ancient cultures. The economic and military pressure of the new mechanical civilization broke down these old defences, and in doing so gave that initial stimulus to population increase which has closed the way back once and for all. India, Indonesia, and China, to mention no other countries, could not now hope to feed their populations without the increasing use of industrial products and the development of industries themselves.

There was a time, it is true, towards the end of the nineteenth century, when it was thought that the condition of special privilege of certain countries—Britain, Germany, the United States—might be preserved and increased by drawing on the labour of the more backward countries of Asia to provide them with the necessary raw materials for their industry and with food for their people at cheap rates. But, if nothing else was to do it, the actual quarrels between the imperialists in the two wars of the twentieth century made this an impossible ideal; it was never a worthy one. Now the rise of the Soviet Union has shown the alternative way of building up a world civilization on a basis of economic equality. Exploitation, however, still persists over a very large

part, probably more than half, of the world today. Where it no longer takes the form of direct colonial administration, it operates indirectly, relying on the monopoly of essential machine production and means of transport which are still largely, though not entirely, in the hands of the old imperialist powers.

No country or region can be economically independent; it cannot avoid being exploited indirectly through low prices offered for elementary raw materials and high prices asked for consumer goods, unless it controls its own basic industry. By that, today, we mean a basic power production, a basic heavy metal and chemical industry, and a basic engineering industry to produce the necessary machinery, particularly the transport machinery. The present transformation is largely concerned with the struggle to build up such industrial bases (Map I, p. 247).

The second and closely related aspect of the present transformation is the major disharmony in the world of the present day—the great unevenness of production and consumption—which means that an average United States citizen has an income 10 times that of the average of the world, and 100 times that of an average Indian, and controls an even greater proportion of productive power (Table IX). This unbalance has to be rectified, and much depends on how rapidly and how smoothly that transformation is actually brought about. This unevenness is, however, rather a symptom than a cause of world disharmony. The fundamental cause lies in the system of capitalist exploitation itself. Through the workings of this system a very small group of dersons in the older industrial countries control a disproportional part, not only of the wealth of the world, but also of the wealth in their own countries. In so far as the nationals of those countries are allowed to enjoy some share of the wealth derived from exploitation, they are persuaded that they have a direct interest in maintaining their privileged position. To justify this they have been given the comfortable theory that they hold it as an inalienable right due to their innate superiority over other races. They are also made to believe that their comparative wealth depends on their willingness to defend to the last their "Standard of Living" or "Way of Life". This they have been doing throughout the years of the Cold War at enormous cost to the world as a whole, including themselves, and with an increasing risk of precipitating a total nuclear war.

The danger against which these people have been led to fight is, however, as I hope to show, an imaginary one, for it is perfectly possible to raise the standard of living everywhere without any diminution of it in any area. Indeed the standard of living may, and probably will, rise still further in the more favoured countries as others catch up. In the latter stages, when all advance together, the new standard of living, that of everyone in the world, will be far higher than it is for the highest today. What need to be thought out are the methods of discovering and utilizing the resources of the world, and particularly the vast un-

TABLE IX

Energy and Steel Utilization in Various Countries

(1956 Provisional Figures)

COUNTRY	*ENERGY (Coal Equivalent)**			*STEEL (Apparent Consumption Expressed in Terms of Crude Steel)*		
	Total Consumption (Million Metric Tons)	*Per Inhabitant (Metric Tons)*	*Per Industrial worker (Metric Tons)*	*Total Consumption (Million Metric Tons)*	*Per Inhabitant (Kilograms)*	*Per Industrial worker (Kilograms)*
U.S.A.	443	8·58	66	101	600	5,000
U.K.	258	5·03	23	19	380	1,700
U.S.S.R.	490	2·45	19	47	235	1,800
France	117	2·68	17	12	276	1,800
W. Germany	190	3·60	19	22	417	2,200
Japan	98	1·08	11	10	111	1,150
India	48	0·12	4	4	9·3	320
China	118	0·3	5	5	8·6	210

Source: Based on *Statistical Yearbook, 1957*, U.N., New York, 1958.

Notes: *1000 Kilowatt hours — 0·7 Metric Tons Coal Equivalent.

tapped human resources, so as to give everyone not only the opportunity of having good physical conditions of life, but also the opportunity of contributing to his own advancement and that of humanity at the same time.

What the so-called backward, underdeveloped peoples really suffer from is not so much their lack of consumption as their lack of the means of production, of a means of building a healthy civilization for themselves. For one characteristic feature of the present state of the world is this deeply felt need of being independent, not only of exploitation, but of charity. Peoples want to be free to use their own efforts for their own welfare. As the cases of Russia and China have already shown, people would rather go through the difficult time of building an industrial civilization without help from capitalists and even in the teeth of their opposition, rather than submit any longer to the conditions of subjection to foreign capital and all it implies in domestic misrule.

Here in this chapter we will mainly be concerned in considering the process of levelling up of relatively underdeveloped countries, treated as an economic problem rather than a political one. The essential political conditions for the transformation will be left till Chapter XII. In order to show what is economically possible, that is, what can be physically accomplished with available world resources, I will assume that a certain amount of assistance will be available to the underdeveloped countries in the form of loans or grants. Later we will consider the corresponding problem of how the industrial countries will provide assistance and what will be the repercussions on the development of their own industries and economies.

Some degree of outside assistance, though very desirable, is not absolutely necessary to transform a country from a primitive to an advanced economy. We know, at least from the one example of the Soviet Union, that in a country with a minimal foundation of industry but with a people inspired by socialism and willing to set to work, it is possible within a generation to build up an industrial system equal to that of most capitalist countries. However, the cost of this effort in human lives and suffering was made far greater by foreign obstruction and repeated military intervention, and it took longer in consequence to achieve success. The example of China since 1949 shows us that with a little help from existing Socialist countries the effective transformation can be effected even more quickly. From such examples we may conclude that given sufficient and intelligent aid, countries with an even lower basis in industry and education should be able to raise themselves to the highest level within a few decades.

Economically speaking, the determining condition is the availability of capital, that is, of real capital in the form of machinery, sufficient in the first place to begin to release the natural resources of the country, both agricultural and mineral, and to build up a modern productive industry. It is this last point that is crucial. Once an industrial base has

been set up capable of making from local materials and labour all the equipment necessary for productive industry, agriculture and transport, the country has achieved real economic independence. It may continue to import machinery, but this can now be balanced by other industrial exports. It is only then, in fact, in the position to create its own capital. No colonial or semi-colonial country as yet has been able to build up such a self-reproductive industrial base entirely from its own resources. Even China and India, who are approaching that state, have had to depend to some extent on foreign loans. So in the last century did Japan (p. 116).

It is true that for at least fifty years much foreign capital has been invested in such countries; indeed the exportation of capital was one of the characteristic features of imperialism of the beginning of the century. Since that time the effect of the two wars has slowed down the export of capital from the old centres of capital export—Britain, France, and Germany. In the original imperialist period, the capital exporting states were almost purely industrial states with relatively small local supplies of minerals and other raw materials, and had an absolute deficiency of agricultural products. It paid to export capital goods, mainly for mines, plantations, railways, and ports, which ensured the ready extraction of the produce of the country which could be bought at low prices as well as consumer goods factories which could be run on cheap labour. The profits of all these enterprises were naturally taken out of the country for the benefit of foreign shareholders.

After the First and even more after the Second World War capital exports from the United States largely replaced those from the older industrial countries. However, this form of capital export was different and even less adapted to help the industrialization of backward countries. In the United States there was no shortage of land, agricultural products, or of most raw materials. It had only just ceased being a raw material exporting country. Consequently there was very little incentive to export capital for developing the resources or the labour of backward countries, when the return for such investment would be bound to be less than that of similar investments inside the United States itself.

The one significant exception is investment in mineral products, especially oil. This has been for years the largest single item in U.S. investment abroad—it was over $5 billion in 1955—and accounts for at least 70 per cent of all investments in the Middle East and Latin America. It was not so much that there was a shortage of oil in the United States, but that the cost of production of oil abroad, in Venezuela and even more so in the Middle East, was only a fraction, about a fifth, of the cost of the same oil produced in the United States. As both could be sold at the same price, oil-drilling became the most profitable of all capitalist enterprises.

In view of this it is hardly surprising that neither the old European nor the new American type of capital export helped to provide the

essential bases of heavy industry in the colonial or semi-colonial countries. Its objective was totally different, the building up of highly profitable industries in the industrial countries themselves and not in those that were being exploited. While it might be tolerable to have some textile factories and a few assembly points for motor vehicles in such countries, the idea of building up rival industrial centres was unacceptable, if only because it would put an end to the enormous profits of exploiting the local raw materials, particularly oil and metals.

It is only in very recent years, following the recognition of the drive to export capital, particularly industrial production goods, from the Soviet Union, that some effort, very slight so far, has been made in this direction (pp. 123 f.). Something of an entirely different order of magnitude is required if the underdeveloped countries are not to lapse into still greater poverty. Indeed, small loans may be almost worse than nothing. Even where investment is used in an internally productive way and the profits are mainly retained in the country, which is only rarely the case, it must be on a scale to provide substantially to the country's real wealth. Unless the scale of investment provides for a rate of increase in wealth and productive capacity much greater than the rate of increase of population, it will be ineffective in bringing a backward and depressed economy into a condition to start a basic industrial revolution.

The difficulty is not really one of lack of capital, but a lack of will or inducement to invest it in underdeveloped countries. There are at present ample resources for capital investment on a scale at least equal to, and probably much greater than, what can be absorbed by all the underdeveloped countries put together, certainly by all those in the orbit of the so-called "Free World". American economy has in fact been over-producing for a large number of years, and has had to resort to all kinds of different devices to check or dispose of the surplus production. By an elaborate system of price controls, the agricultural productivity has been kept well below its maximum level, and even then large stocks of foodstuffs have been bought and stored with no serious prospect of disposing of them usefully. Much food, such as potatoes and wheat, suitable for immediate human consumption is sold to feed animals when it is not actually destroyed.

Industrial production is taken up to the extent of 10 per cent or more with military construction, ships, bases, planes, guns, rockets, some of which was used up in the Korean war, but most is now obsolete and only waits scrapping or distribution as military aid to poor countries. From the point of view of a purely capitalist economy this form of spending, where production is used for something which cannot effectively be sold to the public and so flood the market, is almost ideal, and one must admit that it would be very difficult to find a more profitable alternative. This is a point to which I will return later (p. 215).

What concerns us here is that there exists today in the economies of capitalist countries considerable surplus capacity, and this even in times

of comparative boom. The United States' economy could rapidly produce some twenty per cent more than it does, or the equivalent of some $50 billion per annum, without technical overstrain or encroachment on the standard of living. We know this can be done because it has already been done in the Second World War. In those years, some 200 million additional tons of steel were produced, as well as hundreds of thousands of planes, guns and tanks and millions of military vehicles, and all the time the standard of living actually rose. It would be much easier to convert industry for a concentrated attack on world poverty, than for an atomic war. The most urgent demands for vehicles, machinery and chemical fertilizers could be met with the minimum change of existing plant.

Added to the absolute waste of war preparation is the relatively great wastefulness of the capitalist economy itself, based on the principle of selling as much and as rapidly as possible, and, therefore, of destroying the product in order to be able to buy again. One example, for instance, is the American use of newsprint which amounts to six million tons or the equivalent of 2,800 square miles of forest cut every year. Now it is quite impossible for anybody to read this newsprint—most of it is in any case advertising—but it is felt that it is essential to the running of the economy that it should appear. I remember very well a military project of some importance during the war which was turned down flat because it would mean reducing the American Sunday edition of newspapers to a mere twenty pages.

The United States is not the only country in the capitalist world that could produce capital goods from its surplus, though it could produce by far the greatest share on account of their greater industrial potential. The countries of Western Europe—Britain, France, and Germany, together with the smaller countries that form part of the same economic unit, the "common market", the "free trade area", or whatever name is finally chosen for cartelised heavy industry production in Europe—could afford a considerable export of capital which would in fact stimulate their economy.

It is impossible, short of detailed surveys which could be carried out only through U.N. agencies, to get any estimate of the real capacity for capital goods production of the industrial countries. The best that can be done is to see the magnitude of the problems in financial terms, measured in present military expenditure and in present capital formation in these countries. Some attempt to do this is given in Table XXI (p. 246) which will be discussed in relation to proposed schemes for assistance to underdeveloped countries.

Here, it is sufficient to say that a sum of some $180 billion is set aside each year for capital formation, and $80 billion for military expenditure by the five great powers, U.S.A., U.S.S.R., U.K., France and Federal Germany. These jointly contribute a gross sum of $1·2 billion in aid to underdeveloped countries. To raise a sum of $20 billion annually, the

amount necessary for optimal assistance to them (pp. 243 ff.), would mean a reduction by only one quarter of the military expenditure, while a larger reduction would, as indicated in the table, make possible greater capital formation, a reduction of taxation, and increased welfare expenditure. It would be seen that at any rate in the immediate future, there would be no real question of asking for sacrifices from the better-off countries, because the rate of possible absorption in the early years would be not limited by capital available, but by the already existing facilities, roads, water supplies, etc., as well as the trained manpower that can use this capital as it becomes available. This is a matter which will take a few years even under ideal circumstances.

Table XX (a) and (b) (p. 240) show in greater detail the way in which money from the capitalist and socialist countries has been provided in the form of loans or gifts to underdeveloped countries in the years 1954–1956. The total sums are of a comparable order, but they have been spent in very different ways. The capitalist contribution has been largely in the form of food to relieve immediate want—the socialist, as machinery and plant for industrial construction. The immediate effect of the latter may be less, but the lasting effect will be far greater. The sums provided by the Soviet Union for economic development are actually greater than would appear from the table because it is itself an aggregation of regions of very different economic development: some of them, as in Central and Eastern Siberia, were at the time of the Revolution practically untouched, natural wildernesses; others in Central Asia or Transcaucasia were impoverished, feudal agricultural States. A large amount of capital has been poured into these regions in the last thirty years, but they are still in a state of active development, and it is from the surplus over and above this that any assistance to China or India must come.

I have said that no sacrifices on the part of the older industrial countries would be required; nevertheless it may be well to make the point that if they were required some sacrifices would be no more than just. The comparatively high standard of living that has been built up in Western Europe and the United States has been largely as a result of the exploitation of colonial territories. The present miseries of the people of the latter countries are largely direct or indirect consequences of their exploitation by the imperialist powers. For years these took out of their colonies and dependencies more than they put in, and they are still doing it. The total profits made are hard, indeed impossible, to find, but it is no secret that the reduced British Commonwealth, with its oil and tin, its rubber, cocoa and palm oil, is the chief dollar earner of the Sterling Bloc. Malaya alone, a country of six million miserably poor inhabitants, produced between 1946 and 1951 no less than $1,713 million. In one year, 1950, three British companies between them netted no less than £271 million profits, which make the total sum of £128 million subscribed to the Colonial Development Fund look very small

indeed[1]. Such profits compare very favourably with what used to be made when the Empire was under direct British rule. Further, by holding back industrialization and any thorough exploitation of local resources imperialism blocked all the effective ways by which an ever-increasing population could be provided for.

Now that it is no longer fashionable to talk about colonial exploitation, it goes on in fact at an even greater intensity than before by changing to different methods evolved largely under the influence of the United States. The policy of the United States towards underdeveloped countries could afford to be one of dissociation from the practice of the older powers, particularly of Britain. And colonialism as such was unpopular, if for no other reason, because of the memory of the time when the States themselves were colonies. But now, inevitably, with the drive of economic interests, the United States has come into the colonial field in its new phase, and indeed it has done remarkably well in detaching colonies from the older imperial powers. The new kind of colonialism is one which avoids direct administration except, as pointed out in the Eisenhower doctrine, when the country is threatened by internal subversion inspired, inevitably, by "International Communism". But it can operate quite effectively by financial and trade methods which, indeed, can completely offset any sums which may be provided in the form of aid.

A classical feature of economic exploitation, old and new, has been the waste of natural resources, some, such as oil and minerals irrecoverably, and the ruination of the soil. What is more, as the nationals of these countries have been kept in a state of increasing poverty, relatively and absolutely, the old market which they represented has largely dried up, or is on such a low level of demand that it is increasingly being satisfied by the cheapest products of the other slightly more advanced ex-colonial countries. The export of Indian woven cotton cloth to most countries of Asia is now greater than that exported from Lancashire.

The exploitation itself, viewed technically, was often remarkably inefficient. Many of the most valuable raw materials were never discovered until the last few years: the bauxite deposits of Ghana, the diamonds of Sierra Leone, the oil of the Sahara, were all wealth which could have been exploited years ago if anyone had even bothered to look for it. For example, in the case of Ghana, the whole of the geological survey was the part-time occupation of one official who also had to operate as an adjudicator of mining claims and enjoyed a salary of £500 a year. Even in discovering and exploiting resources, simple greed is no substitute for a people's interest in making the best out of their own country. China had also been overrun by a great variety of prospectors and foreign companies, but they had failed to find—or at least to reveal—as much as a tenth of the resources which were

[1] R. P. Dutt, *The Crisis of Britain and the British Empire*, 3rd edition, London, 1957, pp. 179, 277.

discovered by the Communist government in the course of its first five years of existence.

The other slightly more advanced form of exploitation, that of using cheap colonial labour, has also proved to be a very short-sighted policy. With the development of modern machine production, the advantage of completely unskilled labour disappears, however low its price; it would be impossible in such industries as motor manufacture to substitute hand methods, even if the workers received no wages at all or had to pay for the privilege of working. No arguments are required to convince the people of the colonial or ex-colonial countries of these facts; but they are not sufficiently recognized even by most workers in the industrial countries. Nor is it sufficiently recognized how much more could be got by the working people of the industrial countries from a genuine association with the peoples of the colonial countries for mutual benefit than can be got by exploiting them.

Professor Blackett, in his Presidential Address to the British Association in September, 1957, called for a 1 per cent contribution of the national income of Britain for the help of underdeveloped countries as an example to others, particularly to the United States, to do the same. It is true there have been in the years since the war a number of schemes of aid to such countries. They include the Colombo plan, the United Nations technical aid programmes, the U.S.A. Point 4 scheme.[1] The actual amount of these is shown in Table XX (p. 240); as to their value in helping forward industrialization, I cannot do better than quote Professor Blackett:

"I am convinced that Western pessimism about the possibility of social advance by ex-colonial Asian countries is both unjustified in fact and a serious cause of practical error. It has led the West to overestimate the need of the have-not countries for technical advice from Western experts and to underestimate the need for simple financial help. Admirable as many of the schemes of technical aid have been, particularly those in education, medicine and agriculture, the sending of experts to poor countries without the capital to carry out their plans, could be as irritating as to send a trained cook to a family unable to pay the baker. In so far as expert aid by Western technical personnel is needed by an underdeveloped country, it is usually both more efficient and cheaper to provide money for the country itself to hire those whom it needs. Unless followed up by massive financial help, some of the West's present aid programme may yet merit the war-time wisecrack of 'offering all aid short of help'."

The much advertised Colombo Plan of 1951 is an example of how to put up a good façade for aid to underdeveloped countries. It was originally intended to expend, for the benefit of countries in South East Asia,

[1] When an inquiry was made two years ago at the United States Information Office in London for data on Point 4, the attendant had no idea what it was until a more senior member of the staff said, "Look under Military Aid".

the sum of £1,868 million in six years; of this £840 million was to come from the beneficiary countries themselves, and £306 million from Britain, £246 million being debt repayment and £60 million coming from already allocated colonial development funds. The latter represents only an eighth of what was withdrawn in profits from one beneficiary country alone, Malaya, during the previous five years. The remaining funds, which should have come from the United States, were in the end squeezed out by the requirements of military aid. A number of experts were endeed sent out, but with little, even temporary, economic benefit. By now, the fall in commodity prices has set things further back than when the Plan started. Is it surprising that this kind of aid is looked at askance by the small minority in the underdeveloped countries who ever learn of its existence? Even if what was given with one hand was not taken back more amply with the other, the sums involved are trifling compared with the real needs of the supposed beneficiaries.

In fact, the tragedy of our times is that what has been sent as aid to all these countries has been predominantly arms with which to pursue their feuds with their neighbours, which are counted on to keep them quiet and not to bother their larger and more important patrons. For instance, the artificially created division between India and Pakistan has resulted in both countries spending more than half their revenue on military expenditure, which, though no doubt profitable to someone, would have no sense in any reasonable world, unbedevilled by power blocs.

What we need instead of these tentative and partial efforts to help the underdeveloped countries is a large scale system of investment, or of outright gift to them, administered preferably through an international organization of the United Nations, such as SUNFED, on a scale of something of the order of 20 or 30 billion dollars a year, which would enable a rise in the national income to be at the rate of some 10 per cent per annum, well above the rate of increase of the population. This substantial margin is necessary for the success of any large project of industrialization. How, in detail, such a scheme could be financed and administered is discussed in a later chapter (XII).

Economic transformations are disturbing enough in any case and must give rise to new inequalities. For no one to be worse off, the average must be perceptibly better off. It was for the lack of such margins that the forcing of the pace of industrialization in the Soviet Union in the time of Hitler, and of Eastern Europe in the Cold War period, both necessary to provide a basis for military security, produced the strains and troubles that they did.

And there is another and more positive reason for providing such a margin. It is necessary to secure that the transformation is put through in less than a generation and that the critical stage is not delayed beyond a few years. Real improvements must be made fast enough for them to

be felt from one year to the next by everybody concerned. If there is as well the consciousness that the revolution is being achieved by the people for the people, and not for the benefit of native or foreign capitalists, it will be possible to get behind the development the essential popular enthusiasm and drive. For this is needed to carry it through with a swing and strongly enough to overcome the many, and usually unforeseen, obstacles that must arise on the way.

Something of this sort has actually been happening in China, and I have seen it there myself. It is not just a matter of a few great schemes—the Manchurian steel works, the Huai river barrages, the Wuhan bridge across the Yangtse—but everywhere, up and down the country, the people are themselves striving, using additional machinery when they can get it, and age-old methods of shovel and basket when they cannot, to setting their country to rights.[1] Much of what has been done in China in the last ten years could have been done any time in the last three thousand years by the same number of people using the same tools; what was lacking was the spirit and the direction, which only full socialism can give.

To the degree that the same spirit can be seen in India, it draws from the same socialist idea of mutual aid, though here, as the break has not been so marked, it is more hampered by the old legacy of bureaucracy and corruption carried over from the days of British rule. Also, the incentive is not so great because progress has been painfully slow. On account of the desire to placate the Indian *bourgeoisie* and possible creditors abroad, only a very mild degree of socialism has been introduced, while at the same time the flow of capital from abroad on acceptable terms has been far less than would be needed for effective and rapid industrialization.

Before considering further the specific way in which foreign loans can best be applied to assist the industrialization of underdeveloped countries, it is logical to consider the actual process of industrialization itself as directed, in the first place, by the governments of the countries who set this out as a conscious aim and have behind them the overwhelming support of their people.

The time has clearly passed when such industrialization can be carried out by the enterprise of business men and feudal magnates as was the case with Japan at the end of the last century. This was the first and the only example of an Asian country building up a heavy industrial base on its own initiative in a purely capitalist world. In fact the industrialization of Japan was helped considerably by foreign loans and by the backing of European governments, especially the British, as a counterweight to Russia in the game of power politics. In future only govern-

[1] The most recent development has been the appeal to the native ingenuity of the Chinese villager to devise methods of cultivation and earth shifting which are labour saving, and yet can be made by local craftsmen from local materials (*Peking Review*, 27th May, 1958). (See also p. 294.)

ments with essentially Communist or Socialist policies can put through a thorough industrialization policy. Even a convinced anti-Communist like President Nasser has in fact to use the methods of nationalization.

As a result of experience in the last thirty years, first in the Soviet Union, then in China and in India, we can form a rough picture of the sequence of stages of transformation of a country from a pre-industrial to an industrial state. The simplest division is into three great stages: first that of survey and planning; second that of building up the central industrial base; and third that of its expansion. The first stage is the building of an outline *plan*, which cannot be done without a preliminary *survey* of the actual industrial capacity, the distribution of mineral raw materials, the agricultural possibilities, and, perhaps more than anything else, of the availability of labour and particularly of technologists and scientists. Clearly, where heavy industries such as coal mines or steel works already exist, they can be and should be expanded, and this provides the first instalment of home-produced manufactured goods. More important, perhaps, it provides the training of the personnel for the larger expansions to come.

The experience of the Soviet Union and China has proved that practically all underdeveloped countries possess industrial raw materials, metals and coal, to a far greater extent than has ever been thought (Table X). For despite the search for profit, capitalist enterprise has usually failed to locate anything but the most obvious strikes (p. 113). A first necessity is, therefore, to carry out a thorough survey, using all geological and geophysical methods, of industrial raw materials. This is necessary in the first place to work out the pattern of the distribution of industrial bases conveniently situated in relation, for instance, to coal, iron and water power. Such surveys are large enterprises. Even now, after thirty years of fairly intensive survey—there are 20,000 field geologists at work in the Soviet Union, more than in all the rest of the world combined—they have most of a continent to explore and they are still finding large new deposits. In China with more limited area but much larger population, the training of geologists was made a first priority; and this has already been rewarded by the discovery of vast new deposits of metals, coal and oil. Until at least a rough survey indicates the position of possible centres it would be a mistake to plan the distribution of industry. Later surveys may discover other centres, but at any rate the outline plan should be based on proved resources.

The making of the plan is in itself an enormous and urgent task which cannot wait for the complete results of the survey but must be worked out while its first stages are already in action. Planning now, however, on a national or even continental scale has, since the time of the much derided but epoch-making first Five Year Plan of the Soviet Union, become almost a profession. It is even possible sometimes to avoid old mistakes. The second Five Year Plan of India was drawn up in outline under the guidance of the great Indian statistician Professor

TABLE X

ESTIMATED NATURAL RESOURCES OF VARIOUS COUNTRIES

Country	COAL		WATER POWER		CRUDE OIL		IRON ORE*	
	Total Reserves: Proved and Probable (Billions of Metric Tons)	*Thousands of Tons per Capita*	*Gross Capacity in Millions of Kw at 100% Efficiency at Mean Flow*	*Kilowatts per Capita*	*Reserves in Billion Metric Tons*	*Tons per Capita*	*Reserves in Billion Metric Tons*	*Tons per Capita*
U.S.A.	1303	7·8	87	0·52	4·1†	24	6·9	41
U.K.	171	3·4	1	0·02	—	—	3·8	75
U.S.S.R.	8670‡	43	340	1·70	1·0§	5	35‡	175
France	12	0·3	8	0·18	—	—	6·6	150
W. Germany	224	4·4	4	0·08	—	—	1·5	29
Japan	10	0·1	27	0·33	—	—	—	—
India	65¶	0·2	35††	..	—	—	21	54
China	1500‡‡	2·5	500‡‡	0·83	5·9**	10	12**	20

Source: Statistical Yearbook of the World Power Conference, No. 8, London, 1956, unless otherwise stated.

Notes: * *Survey of World Iron Resources*, United Nations, New York, 1954.
† *World Oil*, 15th February, 1958 (30·4 billion barrels).
‡ *Soviet News*, London, 6th December, 1957.
§ *Economic Applications of Atomic Energy*, United Nations, New York, 1957.
¶ *Statistical Yearbook of the World Power Conference*, London, 1948.
** *Peking Review*, 6th May, 1958.
†† *Electric Power in Asia and the Far East 1951 to 1955*, U.N., Bangkok, 1957.
‡‡ *China Reconstructs*, Peking, April 1958.

Mahalanobis, with the advice of Russian, Chinese and even American planners, whom I saw working in great amity together some years ago under the palm trees of Calcutta.

Once an outline plan exists, which lays down the general distribution and rate of development of industry and the provision for agricultural improvement, it is possible to go further to improve other facilities, particularly transport. At the same time the immediate needs of the population can be met by short-term improvements in agriculture, incidental on the end of a feudal land tenure system, and the stimulation of consumer goods industries such as textiles, which had been usually depressed by the import of foreign goods.

The difficulty at this stage, one which has been especially severe in India, is that once the purchasing power of peasants has been slightly raised by lessened exploitation and improved agriculture they demand the consumer goods they have always wanted but could not afford. The increased demand for consumer goods in turn makes their production the most profitable form of enterprise, and in a free-enterprise system this results in a pressure either to import consumer goods or machinery for manufacturing them. The building of a consumer goods industry where capital is short can only be to the detriment of the building of heavy industry which cannot expect to be profitable for a number of years. The attempt to meet this difficulty by stimulating handicraft industry can only be in the nature of a stop-gap though it has been adopted in China and India. There is an abundance of labour and skill in such countries, but inevitably the handicraft production is very much more expensive, however low the standard of pay or gain of the individual handicraftsman.

The only hope of a balanced and efficient system is to press on with the second stage. This is the stage of building up basic industries and large-scale projects. And here the full advantages of the planning can be realized, because it is possible to work nearly always on multi-use projects which combine, for instance, flood prevention, irrigation, power production, and navigation; or coalmining, steel production, and fertilizer production. It is just these kinds of projects, which at this stage cannot be undertaken by the technical resources of the underdeveloped countries, that give rise to the heaviest demands on foreign capital. Here there is a serious danger that the costs may be excessive, especially in the case in which the government of the country concerned puts itself entirely in the hands of foreign experts with the backing of foreign companies. This method not only costs more but is of far less value to the country than the highly economic methods practised by the Soviet Union and China

The main difficulties of industrialization are at the start, when neither equipment nor trained personnel are available from within the country itself. It can end only with the development of an independent metal, engineering and particularly machine building industry. This period

which even in favourable circumstances may last at least ten years, is the most difficult one in industrialization, because it is then that the investment is a maximum—that is, more material and labour is going into non-productive uses, and returns have not begun to come in. Such periods, therefore, put the greatest amount of economic, and consequently political, strain on the régimes under which they are carried out.

We have seen examples of this both in Asia, particularly India, and in Europe, in Poland and Hungary. There is always an extremely difficult decision that needs to be made about the rate of industrialization and consequently the rate of investment. Under conditions of severe strain, such as occurred in Russia just before the Second World War where it was essential to build up industry for military purposes in defence against Hitler, investment may be at the effective rate of something like 25 per cent—that is, only three-quarters of the available manpower and resources can be devoted to agriculture and immediate production, and this involves a definite lowering of the standard of living. Too slow an investment, on the other hand, results in postponing the return from the investment to an indefinite future, a generation or more away. This lowers the popular interest in these schemes and the possibility of making use of the willingness and enthusiasm of the people to put them through.

It is very difficult to avoid both these kinds of mistakes, and there is a tendency to waver violently from over- to under-investment and back again according to particular temporary stresses and strains. The economy in most countries undertaking an industrialization programme is based at the outset on agriculture, and their people are usually living in a condition of marginal agricultural production, unable to store surpluses to carry them through poor years. A year or two of drought may wreck many promising programmes. This danger can only be obviated if the units of planning are sufficiently large, so that the risks can be spread, and a bad harvest in one part balanced by a good harvest in another. This should be the case in large countries such as the Soviet Union and China, and to a certain extent in India. This was certainly not the case in smaller countries of Eastern Europe, and here, as is now evident, mutual aid and dependence on countries with agricultural surpluses is the only answer.

There is nothing intrinsically wrong with a high rate of basic industrial development, but to carry it out without hardship or crises implies a much more peaceful and co-operative world than we have been living in for the last thirty years. Capital investment can be covered by long-term loans, and difficulties about food production by purchase of surplus food. At the same time the industries would no longer need to be diverted, as they have been so often and still are, by having to produce military equipment. As long, however, as the maintenance of strain and the deliberate creation of difficulties in the economy of foreign countries

is a matter of international policy with the object of bringing down their governments by their own internal tensions, that is as long as the Cold War lasts, we cannot avoid this, and must expect things to proceed as they have in the face of great difficulties.

The third stage, which is now fully reached only in the Soviet Union, but will be in China in some ten years' time, is that of the expansion on the basis of an already established heavy industry which can now proceed at the same time in various directions. A first claim is for the building up of consumer goods industries on the most modern basis, and here there is a great advantage in waiting until more or less automatized plants can be directly installed and the industry is not cluttered up with obsolete machines, as are, for instance, most of the factories in Britain. Fertilizers and implements can flow into agriculture and raise yields; heavy plant can be turned from construction of large enterprises to make houses, the demand for which is a first priority, and rapid advances follow. Moreover, after all that, there should be a surplus which can be used to help the development of other non-industrial countries.

As not all countries are likely to enter the phases of development together and as they will not proceed at the same rates, in a reasonable world, there should be from one or more areas at any time, at any stage, the flow of goods, particularly of capital goods, which should allow for fairly continuous employment in the older industrial countries for some decades until all countries have reached the present industrial scale (p. 257). At the same time some will have gone beyond it into the full utilization of the new scientific industrial revolution.

After this brief review of the stages of industrialization we can return to the question of the role of foreign aid in furthering this process. As I have indicated (pp. 109 f.) the whole idea of investing in industrialization of a backward country is contrary to the traditions of capitalism, and the one exception, Japan, only serves to prove the rule (p. 116). Not only did the old imperialist countries deliberately not promote it in their colonies, but after more than a century of good neighbour relations with the United States not a single substantial industrial base has been set up in Latin America. Now, however, that some of the underdeveloped countries seem set on industrializing, something is being done to help them, if only to forestall other help which might come from Communist countries. Thus we are witnessing the development side by side and often in the same country of contrasting methods of investment and aid from capitalist and socialist economies.

The capitalist method, slightly modified from the old colonial days, consists of setting up the plant, nearly all of it produced in the parent industrial country, on its new site under the direction of experts and workmen taken from the industrial country and employed at wages similar to those which they received at home, usually vastly greater than those prevalent in the country itself. The general management of the

plant, whether factory, foundry or mine, remains in the hands of foreigners, and nationals are for the most part employed at very low wages in the more manual work. Even where contracts for nationalized industries are given out to foreign firms, there is a natural tendency to include the maximum rather than the minimum of expensive imported equipment, and to employ highly paid foreign staffs to supervise its installation and subsequent working

There is a continual struggle as to the type of employment of skilled and semi-skilled workers and foremen. From the company's point of view it would clearly cut costs to employ nationals for these posts, and even to train them for it, but this has always been resisted by the European staff who often, particularly in South Africa, have enforced their privileges by strikes and political action. There is also the danger that if the nationals really learnt how to run works in practice they would set up some of their own. And this, in fact, did happen to a large extent, even during the British administration, in India, though mostly in the consumer goods industries.[1]

The profits of the foreign enterprise naturally go to the capitalists or the shareholders situated in the parent country; it is also usually stipulated that these should be paid in the currency of that country. Against this a certain rake-off is usually allowed to the local government, if it is nominally independent, in the form of shares or bonuses, as well as an indefinite but probably small amount as bribes to officials. The granting of independence has, indeed, usually accompanied the demand for open or tacit guarantees that these positions of foreign enterprise should be respected.

The relatively small amount of American capital that has been employed in setting up industries in underdeveloped countries is explained by the extremely stringent conditions which are demanded for such investments. In one case these were: that all the preparatory site work should be done free by local labour, as, also, was to be the training of the unskilled and semi-skilled labour force; that all the management and key personnel should be U.S. citizens paid at U.S. rates of pay; that all profits should be exportable in dollars; and that, finally, there should be a guarantee against oppressive labour conditions, that is oppressive to the firm, as well as against nationalization. It might be difficult to see what the people of the country in which such factories were put up would gain from it, but, though they would clearly be exploited, they would at least be employed and paid. For in default of capital it was not possible even to do this in view of the chronic unemployment which is the lot of all underdeveloped countries. As a matter of fact this system has not spread very far, not because it was unacceptable to underdeveloped countries, but rather because it did not prove profitable enough to attract much private American capital.

[1] The one significant exception was the first steel works in India set up by the cotton millionaire Jamshetji Tata in 1907. No British firm was interested.

The whole pattern by which new industries are to be set up in underdeveloped countries is, however, likely to change radically as a result of the initiative taken by the Soviet Union and other Socialist countries, in Eastern Europe. Unlike the United States, they have at present extremely little disposable capital for foreign investment, but they can make it go much further. This is fundamentally because their interests in making such investments are different. In the first place they are genuinely anxious to see all underdeveloped countries industrialized. Their socialist theory is here directly opposed to that of the Manchester school which considered that the natural division of the world was into manufacturing and raw material producing countries. Instead, they wish to see a world composed of a number of socialist countries or regions, each industrially and agriculturally independent and trading in both manufactured and raw materials alike, for convenience rather than necessity. This policy is the one which has been practised in the last thirty years in the Soviet Republics of Central Asia and Transcaucasia, which are now well on the way to full industrialization.[1]

In the second place, the Soviet Union or other socialist countries in making a loan do not require the maximum return on that capital. It has not been the principle that they have used in internal development, where it would certainly have paid them to develop consumer goods rather than heavy industry. The object of Socialist aid is to make the minimum of capital provide the maximum industrial potential in the country it goes to, without any injury to its economic independence. The general long-term objective is the building up of a prosperous socialist sector of the world, able to stand on its own feet, and free of any dependence on capitalist interests.

Soviet aid on the largest scale is being given in China, where I have been able to see it first hand. In the first five years of the Chinese Republic some two hundred Soviet enterprises have been set up in this country along the following lines: the finance is by means of a 10–20 year loan at low interest, usually 2 per cent, and payable in the goods of the country and not in hard currency. While the preliminary work is being done, the future management and the key workers are taken to the Soviet Union, where they work in similar plants pending the construction of the plant in their own country. This is carried out almost entirely by local workers and engineers with a very few technical advisers from the Soviet Union. Only the minimal elements of plant and

[1] The Central Asian Republics of the Soviet Union, for instance, have highly developed cotton and silk industries, but have also opened up many mining and metallurgical industries, producing 6 million tons of coal and 200,000 tons of steel. Industrial employment is now over a quarter of a million and has more than doubled in the last decade (*U.N. Economic Bulletin for Europe*, vol. 9, No. 3, November, 1957). In Transcaucasia, apart from the great oil centre at Baku, there is also a growing engineering industry at Tiflis, with a steel production of 650,000 tons a year. The educational standing of Azerbaijan, Georgia and Armenia is very high.

equipment, which cannot be produced in the country itself, are used. Once the plant is set up, the selected workers return to operate it, and the Soviet experts only remain long enough to get over the teething troubles. After that it is entirely Chinese operated. I myself saw three big steel mills—a rolling mill, a tube mill and a plate mill—set up at the Anshan steel works in Manchuria, an almost fully automated plant, less than two years after erection and with an entirely Chinese staff running them.

In India we can see the picture of three methods of industrialization in the same field being run in competition with each other. The Soviets have exported a complete steel plant to India, rather on the lines already indicated for China; at the same time a British firm is setting up, for the Indian Government, another nationalized steel plant, while American capital is financing extensions of the privately-owned Tata Steel Plant. It will be interesting to see the relative economic success of these enterprises. The evidence so far is that technically the Soviet plant is equal, if not superior, to the other two.

In any case it is already clear that it will be impossible, in view of such Soviet offers, to demand the same stringent conditions as in the past for the provision of capital plant from the Western countries. This will probably almost entirely preclude the use of private capital for industrialization of underdeveloped countries and make it obligatory for the advances to be made either through governments or by international agencies such as the World Bank. The time has passed when such agencies can act only in a restrictive way. The refusal to finance, for instance, the Aswan Dam was the immediate cause of the Suez Canal crisis, and this has served a notice on all the older imperialist powers that they must change their methods if they are not to be supplanted by their rivals.

The kind of investment required by underdeveloped countries is one which, while leaving them free to effect their industrialization with their own nationals at their own rate, will provide them with the machinery necessary up to the point at which they can produce it for themselves. What they would like to have ideally would be long-range loans at low or nominal rates of interest.

It would in fact pay capitalist countries as a whole, though not individual firms, to give their machinery away: to invest, as it were, simply in the future of these countries. For once the standard of living in the latter began to rise and industrialization began to pay off, they would provide an enormous market, not only for further production goods but for consumer goods which could be really afforded by all instead of only by a small wealthy *élite* as they are now. A few gold-plated Cadillacs owned by Arabian sheiks would mean far less to American car companies than if every Arab family had its jeep. Not only would it pay capitalists to help industrialization, but it would pay them all the more, the faster they pushed the industrialization through, for this

would hasten the time when the new consumer goods markets would open which might well be in time to ease the next slump.

Such considerations may, though I somehow doubt whether they will, induce capitalist countries, or rather their bankers, to advise really serious long-term investment in underdeveloped countries as a straight business proposition. Such loans could be secured on the proved natural resources of the country for the purpose of turning them into saleable value. The amount of capital required for most of these is very great and the time of waiting for returns very long. The water power and atomic power resources of India are vast, but for the most part they are quite useless to India today and will be until the equipment for really large dams in the Himalayas themselves and large atomic power stations and concentration plants can be built up. The potential wealth of the Amazon basin of Brazil is also vast—a tropical area with an abundant, reliable rainfall—but before it can be realized the forests have to be cleared and the streams have to be regulated, such a vast capital undertaking that no one has yet been found to finance it. The classical case is that of the Aswan Dam, but here no one knows whether it was politics or business that decided to call off the deal.

The prospects of such loans are on their own merit not very bright; apart from their unattractive interest rates they offend some of the deepest prejudices of rugged individualists. They argue "if these people cannot pay for their development, why should they be allowed to have it? You cannot expect other people who have by their own industry or by that of their ancestors raised themselves above this primitive level, to give their wealth away to help the others out of pure charity". This was the basis of the slogan immediately after the war, directed against Roosevelt, about "no milk for Kaffirs". (The question of providing long-term loans will be examined later from different points of view) (pp. 243 ff).

Behind these vocal objections, which can be heard regularly when the U.S. Congress discusses foreign aid, lies a more serious one which stems from the very nature of capitalism. Created to exploit scarcity, monopolist firms have a reasoned objection to all building up of productive capacity that is out of their control and can thus be used to bring down prices. Oil wells and refineries in foreign parts may just pass, but steel and engineering works are definitely dangerous. In spite of the superficial attraction of low wage rates, it is both economically more profitable and politically less dangerous for American capital to invest in productive industries in reliable capitalist countries such as Britain than in backward India or West Africa.

Against all these arguments there is now a new one, likely to tell much more, and which is already being heard, namely that unless the capitalist powers put up the money, it will be done by the socialist countries, particularly by the Soviet Union. This kind of competition is possibly the only useful by-product of the Cold War, and its benefits are already

being felt from India to South America, where beginnings are being made in the opening up of oil wells with Russian rather than American machinery. Until recently the capitalist world had a monopoly in the means of exploiting natural resources, particularly minerals and oil. Now they have to face a new kind of competition, and not merely that between one oil company and another, such for instance as has occurred in the Middle East where by a judicious use of bribery American interests were able to stir up Persian national feeling to get the English oil companies out and themselves in. The Soviet Union is not concerned with extracting oil for itself or making profit out of its cheap exploitation, but rather with promoting the means of such extraction by providing drilling and refining equipment to be worked by trained staffs of the country itself, ensuring them a larger share of independence and a corresponding weakening of the hold of capitalism.

This is only one example of a new kind of competition that is bound to arise in the next few years in all spheres where capital goods are in request. It may not be profitable in the ordinary way to lend money at no interest at all to such countries, but if the alternative is a corresponding loan from the Soviet Union then the expenditure may come under the heading of military aid, for which there has never been any difficulty in extracting money from taxpayers, and be to the profit of the firms that provide the actual goods. It may, however, take some time before the effects of such beneficent competition begin to make themselves felt, and it can only really fully enter into activity when the phase of military build-up for the Cold War is over and the foreign aid in goods replaces foreign aid in weapons—a consummation which the threatened recession in the United States may bring closer.[1]

Meanwhile the problems of the underdeveloped countries remain acute. Their solution depends on how soon they can set up autonomous industrial bases (pp. 244, 257). Such a base implies, as already mentioned, the ability to produce all the basic raw materials—the coal, the steel, the aluminium, the power—and to possess an engineering industry capable of producing machines, machine tools, vehicles, and heavy contracting plant largely from local raw materials. In addition there is required a heavy chemical industry, capable of processing fuels and producing fertilizers, industrial chemicals, fibres and plastics; a light chemical industry, capable of producing pharmaceutical and photographic requirements; and an electronics industry. In the world today there are only some ten such centres—in the United States, in Britain, France, Germany, Japan, and the Soviet Union—the number chosen may be somewhat arbitrary as it depends on whether for instance, we chose the British-French-German complex based on the North Sea coalfields as one industrial centre or whether on the other hand, we treat the Ukrainian, Ural, and Siberian centres as separate.

[1] *The Sino-Soviet Economic Offensive in the Less Developed Countries*, Washington, 1958.

In whichever way it is looked at, however, there is room in the world as we see it at the moment for about thirty-five such major centres. Some are already on the way to being formed, as in China and India; others, like those in the Congo and Rhodesia, are still in the state of complete colonial exploitation, and will only develop fully when this is removed. There is certainly room for further centres in the Middle East, in North Africa and West Africa, various parts of South America, and in Indonesia, to choose only the most obvious (Map I, p. 247).

The study of the development of modern industry in the last hundred years shows that the setting up of such a centre is a nuclear kind of process—once it has really got going it grows extremely rapidly—and we may take as examples, the onset of modern industrialization in Britain in the 1830's, in Germany in the 70's, in the United States in the 80's and in Japan and Russia in the 90's. The analysis of the production figures of the key material, steel, in different countries (Fig. 4 (a) and (b) and Table **XI**) show how, in every case, once the first million tons per annum has been reached, production can increase at the rapid rate of 10 to 20 per cent per annum, until interrupted by slumps or wars, or slowed down by a policy of restriction, as Britain has been ever since 1880. Each successive appearance of substantial steel works acts as a nucleus to a whole engineering manufacturing centre.

New centres of this sort are now ripe for development, and the troubles of our times can only serve to delay the onset, but they cannot halt the development once it gets started. As electrical power production improves in its range of distribution and even more so when atomic power comes in, the old association between these industrial bases and the coalfields will be largely broken. This does not necessarily mean they will leave the coalfields when they are already established there, but there will be far less need to establish them there in the first place, and bases may be set up where there is no coal or fuel at all, but merely a large population.

One of the problems of the underdeveloped countries in their present state of land pressure is agricultural underemployment, that is for the lack of adequate labour at critical periods it is necessary to maintain between harvest and ploughing a large number of people for whom no work can be found. In the past, before the development of industrialization in Europe, there was handicraft work in the form of weaving, pottery, and metal work, but this has been destroyed because it could not possibly compete with machine-made products. The alternative is to provide industry to occupy these people, and an even larger number

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Fig. 4 (a) shows plots on a logarithmic scale of the steel production of the world and of various countries, virtually since the beginning of the modern steel age. It brings out very clearly the interruptions due to wars and slumps. (The 1957 slump has been omitted for lack of data.)

(b) This is derived from 4 (a) by leaving out all periods of depression in the industry. It brings out more clearly, by changes in slope, the effect of steady restrictions of output. This is particularly noticeable for the United Kingdom.

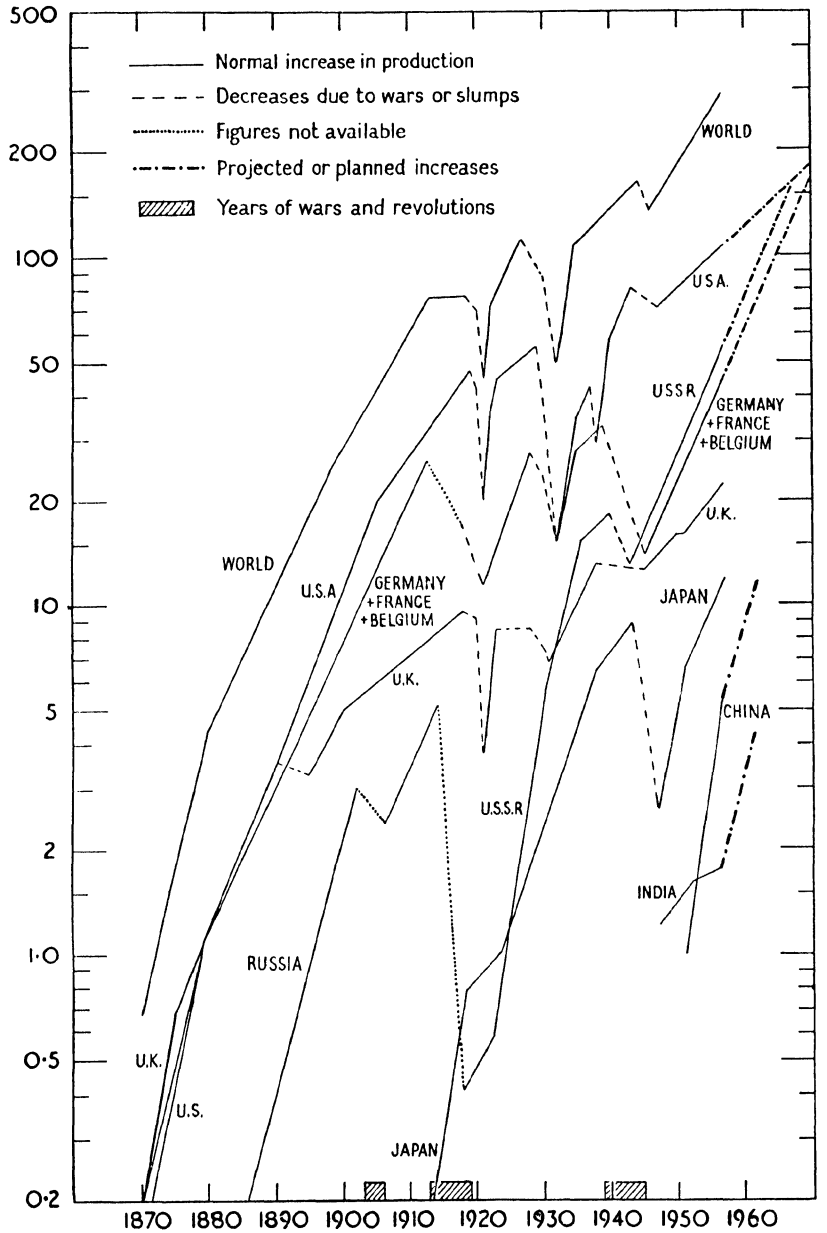


Fig. 4 (a).—Steel Production Trends.

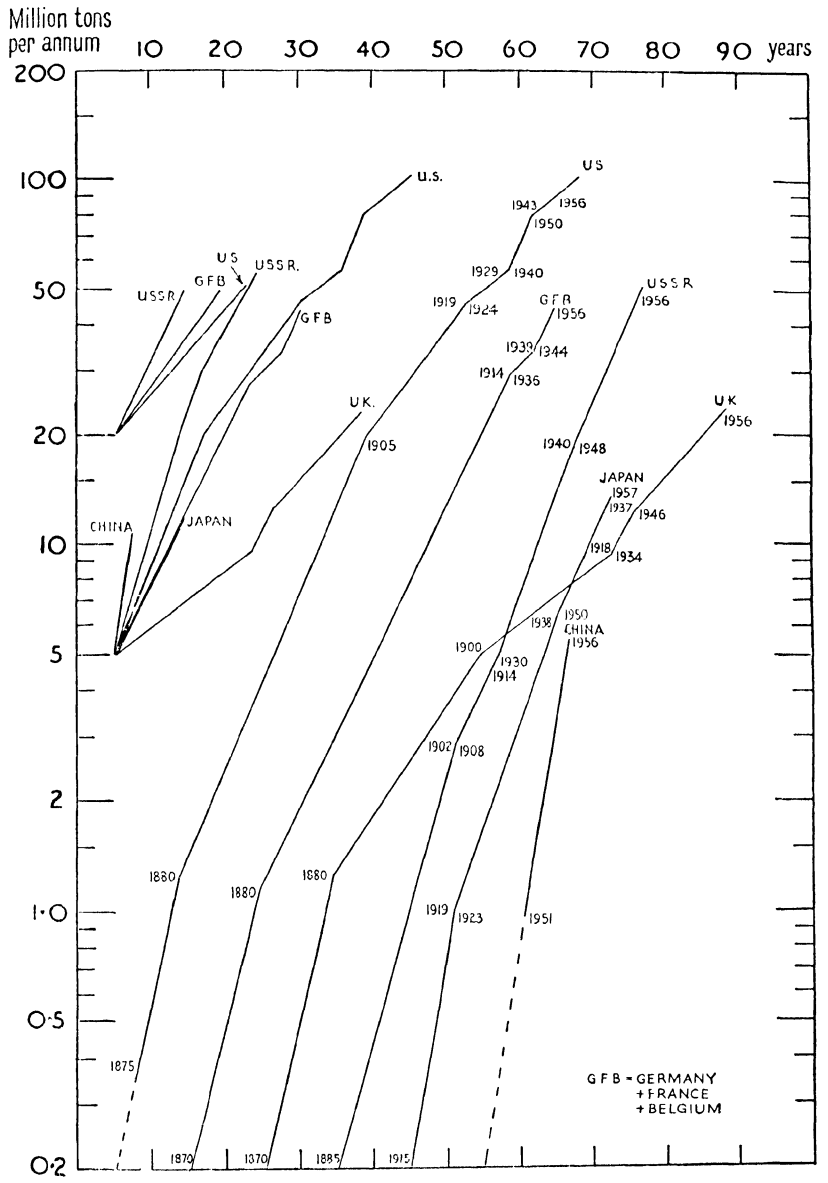


Fig. 4 (b).—Steel Production, omitting years of slump, revolution and war.

TABLE XI

RATE OF INCREASE OF STEEL PRODUCTION

Country	*Year in which 5 million tons was reached*	*Production in 1957 (Million tons)*	*Average Rate of Increase (per cent)*		*Maximum Rate of increase (per cent)*
			Whole Period	*Good Years*	
U.S.A.	1892	102	4·7	6·6	12
Germany, France, Belgium	1894	44	3·5	6·4	10
U.K.	1900	22	2·6	5	10
U.S.S.R.	1930	51	9	13·8	17
Japan	1935	12	4	13·3	16
China	1956	6	—	—	20*

Sources: Statistical Yearbook, 1957, U.N., New York, 1958.
Woytinsky, *op cit.*, 1953.

Notes: * Derived from production in six previous years. Increase of production, 1957 to 1958, is over 100 per cent (p. 294).

that may be displaced as agriculture itself becomes more mechanized. For that reason we may expect to find great new industrial centres in the Indian and Chinese plains, and in such countries as Indonesia.

It does not by any means follow that every underdeveloped country needs to be industrialized in the same way. The achievement of full-scale industrial independence, implying an autonomous power production and engineering base, is only open to countries of a certain size, population, and raw material resources. Even in the older countries of Europe only a few have achieved this degree of autonomy, effectively only Britain, France and Germany, and possibly Italy (though there lack of coal supplies put it in a very weak position industrially).

The other countries in Europe, highly specialized as they are in industry and science—Belgium, the Netherlands, Switzerland, Sweden, Denmark—are effective economic clients, though by no means clients exclusively dependent on any one industrial country. They have taken up certain aspects of manufacture which are complementary to those in the large countries, and which offer special skills and equipment essential to the industries of the larger countries. This may enable nationals, as in the case of Switzerland and Sweden, to attain actually a

Table XI shows, in numerical form, the data from which Figs. 4(a) and (b) were drawn. It can be seen that, while the technical limit to the increase of steel production is from 16 to 20 per cent per annum, the actual rate of increase in capitalist countries is much less, even in periods without slumps.

higher standard of living than the larger industrial countries themselves. Switzerland is an interesting example; quite apart from its advantages as a centre of banking and tourism, Swiss specialization on its precision tools has made it an indispensable contributor to the engineering production of all Europe even in the years when it was divided by war.

The problem of industrializing the small country with the distinctive culture, such for instance as Burma and Ceylon, should be tackled in the light of these solutions. As in Europe, it could become a specialized sub-centre of industry. The alternative is for it to form a part with other countries, small and large, of a jointly planned and operated heavy industrial centre including in its own territory some of its units and sharing the benefits of the others. This is effectively what has happened to the smaller republics of central Asia in relation to the industrial centres of the Urals and Siberia.

What has been proved to have been a mistake is the attempt to create in a country without adequate territory or resources a completely autonomous heavy industry. Costs are multiplied, because here not only machinery but raw materials such as coal or ore have to be imported, and a heavy drain is put on manpower to the detriment of agriculture. It was policies of this sort in Poland and Hungary in the Cold War years that formed the economic background for the political troubles of 1956. Czechoslovakia, which possessed a sufficient industrial base to start with, was not affected. The over-centralized economies have since been modified in the direction of greater mutual dependence between the Eastern European group of countries and despite losses and disorganization it appears that a viable economy can be built up which, while not attempting so much, will achieve more.

It may be, however, that the day of the large centre of heavy industry is itself passing, for whereas it may still be most economic to produce the major basic raw materials, such as steel, fertilizers, and aluminium, in a few large plants, much of the rest of production can be scattered over a wide area, thus avoiding the necessary concentration of people into towns with all the problems that this raises. However, it will be difficult to avoid this concentration for some time to come, because we have not yet found a substitute for cities both in respect to the variety of employments they provide and to their other amenities and the advantages of being near an administrative centre. What drastic action is needed to break up this concentration has been shown recently in the Soviet Union, where the new regionalization plans have abolished some 25 Ministries, each of which controlled the particular industry throughout the Union, and replaced them all by local economic councils covering all industries in forty different regions.

In general it will be desirable to reduce the burden of transport, which is always a heavy expenditure and not likely to get lighter in the era of the expensive motor highway and the aeroplane. In the first stages of industrialization, however, transport must necessarily play a large role,

especially in countries which have considerable, barren or underpopulated territories close to highly populated ones. This is true even in such concentrated areas as India or China. There, as in the nineteenth century in North America, the provision of a railway or a road is the first stage in the general transformation, but the speed these can be built will depend on the immediate availability of capital, particularly in the form of heavy contractors' plant—bulldozers, scrapers, cranes, dredgers, etc. Indeed, probably the quickest means of providing both food and bases for an industry in an underdeveloped country would be massive imports of such plant, which could act as the pioneer corps of old times in opening the ground for further advances. A minimal dose of capital would also produce the largest effects in agriculture in the form of fertilizer and seeds of the better types of crops which are extremely easy and quick to introduce once they are recognized. Large-scale, efficient, co-operative farming must wait for machinery and the trained personnel to run and service it.

All plans for developing these countries—and I have taken some interest in the plans both in China and India, as well as other countries in Europe—foresee a balanced development between industry and agriculture, but it is not always easy to hit on the correct balance. The knowledge that without an industrial base nothing will be possible in the long run tends to weigh the balance in the first place towards industry. But if this is overdone, or, as is quite likely to happen, if unforeseen meteorological influences, droughts or floods, supervene, it is necessary to switch back to intensified agriculture. We have yet, in spite of experience, no really foolproof theory of development. What is required, therefore, is to preserve a very considerable flexibility in planning. But the planning itself is absolutely necessary. Piecemeal developments have been going on in all these countries for fifty or more years, with little overall improvement and with a great deal of unbalance, usually in the favour of luxury goods production for a small class in an ever more impoverished population.

Many problems of underdeveloped countries could be solved at once if they possessed available supplies of raw materials which could be sold at once for foreign currency, that is for foreign goods. The normal exports of such countries are largely agricultural products, often food. To export a sufficient additional amount of these to pay for industrial equipment is, in general, difficult on account of the growing shortages developing in all the pre-industrial countries with increasing populations. Where this has been done successfully, as in China, this is due to a new policy of favouring all methods of increasing agricultural production, as they arise, from local initiative (p. 116 *n.*). Another type of product, that of handicraft industry, is also barred by its prohibitive price in comparison with machine-made articles. Nevertheless, in a rational world it would be possible to do something in this direction by making use of the fact that a skilled population could

carry out the production in a semi-mechanized way of articles requiring a considerable amount of hand-labour, essentially luxury articles, but in quantities which might bring in substantial sums of foreign currency. This again, however, would require organization and capital.

Taken altogether, although it would be possible in an ideal world to finance industrialization by exports, this is very far from the case now, at least within the bounds of the free world. It might seem that an exception to this would be mineral wealth, but this would only be the case if the people can retain for themselves the real value of what they are selling—something which has never before happened in the history of Capitalism. For all the copper of Chile and the tin of Bolivia, there is very little to show for the people in either of the countries. Like the silver of Peru in the old Spanish days, it has sailed abroad to enrich those who never worked for it.

When anything of real value can be produced in a backward country, it is almost invariably found that it is already the property of the exploiting companies and little of it is used for internal development. When it is a question of giving up colonies, those which yield valuable products such as metals, and cash crops such as rubber are the last to be abandoned. Notice the difference in behaviour of the British government with respect to India, which has no valuable raw materials, and to Malaya which has. Malayan tin and rubber are still the important though somewhat insecure supports of sterling. The one outstanding exception is oil which can be disposed of most profitably; that is why in principle there should be no difficulty in raising the standard of living in the Middle East, for instance, more rapidly than anywhere else. In practice, however, it is very well known that the standard in the Middle East is almost as low as any in the world, and that the royalties paid for oil go into the pockets of rulers or governments officials who find it more convenient to invest them in foreign securities than to use them to help their fellow citizens.

An oil engineer remarked to me many years ago: What had California got that Iraq had not? Sunshine, water, oil, and yet why was it that the inhabitants on the banks of the Tigris were much worse off than their ancestors in the Garden of Eden, while the Californians enjoy what was probably the highest standard of living in the world? The answer is that the wealth produced in California stays there, together with much additional wealth brought there from elsewhere; whereas that which is produced in Iraq is nearly all exported. The Iraqi people showed in July 1958 that they could no longer tolerate these conditions.

If this kind of exploitation could be ended, some, at any rate, of the poorer countries would be able to finance their development out of their own resources by immediate cash payments. This would happen if, for instance, instead of giving oil concessions to foreign firms and letting their oil be sold at an enormous profit in which they do not share, the peoples of these countries were to organize the extraction of the oil

themselves. They could at first hire only the technicians to do the necessary drilling and refining, and later acquire sufficient skill to do both of these themselves (p. 123). The fear that this might happen stimulates much of the concern of the Western Powers about Communism in the Middle East. For practical purposes Communism means using the resources of a country for the benefit of the people in it, and this, rather than any fear of Marxist theory or Russian invasion, is the major dread of the oil companies and their backers.

Most underdeveloped countries, however, have no oil deposits or have not yet found them. They may be driven to the hard choice of being obliged, without recourse to foreign capital, to acquire foreign currency for imports of machinery. It may be necessary to distort the economy in a direction which is not one to give the maximum increase of the standard of living of the people. In the Soviet Union, for instance, during the 1930's, grain was exported at the very low prices of the slump, at a time when it was badly needed in the country, to buy expensive machinery required for the industrialization. The poorer a country is the less likely it is to be able to retain or sell profitably the few available resources it possesses. A pathetic case to illustrate this can be cited from India. That country, with its vast and largely useless population of cattle, is the biggest producer of bones in the world. These bones are at present bought and shipped to the United States where they are boiled down for glue to make some varieties of candy—Indian soil, poor in phosphate, being still further robbed by this process. It would be perfectly possible, given the capital, to set up factories in India which would preserve the phosphate and either keep the glue or sell it at a good profit.

By and large, it is far preferable to finance industrialization by long-term loans than to depend on trade, except where covered by long-term agreements at fixed prices. Nevertheless, trade has a very important part to play in development, and the planning of international trade, making every use of the preferential cost of production from one place to another, is one of the practises that can be carried over from the period of capitalism to advantage. However, in the years since the war there has been no real possibility of such free trade between the socialist and capitalist countries on account of the embargoes on metals and machinery, imposed ostensibly for military reasons. Actually this has been done to hinder by every means available the economic development of the socialist countries, with the hope that the resulting strain would provoke a breakdown. Nor have other countries like India been much better off, because of the scarcity of substantial loans except for military purposes or at least in return for military alliances.

The schemes that are being tried today to form common markets and other trade devices inside the industrial countries themselves are not likely to be of general benefit, however much they may help German capitalists to dominate those of France or Britain, because essentially

all those countries are producing the same kind of goods and consuming the same kinds of raw materials from outside their common boundaries. What is necessary for fruitful trade between old industrial and newly industrializing countries is a planned change-over of trade from the old-fashioned exchange of consumer goods for raw materials, first to one of producer goods against raw materials, and then of producer goods against semi-finished materials, There may be a good case for the development of the easily installed and operated mass-production industries of the type of textile and motor vehicle production in the new countries for the first few years of industrialization, leaving the older countries to develop still further the highly specialized and new industries of atomic energy, electronics, and precision engineering.

Such a general tendency will certainly make itself felt within the next few decades, but it might be very well to plan its incidence in advance to avoid the trade wars which would follow its casual introduction. The period is rapidly passing in which trade can be conducted between individual merchants. The relative bargaining power of the big capitalist trusts against all other traders has in any case made this a most unfair arrangement. Even where farmers, for instance, are free producers they are in no position to bargain against a company that buys the whole crop and sells it at its own price abroad.

We are entering a period of State trading. Even in the United States the Federal Government, through its controls of surpluses and aid allocations, can control the economic development of most parts of the "Free World". Only when arrangements can be made over reasonably long periods at guaranteed prices is some kind of budgeting possible, and without budgeting there is no possibility of forward planning. It should be also evident that it is quite impossible to carry on the internal development of a backward country without some form of economic control and socialist planning, and indeed even in India, where there has been the least break with the capitalist forms, this is in fact being done. The reason for this is that the units of modern production are large and tending to grow larger and that, especially in a country which has not a long history of industrialization and therefore does not contain much locally accumulated capital, only the State can afford to finance such enterprises.

I do not propose to comment on the internal and administrative problems of developing countries. In the first place this would take far too long, even in the form of a factual survey, whereas criticism is out of place in operations in which the essential feature is that it shall be done by the people themselves. In many such countries there is a legacy of colonialism, which is not only shown in its negative features, namely the absence of a suitably trained people, but in the effective freezing of old forms of religion and customs long after their utility of social inspiration and culture has disappeared. This is not necessarily a deliberate action on the part of the colonial powers, but is very often, and

this applies particularly to the religious aspect, due to the attachment of the peoples themselves, who find in these forms the only way to resist cultural absorption by the foreign power. But once that power has released its hold, however partially, the old forms can become in their turn brakes on advance and give rise to internal struggle and strain.

These restrictive factors can be overcome only by the impetus of an independence movement, one pledged to escure economic well-being for all, through the efforts of the people themselves. We are indeed now witnessing in different countries—not only in Burma and India, but also in Indonesia, Egypt, Tunisia and Ghana—how the process of internal liberation is effectively working out. In view of the general political state of the world, it is in fact a miracle that anything can be done at all, for far from receiving assistance, for the most part the new states have had to work against open or concealed hostility from the old colonial powers. They also suffer, and this is often just as bad, from compromise liberation settlements, which secure the property and interests of the nationals and the companies of the former colonial state in such a way as to make rational and particularly socialistic planning impossible. This was the intolerable situation which has only recently been put an end to in Indonesia at immense cost and after a destructive civil war fomented from abroad.

One of the basic difficulties, for instance, in securing investments from capitalist countries is the requirement of some guarantee against nationalization. If the country gives the guarantee, it is no longer master in its own house, and its plans for remodelling the economy of the country have to work against the pressure of cheap consumer goods from abroad and the continued payment of profits in foreign currency. If, on the other hand, it refuses to give such a guarantee, it has to face an absolute blockade of capital and often of other services.

Nevertheless, the process of economic and political liberation goes on irresistibly. It is driven on to further stages once it has already started and the example of what has been done in the countries that were first to achieve some degree of liberation is already putting great pressure on the remaining colonial powers, which sooner or later will have to relinquish their hold and let the peoples of the countries look after themselves. It is often said that they are naturally incapable of doing this, and certainly every precaution was taken in imperial times to see that this should be so by severely restricting their educational opportunities to the lower grades required for minor administration. Even this difficulty can be and is being overcome, as we shall see in Chapter X devoted to the question of the training of personnel.

In conclusion it may be said that the problem of raising the level of the standard of living all over the world to that of the most advanced countries of today is not only technically but also economically feasible, that is, the capital needed for the transformation in the form of raw

materials and machinery exists in a usable form. Further it could be made available without any loss to the people of industrial countries provided that the burden of military preparations was lifted from the backs of their people. Basically, we can see that this should be to the advantage of both the underdeveloped and the other countries. Many of those who are most concerned with preserving their standard of living do not realize that by trying to keep down the underprivileged people of the world they are doing more to endanger that standard of living, both by increasing the risk of war and by inviting slumps by limiting markets, than if they came into a general scheme of mutual help, first to give the others the advantages which they have had themselves, and then to enjoy with them a common prosperity.

VIII

ECONOMIC PROBLEMS OF INDUSTRIAL COUNTRIES

In the last chapter we considered, primarily, the methods by which countries on the pre-industrial economic level can be raised to an industrial one. But as indicated there, this is extremely difficult to do without assistance from the already industrialized countries. I have tried to show that this assistance will also be of great value, in the first place, in helping the further progress of those industrial countries by providing them with a stable market for the construction of producer goods and, subsequently, for building up a much larger market than has hitherto existed for consumer goods and other specialized producer goods. In this chapter, I want to examine a little more closely what this will mean to the industrial countries both in the capitalist and socialist sectors. In the next chapter I will be dealing with the special case of Britain in more detail.

The present state of technical and economic development of the industrial countries marks a decisive phase inside a general transformation, a phase which in many respects is critical, that is, one in which the intrinsic technical and economic developments are of a kind that do not permit return. Three features characterize this present phase: they are *the scientific-technical revolution*; *militarization*; and *the upsurge of underdeveloped countries*. The *first* of these, the scientific-technical revolution, has already been discussed in earlier chapters. It differs from the original Industrial Revolution in the far greater part science plays in it. It is characterized by the appearance of atomic energy and of automation in industry, and is of equal, if not greater, absolute importance than its predecessor in changing the whole method of production, not only in manufacture and transport, but in every form of human activity. This has, however, been very largely held back and diverted by the effects of military requirements, the *second* characteristic feature of our time. This century has been a century of wars and revolutions, and as its political divisions appear to accentuate, more and more human energy and ingenuity is given to the preparation of military weapons and their accompanying equipment, together with the vast factories required to produce the fissile materials, bombs, and rockets. It is true that it is unlikely, at least in Capitalist countries, that atomic power would have

been developed except as a by-product of nuclear weapons. Nevertheless the need for nuclear weapons is at present the major factor holding up the further application of atomic power for civil uses (p. 166).

It is by no means only for political reasons, that is, as a consequence of the division of the world into two economic and political camps, that this militarization has occurred. Militarization has proved to be an essential feature of capitalist economy in the period following the economic crisis of the thirties, and much more so in the Cold War period. Military expenditure has been invoked to solve one of the recurrent problems of capitalist economy—how to keep up profit from production without at the same time flooding the market with useful goods. The answer, as it appears in practice, is to produce useless goods. And from this point of view weapons are not only useless but have the additional good quality of becoming rapidly obsolescent, so that however many are made, even larger numbers are soon required.

Production of weapons, indeed, satisfied Maynard Keynes's idea for maintaining profitable production in times of slump, of putting bank notes at the bottom of mines, filling them up, and then paying miners to dig them out again. Although no reasonable government would follow this advice, the far greater absurdity, of constructing aeroplanes that fly only to burn up petrol, are replaced by other faster aeroplanes, and then by even more expensive rockets, can be sold to the public as a defence against the very terror weapons that are being produced. However that may be, the increasing military sector of capitalist production has a far greater technical and economic effect than its size, great as it is, would indicate. Its effects on the development of science have already been dealt with (pp. 20 ff.) and its most serious consequence in maintaining world tension and perpetuating world poverty will be discussed later (pp. 216 f.). We will return to it in this chapter in linking the question of disarmament with the reopening of world trade.

The *third* major feature of the modern industrial situation, the upsurge of the underdeveloped countries, is a reflection of the marked unbalance between the rate of advance in the industrial countries and those in the rest of the world. This is another aspect, the dynamic or differential one of the disparity, already mentioned (pp. 25 ff.), of the standards of living between the two parts of the world. Figures shown in Table XII, p. 140, indicate the rates of increase of productivity, total production and consumption of the average person in various countries ranging from the United States to India. It will be seen that where the advance is greatest, in the United States, it amounts probably to a rate of advance greater than any achieved in human history. In India, on the contrary, instead of an advance we have had a recession, a gradual impoverishment, only just reversed by the measures of the Indian Government in its First and Second Five Year Plans.

Now this unbalance is a natural consequence of capitalist economy and, if unchecked, would inevitably get greater and greater. This is

TABLE XII

Indices of Industrial Production and Consumer Expenditure

1938 = 100

Country	Index of Industrial Production		Index of Industrial Production per Worker*		Index of Industrial Production per Man Hour†		Index of Private Consumer Expenditure at Constant Prices	
	1948	1956	1948	1956	1948	1956	1948	1956
U.S.A.	217	288	141	166	125	145	153	201
U.K.	117	158	119	149	119	149	99	115
U.S.S.R.	150	470	120	274	..	..	110	220
China ‡	..	205	..	150	..	..	..	113
India	114	177	86	116	84	112	..	..

Source: Mainly *Statistical Yearbook 1957*, U.N. New York, 1958.

Notes: * This index has been obtained by dividing the index of general industrial production by the index of employment excluding agriculture.

† This index has been obtained by dividing the index obtained in the previous column by an index derived from the average hours worked weekly in manufacturing industry.

‡ 1952 = 100

because the profitability of investing money in firms in the advanced countries, making products which can be rapidly sold at high profits, is far greater than most investments in the pre-industrial ones. For there, except in oil and mines, great investments have to be made for some considerable time before returns can be expected. Foreign investment has been a method of exploitation, rather than of assistance to backward countries.

In the limit, it would result in the advanced states, particularly the United States of America, getting so rich that the rest of the world would consist of beggars whose only means of subsistence would be charitable distribution of food from the American citizens themselves. Such a situation has not yet occurred on a large scale, but it has a precedent in the treatment given to the former masters of the North American Continent—the Red Indians. Some of the very last tribes were herded on to totally unproductive reservations where there was nothing for them to do, but they were charitably fed on the carcasses of slaughtered cattle to make up for the buffaloes they could no longer hunt.[1] This logical nemesis of human equality could only happen in the absence of sufficiently strong countervailing factors. However, there are such factors and they are growing rapidly growing in strength.

First of all there is the growing determination of the peoples of the unindustrialized countries to change their state of dependence and inferiority, even to the extent of offending their former colonial masters, and secondly, and possibly more important, there is the existence of an ever-growing socialist sector of the world, now fully equipped industrially and advancing, technically, even more rapidly than the capitalist sector. The effects of these factors on the underdeveloped countries themselves has been discussed in the last chapter; here we have only to consider them in relation to the other features of technical revolution and of militarization in assessing their effects on the economy of the industrialized countries both capitalist and socialist.

In the capitalist sector there have, indeed, been marked changes in the last few years, more specifically since the outbreak of the Second World War in 1939. An obvious feature has been the welcome one of the apparent flattening out of industrial crises and of some approach to full employment. This is most marked in countries such as Britain and France, which lag somewhat behind in the path of technical development, but even in the United States the situation seems still far from critical. There are now (June, 1958) some five million unemployed there, but this is out of a working population of some 68 million, or 7·2 per cent, as compared to the British figure of 440,000 unemployed, or 2·0 per cent of the working population. At the same

[1] The situation of their surviving descendants shows what happens in a capitalist society to those who have little effective demand. The average income of the stateless North American Indians is less than a fifth of that of United States citizens. (Letter, *New Statesman*, 5th April, 1958).

time, although there have been about three or four alternations in the rhythm of production in the capitalist industrial countries since the war, the U.N. index of industrial production of the world[1] (exclusive of the U.S.S.R., Bulgaria, China, Czechoslovakia, Hungary, Poland, Rumania and the German Democratic Republic) never fell, though it remained constant in the years 1948–1949 and 1953–1954. Its greatest annual increase was 14 per cent between 1949 and 1950, as compared with an average of 5·2 per cent. It must be remembered that all these figures refer to the somewhat abnormal situation of recovery from a major war.

Until the opening of this year, 1958, there had been no sign of crises or mass unemployment in any major industrial country. This has led the naturally unthinking people to assume that the problems of Capitalism are solved. Actually, this was also generally the view before 1929. The speeches of President Eisenhower in 1958 seem echoes of those of President Hoover in 1929. Whether or not the optimism of the Republicans of our day is justified remains to be seen. In both periods it may be noticed that though production only fell slightly, productive capacity had greatly increased, so that the proportion of unused capacity grew to nearly half even before any crisis occurred (p, 293).

Whatever may happen now, it is still important to examine why two decades that could have seen two crises have passed without them. True, we have had two wars, one of major importance and the other not so minor, just when crises might have occurred in 1939–45 and 1950–2, and a far greater amount of armament production over the last twelve years than has ever been known in peace-time. The repair of the damage after the Second World War was a major industrial undertaking. So has been the first stage of the transformation of mechanical and chemical industry towards automation. Finally there has been at least some capital investment in undeveloped countries. This last point is the weakest of the three, because, as has already been discussed (pp. 109 f.), the investment in these countries has depended mainly on the profitability of the raw materials exported from them. Any serious falling in the demand in the central industrial countries will react, and is in fact already reacting, on this, as is shown by large falls in prices and a corresponding weakening in the purchasing power of the poorer countries, in a way very similar to that that occurred before the great crisis of the thirties. There is a critical level which must be passed before such a falling off of demand provokes a chain reaction and brings about a general cutting down of production. We seem to be rapidly heading towards this level. Nevertheless it is still maintained by official economists that there are sufficient financial devices in reserve to stave off this evil day.

We are not here, however, really concerned with predicting at which point in the oscillations of the trade cycle such a drastic collapse would occur, or even whether it would occur at all. The major point that needs

[1] *Statistical Yearbook, 1957*, U.N., New York, 1958.

to be made here is that industrial production in capitalist countries has a possibility of very considerable expansion, one that has exhibited itself to the full only in times of war, but could be stimulated at any time if effective demand could be created. In other words the facilities for the rapid industrialization of the rest of the world are there, it is only a question of how they can be released. The very existence of large unused capacity for steel production without even building new plant shows how immediately available these facilities are.

Another weak point in the capitalist economy today is the saturation of the domestic market with durable capital goods—motor-cars, refrigerators, etc.—and the necessity to apply more and more sales pressure, advertisement, and credit offers to dispose of them. With this, but only in the United States, there is a corresponding problem of agricultural surpluses: how to dispose of the food and cotton bought by the government at prices above those of the world market. The combination of excess productive capacity and failing markets is a classical formula, if nothing else happens, for a depression, but it also offers the possibility of the most rapid recovery in a period of directed transformation of the economy of the world as a whole.

All these considerations refer to temporary and periodic fluctuation in the actual production of capitalist industrial countries. They do not alter the underlying technical basis of production. If the volume of production falls it is not because the means are lacking to make it rise; it is not a technical but an economic failure. Goods are not made because they could not be made, but because they could not be sold—at a profit. There is no problem here of the capacity of capitalist countries to finance the internal transformation of their industries to full scientific automation. If it is being held up for the moment in the motor-car industry, it is only because it has been too successful. Reuther's wise-crack now has an ominous ring "Can you collect union dues from these boys?' said the boss, pointing to the automatized production lines, "No," said Reuther, "but can you sell your cars to them?"

No doubt, one of the effects of the slump will be to prepare for the introduction of even more automation, in order to take advantage of the next boom, but this will only increase the disparity between production and wages.

The great monopolies that directly or indirectly control the whole of capitalist industry have ample means from their internal reserves not only to remodel but vastly to extend their production so as to be able to provide enough for the whole of the rest of the world. They could easily finance the industrialization of all the underdeveloped countries, if in their judgment it would pay them to do so, that is, if there were not bigger profits to be made elsewhere—for instance, in defending democracy with ever greater deterrents.

In spite of all their power, however, they are not free agents—still less the people that work for them. Inexorably, all their activity—the volume

of production, the rate of capital investment, the flow of development and research—is at the mercy of the state of the market and the estimates of profit margins. It would seem on the face of it that there was something radically wrong here. The new scientific, productive machine has indeed outgrown the financial system that first brought it into existence. If we have bigger capacity than we had dreamed of before, we must have bigger aims. The objects of profits, even big corporation profits, are trivial compared to the real benefits measured in human well-being, that could be poured out if the new methods were allowed to be freely used and developed at ever-growing rate. If this cannot be done because of the laws of economics, then it is about time those laws were looked into. People are asking if they are really laws of Nature or conventions to protect particular interests, and whether in either case they have any relevance to a world of free power and unlimited automation.

On the world scale, or more accurately on the "free world" scale, we have once again the oldcontradiction of the thirties but in a differenet form. Then it was simply "poverty in the midst of plenty". Now it is not so easy to put in a phrase. Essentially it is the presence of *surplus productive capacity* in one part of the world while in the other there is a crying need for just those goods that this capacity could produce, the capital goods that could end once and for all the productive incapacity of the majority of the human race. The very existence of this apparently unbridgeable gap is a source of strain which must be removed in one way or another. In the past such strains have led to war, which did not remove them but led to such destruction that there was a temporary relief in repairing the damage. Another war would certainly produce enough damage, but whether afterwards there would be any means of repairing it is another question. Besides, now that all countries—even the universal supplier of weapons, the United States of America—are vulnerable to nuclear attack, war is no longer a practical proposition. This does not mean that war preparations already built into the capitalist system of production will stop, or that the danger of an unintended or purely accidental war will disappear. It only means that it is less likely that war will be used as an instrument of policy, and that it will be easier for popular pressure to bring forward the alternative of peaceful coexistence, to see if this would provide the answer to the problems of surplus capacity and unfulfilled needs.

The situation of industry in the Socialist sector is quite different. Here the volume of production, though smaller than in the older industrial countries, is increasing far more rapidly, and already has indications of passing even the United States within a decade or so. The rate of capital formation is relatively much greater and in certain fields is even absolutely so (Table XXI, p. 246). But all this has been done at the expense of slowing down on consumer goods and housing. Nor has it been possible, despite great efforts, to keep the rate of increase of agricultural

products up to that of industry. Such an austere economy could be maintained in the times of stress before the Hitler invasion and even during phases of the Cold War, but should be no longer necessary in a peaceful world. One large section, by far the largest in population, of the socialist world—China—is still in a very early stage of industrialization, and a vast added load has been put on the economy of the Soviet Union and Eastern European countries to produce the necessary capital goods (p. 294).

The brake on progress in the socialist sector is capital shortage, rather than lack of markets which are, in fact, altogether in excess of present productive capacities. What may appear in the short run as a brake may, in the long run, be a stimulus to reach far higher productive levels, and this is certainly how it is being taken by the Soviet Union and its partners. Heavy industry in the Soviet Union has long passed the point when it is autonomous and self-regenerating; it has even enough strength to get going other autonomous centres as in China. Nor is Soviet industry so concerned with straight production that it has no time for improvements. On the contrary, it is well advanced already along the road of planned internal conversion to the modern type of scientific industry, mainly by the development of atomic energy and automation, together with increasing stress on scientific agriculture and medicine[1]. These are not left to develop accidentally, but for the last three years in the Soviet Union, special Ministries and sections of the Planning Commission have been set up to further them, with already marked success. Even more important for the future is the fact that all these enterprises are backed by a body of well-trained engineers and scientists which is being added to more rapidly than in all the capitalist countries combined (Table XV, p. 185).

These achievements have for the last few years begun to be recognized, even in circles in capitalist countries who had previously considered the Soviet Union as an industrially backward country and its socialist economy incapable of effective direction or of the development of advanced industry. The capitalists are beginning to see, moreover, that a new world pace is being set by this change; that, unless they themselves can equal it by corresponding transformations in their own countries, the sheer weight of technical and scientific advances in the socialist sector will act as a magnet, drawing peoples first from the uncommitted part of the world and then from their own populations to try to achieve a system of such proved efficacy and prosperity. That attraction has already been exercised by the Soviet Union and China under extremely difficult conditions, and where every effort of propaganda has been used to magnify their shortcomings and create hostility to them. It is likely to be felt far more strongly now that it is becoming apparent that the

[1] N. S. Khrushchev, *Report to the 20th Congress of the Communist Party, Moscow, Feb., 1956*, London, 1956 and "Drafting a long-term plan for the development of the national economy", *Soviet News*, 27th September, 1957.

Socialist countries are not only industrially strong and scientifically advanced, but have also been able to provide for their peoples a standard of life far better than that of all other underdeveloped countries and rapidly approaching that of the wealthy capitalist countries.

It is along this path—working towards a higher standard of living and the attainment of an effective surplus in agricultural production and raw materials—that the economies of the socialist countries are now bent, and despite the strains to which they have been subjected their achievement so far would seem to give some promise that the later stages will also be reached. Once freed by a massive public work programme and extended agriculture from the danger of natural crop failures or disasters, and guaranteed by a reasonable peace settlement from the persistent threat of war, the advance will be far more rapid.

If we examine side by side the present position of the capitalist and socialist industrial countries it will be seen that in the field of technology they are both in volume and quality of production essentially similar, and both are partaking vigorously in the transformation towards the new atomic-automatic pattern. Economically, however, they are in very different situations. The socialist sector, though growing more rapidly, is still much smaller and has the greatest difficulty in meeting industrial demands and those for consumer goods at the same time. On the other hand, the larger and wealthier capitalist sector has unused productive power and has to hold back its expansion because it cannot find markets for its goods.

This is not because such markets do not exist. Besides the rapidly industrializing socialist countries, there is the even larger sector of former colonial territories that are shaking themselves loose from the political ties of capitalism. It is clear from what is going on today, that their first immediate prospect of industrialization will come from the joint efforts of the socialist and capitalist countries, in ways which will be discussed later (p. 243). But this can only happen when the antagonism and military threats of the Cold War are at an end. It is indeed, as we shall see in Chapter XII which mainly deals with this subject, the attachment of monopoly interests to the maintenance of arms production and of the Cold War that remains the chief obstacle to the full use of the industrial capacity of the world for useful purposes.

It is, however, no advantage to any sector of the peoples of socialist countries to maintain the present Cold War. Hence their repeated stressing the need for peaceful co-existence. But it is precisely in their demand for it that capitalist governments find another reason to refuse to consider it on the simple ground that what is good for the Communists must be bad for them (p. 220). There is also the hope, which has been preserved and cherished in certain circles consistently since 1917, that if the socialist world can be sufficiently isolated and deprived of any external assistance, its own internal tensions will disrupt it and allow capitalism to resume its sway.

To pass from the divided and frustrated world of the present day into one in which the potentialities of the new technology can be fully used, involves a parallel transformation of world economy and internal national economies, particularly in the industrial countries, for the industrialization of the underdeveloped countries is in itself a world problem. We have to examine how the former would be affected by any serious and common effort to raise the world standard of living; in particular, how a different attitude towards economic dealings with underdeveloped countries would affect the old centres of industry.

This has been discussed in Chapter VII from the point of view of the underdeveloped countries and much of the argument need not be repeated here. The conclusion reached was: firstly, that such countries needed outside help in the form of capital goods to set up their industries to the stage when they became self-regenerating; secondly, that few of them would be able to pay for this in terms of immediately saleable raw materials; thirdly, that private investment by foreign firms was unlikely to be attractive; and, lastly, that the only practicable solution was the provision of capital, either separately or through international agencies, in the form of long-term low-interest loans.

In any case, the provision of much of the capital, for the first stages at least, of industrialization, must come from already industrialized countries. There is no difficulty, as has been shown, in the actual material production of this capital: the steel, the machinery, the fertilizers are either there or could readily be produced; here we are concerned both with the problem of how to finance it and with its effect on the industrial countries themselves.

The normal way of financing it would be by means of a long-term loan at small or nominal interest, at any rate for the first few years (p. 243). On account of their scale only governments can provide the necessary security for these loans. And governments, unlike private firms or banks, who have only their shareholders' profits to consider, have quite considerable reasons for granting them. The capital required is in the form of materials or machines produced in the industrial countries, and their purchase would mean a corresponding increase of wages and profits in those countries. It would be, in fact, exactly the same, from the point of view of national economy, as the present production of military weapons and equipment which, though absolutely useless, maintains the activity of the industries in most of the capitalist countries. In so far, therefore, as this military production is what holds back the danger of a slump, long-term loans for industrialization of Asian, African, or American countries would fulfil the same role.

This type of low-interest loan financing is already an acceptable one in most industrial countries. It goes with the type of economy, establishing during the slump and reinforced in wars, of budgeting for a deficit; in other words directly or indirectly borrowing from people on the security of the government. This is an operation which, at least in times

threatened with slump, even pays for itself because it avoids the alternative payment of unemployed relief or the construction of public works of a kind that are not worth undertaking for their own sake.

But it would also do more, for, at least after the first few years, it would provide new purchasing power in the underdeveloped countries which would react on imports from the industrial countries and help other industries, such as textiles and semi-luxury goods, not involved in producing the raw materials or machinery. In a period such as the present, where there is considerable anxiety even in the United States about what is politely called a recession, these arguments have far greater force, as they also have for countries such as Britain, which are even more sensitive to trade variations than the United States. For, on account of the competition they have to face in their exports of machinery, they have correspondingly greater need for prosperous customers in the underdeveloped countries.

These arguments which may seem convincing to an ordinary citizen have, however, but little appeal to the directors of big corporations or to the politicians and publicists who share their interests. There are many weighty financial reasons, although they may not appeal to ordinary people, why it is always better to invest money in destruction rather than in construction. Military expenditure is notoriously the one in which it is easiest to make profits, because the goods are usually wanted in a hurry, there are no awkward questions about costs, and they are either immediately used up in war or soon become obsolete. In any case they do not, like old models of cars, threaten to compete with new production.[1]

It is true that the arms may be, and very often are, used to kill the nationals of the country which makes them. Those who suffered for instance in the war against Japan had the benefit of being attacked by weapons made largely from British and American steel and by explosives made in British-built chemical factories; but this regrettable diversion did not affect the profits of the firms who sold them to Japan. Against all these advantages of armament production, investment in productive industry abroad has few attractions, there is a very real fear that the building up of industries any where in the world, especially in areas out of control of the owners of the older industrial countries, is asking for trouble. Why should we go out of our way, it may be asked, just to build up new rivals? Many regrets had indeed been expressed about the early industrialization of Japan. It might lead to a multiplication of productive capacity which would cause a break in prices, would lower profits and induce slumps.

This argument of course applies equally well to public productive investment inside the old industrial countries themselves; hence the violent objection from business circles in the United States to President

[1] In the original contracts for the war-time jeep there was a clause insisting on complete scrapping after conclusion of hostilities.

Roosevelt's policy of public works, like the Tennessee Valley Authority, that were actually useful. It is only when the interests of bankers and capitalists appear to be absolutely in conflict with those of ordinary people, that is during an active slump itself, that they can be over-ruled within the orbit of capitalism.

This idea of the new Bourbons of capitalism of attempting to retain the monopoly of manufacture in their own countries is in line with the mercantilist policy which was adopted in the earliest days of British industry of trying to keep all the manufacture of the world in her own hands. In the long run it proved a futile policy and one, as the free trade era showed, that did not actually pay nearly as well as that of recognizing the ultimately inevitable development of industries in other countries of Europe and America. In this age, the policy of monopoly of 'know-how' is not only more stupid, it is one no longer possible to apply. Whether they like it or not, in thirty years or so, there will be in the world several new basic industrial centres, perhaps twice or three times the number there are now, and a highly developed and widely distributed subsidiary industry (p. 244). This increase in the world industrial level will tend to restrict, in the long run, the supply of raw materials to the older industrial countries. It will certainly put an end to the policy of treating the whole world as raw material suppliers to the United States, which already, with only 9 per cent of the population, consumes well over a half of the key raw materials of the 'free world'.[1] The result, it is to be hoped, will be some attempt to use these materials less wastefully.

In their various ways the entry of new countries into the industrial sphere is bound to have an effect on the older industrial countries, but whether this effect will be good or bad will depend very largely on their reaction to it and even more on their speed of reaction to it. If they anticipate it intelligently and change their industries accordingly they can, if not maintain their supremacy, at any rate not put themselves at any disadvantage with respect to the rest of the world. For they have one asset which is their long experience of industrial production. This may, of course, be wasted but it can also be further developed.

It is relatively easy for a newly industrialized country, as the examples of the Soviet Union, China, and India have already shown, to set up with the assistance of foreign engineers very large standard-types of heavy and mass production manufacturing industry, blast furnaces, rolling mills, assembly-line motor plants, synthetic-chemical industries and so forth; and these can actually be producing even before enough native engineers have been trained to design and improve them. This stage is long past in the Soviet Union: at present the capacity of the Soviet engineers in the planning of new construction is probably ahead

[1] In the official report *Resources For Freedom* we find as accepted policy: "to insure an adequate and dependable flow of materials at the lowest cost consistent with national security and with the welfare of friendly nations."

of any in the rest of the world, notably, for instance, in the major industrial developments in the steel industry, such as continuous casting and the use of oxygen. It soon will be so in China also; hence the urgency for countries like Britain to hasten with their trade agreements.

For some time, however, in two or three decades, the competition to be faced by the old industrial countries will be mainly in these lines of mass production goods. If these are the lines on which the industrialists in the older countries choose to compete in they will certainly be beaten, because in them the newer countries will have more up-to-date machinery with lower working costs, quite apart from the factor of wages. On the other hand, the older industrial countries are in a position, which the others are not, for developing new lines of industry, making full use of science and of their existing technical skills, together with the indefinable but very real advantages of having a very diversified auxiliary industry which can supply all the parts and fittings for new industries as and when they are developed. In Britain, for instance, the atomic-energy plant-producing industry and the automatic-control industry would be obvious examples.

So far I have only discussed the reaction of the industrial countries to the demands for industrialization of the other countries, but another factor of equal importance and absolutely complementary to it is the effect of the changeover from military to peaceful production in both capitalist and socialist countries, which would be the natural consequence of any serious disarmament programme. It is perhaps the fear of this in capitalist circles that has, as much as anything else, held up disarmament negotiations for so long, because here the apparent interests of the capitalist and socialist countries are most violently opposed. It is quite clearly in the interests of socialist countries engaged in rapid construction, and having no fear of over-production or slumps, to wish to reduce their military expenditure; but, as already indicated, the military expenditure of capitalist countries is a kind of insurance for full employment and large profits even in peace-time, and its abandonment is looked at with a fear greater even than that of war itself, at least until the advent of ballistic rockets.[1]

Nevertheless, as pointed out in Chapter II, the tendencies of military technique itself are pointing more and more towards the necessity of partial and, probably, of total disarmament. Large sectors of military equipment and many of those which put the heaviest demand on industrial resources are already obsolete. The so-called conventional armaments, the ground forces with their tanks and heavy guns, would be practically useless in any major war and little enough use even in colonial wars. So would the larger naval elements, such as aircraft carriers, and armoured battleships. The same fate seems due for the most

[1] Even then Mr. Meany, the Chairman of the A.F.L.-C.I.O. Joint Committee can advise the President that to combat the slump and create employment he should spend another £20,000 million on armaments over the next two years.

expensive and the most rapidly developing forms of armament, the aeroplanes, both bombers and fighters in the face of cheap, homing, guided missiles (p. 12). It is one thing to build up a so-called defence force which is believed capable of at least destroying the enemies' cities, if not defending our own, and quite another to spend vast sums of money on machines which are not even able to frighten the enemy, much less to injure him.

Now it is true that in the place of aeroplanes we are developing rockets of various ranges up to inter-continental ballistic missiles, and that these at the present moment appear to be extremely expensive weapons. A single super rocket, which shoots off and does not return, may cost something of the order of half a million dollars. No doubt with the lavishness of the military supply departments, some hundreds of thousands of these, far more than would be needed to kill all the population of the world, are already stockpiled. It is probable, however, that the Soviet rocket engineers, whose technical achievements are no longer doubted, are able to produce rockets considerably cheaper, as there it is not necessary to make any profit at all out of it. In any case, however expensive rockets may be to produce, they can by no means take the place as profit makers of all the aeroplanes, ships and tanks that they have superseded; nor, and perhaps this is more important, do they require anything like the servicing by forces of millions of soldiers, seamen and airmen. It is true that proposed American rocket bases in Britain are going to cost some ten million pounds at least, but this again seems rather a dubious expense in view of what we have heard about the Soviet rockets not requiring launching sites at all, and being therefore much harder to knock out (p. 12). Already, both the Americans, with their Polaris, and the Soviets, with their Comet, have ballistic rockets that can be launched underwater from submarines, which would be far more difficult to detect.

Sooner or later, and let us hope sooner, the absurdity of the whole business of war with hydrogen-bomb-loaded rockets capable of destroying everybody without any possibility of defence will be realized. The attempt to put off this fate by burying whole populations—or a selected *élite*—underground in presumably hydrogen-bomb-safe shelters will also reveal itself as a costly absurdity (pp. 12 f.). When this is fully realized, popular pressure will force capitalist governments to hold back from the race to nuclear suicide and, as a consequence, to abandon the whole policy of deterrence. At that point, the decision to disarm in reality, and not merely to talk about it, will at last be taken.

This decision in itself, still more the actual first steps in disarmament, even if these occur in stages spread over several years, will have important implications in the industrial field. Some of these are already apparent, not arising from disarmament but from the obsolescence of military aircraft, particularly in Britain, but also in the United States, at least in California, the great centre of the industry. The first people

to be affected are not so much the workers as the designers and scientists, because owing to the nature of aircraft design and manufacture the thinking out of a model must occur several years before anything can be expected in the air; and the cutting short of programmes means putting these people out of work altogether. Only some of them can hope to be absorbed in rocket-engineering because this requires quite different types of technique. Nor can the military aeroplane engine designers, for instance, hope to find much employment in the relatively limited field of civil aeroplane design. With any real disarmament, it would no longer be a question of transferring technologists or skilled workers from one place to another within the field of military production. Rather, would it be a matter of releasing them as they become available for the tasks in a new expanding civil industry for which their experience most suited them. No scheme of disarmament can, with the best will in the world, be an instantaneous one. Its stages and the time they take must be agreed in advance and written into the disarmament treaty. Thus there should be every opportunity of an organized transfer of skilled personnel to their new task, with retraining if necessary, but none of the frustration of unemployment.

One opening can certainly be counted on in a sudden acceleration of the process of automatization of all industry. It is just the type of expert released by the cessation of modern weapon building that can be most usefully employed for this purpose. The electronics and control-gear of modern planes and rockets, without any serious alteration in principle, could be adapted to controlling industrial processes, and the higher class of designers, who work not by copying other designs but from first principles, could switch over to the general re-designing and thinking out of the whole of industrial production planning. This operation would also involve a considerable investment in the internal conversion of industry in its new forms, and the scrapping of much existing industry.

The transition itself is bound to cause great changes in the economy of the older countries. Some of these have already been alluded to, but the most important perhaps is that which affects the industrial workers, involving a general and rapid up-grading from semi-skilled to skilled, and a corresponding demand for more technologically and scientifically trained young people (Chapter X).

The great advantage that will accrue from the cessation of military production will go far beyond that of the individual industrial countries, for with disarmament would come the really serious possibility of the breakdown of international secrecy and a real possibility for technical co-operation. The effect of mixing the sets of ideas arrived at largely independently on both sides of the old Iron Curtain would be technically explosive: out of the combination many radically new types of industrial processes would be certain to grow.

In another way the ill effects of shutting down military production in its negative aspect would be largely cushioned by an accompanying

breakdown of the embargoes on types of exports to the socialist countries. The original, at least ostensible, reason for these embargoes was that the particular materials, components or machinery could be used for military purposes. It was on these grounds, for instance, that the Americans maintained their embargo on antibiotics to China, causing far more civilian deaths than it did to hinder the Chinese military effort, subsequently forcing the Chinese to build their own antibiotics industry to become independent of imports. The technical advances in the Soviet Union, and the even more rapid entry of China into the production of high quality mechanical and electrical equipment, have already made nonsense of the military excuses for the embargoes. They should also serve as a warning to the capitalist powers that the longer they delay lifting them, the fewer openings there will be in the socialist countries for their machinery and manufactures.

However, if qualitatively pointless, the embargo had considerable quantitative effect. The Soviet Union might be able to, and did indeed produce everything that was embargoed, but it did it at a cost, using up resources to do it that could have been employed more effectively elsewhere. According to the Cold War argument of embarrassing the Soviet Union in every possible way the embargo is still justified. But this is only if we neglect, on the one hand, the contribution it makes to international tension and, on the other, the great advantages on both sides of the Iron Curtain that would follow if it were abandoned. The resumption of unimpeded trade over the whole world, on a strict economic basis, would lead to an immediate demand for mechanical, electrical and chemical plant from the socialist countries, on such a scale as would completely offset any temporary dislocation in the industries of capitalist countries due to disarmament. A foretaste of this has been given in Mr. Khrushchev's letter to President Eisenhower[1] offering to purchase several billion dollars worth of chemical equipment from the United States to help in the creation of a large plastics and fibre industry in the Soviet Union[2].

The shutting down of military production and the use of manufacturing capacity to help industrialize backward countries are not the only factors which would lead to an increase in industrial activity. The other enduring factor is of a more purely internal nature, namely the change-over to the new type of scientific and largely automatic industry described in an earlier chapter. Even though this is at present held back by military requirements and by political and financial restrictions on capital-goods export, this transition is going on and making its effects felt. The removal of restrictions will only accelerate a process already under way.

In this chapter we have examined the cumulative effect of three aspects

[1] *Soviet News*, 6th June, 1958.

[2] See Footnote 1, page 242.

of the transformation of our time—the onset of automation, the industrialization of underdeveloped countries and disarmament—as far as they affect industrial countries. We may conclude that if handled wisely in an atmosphere of peace not only will they serve to maintain industrial activity, but also to set off a new spurt in production which will realize in practice in a very short time the full potentialities of the new Industrial Revolution. This does not mean, of course, that the older industrial countries can expect to have the monopoly of that revolution, but they will be able to pioneer in much of its development. For the new revolution will spread, and has indeed already spread, very much more rapidly than the old. Instead of producing just one or two centres of advanced technology on a background of relatively unaltered or even degraded handicraft production, as did the old Industrial Revolution, it can only lead to a transformation in which old and new centres will stand as common and interdependent elements in world economy.

IX

BRITAIN'S POSITION IN THE NEW INDUSTRIAL WORLD

We are in Britain, of all industrial countries, the most exposed to the dangers and strains of the present world situation. Compared with our resources, we bear the heaviest burden of war preparations. This country, used as a base for atomic bombardment, would be the most immediate and certain target should a war break out. Not only does our arms budget increase our risk of destruction, but it is also the major immediate factor in depressing our standard of living, just at a time when the people of this island, with its great resources and industrial traditions, could move forward to a new era of prosperity.

The hopes that successive generations cherished after two destructive but victorious wars have been frustrated. We have known enough prosperity, however uneven, to have some notion of what could be achieved —the new towns and cities, the hospitals, theatres and sports stadiums, the fine modern schools and great new universities and research centres. a people well-fed and well-clothed, enjoying both its work and its leisure. Especially in the immediate post-war years, many of our best professional people—our architects, educators and planners—were encouraged to dream their dreams and set them down on paper to inspire others. But to-day these hopes seem far away, buried beneath the years of recurrent sterling crises, and of the wage freezes and social service cuts that were supposed to, but did not, bring stability, for they failed to deal with the increasing difficulty of paying for the imports we need. Now we are facing still another economic crisis of world dimensions.

To-day, responsible leaders tell us we shall be very lucky if we maintain our present living standards; that we must look forward to years of economic difficulty, producing more but consuming less; that, far from making plans for a new and splendid land, we must cut our coat according to a fast diminishing cloth. Just when we had come to believe that we were finishing for good with Distressed Areas and dole queues, we are told to regard some degree of unemployment as a necessary check on the people's excessive claims to live better than their fathers did.

All this, though real enough to-day, need not be our fate. There was

nothing wrong with the dreams, only with the restrictive policies which frustrated them: and these policies can be changed if people have the insight and the will to change them. For the potential strength of Britain in the new world that is growing up around us is, for good reason, not smaller but greater than before.

It is true Britain is no longer the dominant world power that it was in the nineteenth century. The development of the Dominions as autonomous units, on the one hand, and the rapid liberation of the colonial territories in Asia and Africa, on the other, have reduced Britain—almost though not quite—to the same stature as the old industrial countries of Europe such as Germany or Sweden.

But Britain is still the first industrial country after the two giants of the U.S.A. and the U.S.S.R. and in many respects, particularly in world trade and finance, still occupies a leading position. For the American economy, great as it is, is very largely turned in on itself with its enormous and wealthy internal market; whereas the poorer Britain depends more on the services as well as on the goods that it can exchange with the outer world.

In world politics, Britain's position is equally important. As it is the strongest ally of the United States in the Atlantic Bloc, this country should be able to moderate the policy of the alliance and thus have a share, much larger than its economic or military strength might indicate, in determining the issues of peace or war, that is, of life or death for most of the peoples of the world. That issue has, in the first place, to be settled within Britain itself. For although successive governments, Labour and Conservative alike, have adhered to the policy of N.A.T.O. and the continuance of the Cold War, these policies run counter to the whole pacific tradition and sentiment of the British people. And now at least the people of Britain are wanting their say. A demand for nuclear disarmament and relaxation of international tension is visibly growing, especially in the Labour Party.

The significance of this on the world-scale is that a change in the direction of British economy and politics would alter the whole balance of the world economic and political position. Some kind of change is in any case made necessary by the need of the country to adjust to the new world conditions. For Britain is more dependent than any other country on its political and economic relations with the rest of the world, due to her concentration ever since the Industrial Revolution on manufactures and trade. The territorial possessions of the famous Empire were rather an expression of Britain's dominating trade position than its cause. That position has not been lost and helps to compensate for the small size of the island of Great Britain and for the fact that it is far from self sufficient in food, though the actual productivity of British soil is as great as that of any in the world.

The change in Britain's world position has not, as some people feared, resulted in any serious weakening or even in any violent change in its

internal economy; the post-war period, despite continual alarms and crises, has been one of full employment. It has been the longest period for 70 years free from slumps and has seen the greatest rate of increase in production of manufactured goods. This is because the pattern of British industry is geared, through its well established trade networks, to part of wider pattern including most of the rest of the world, particularly underdeveloped territories, both inside and outside the former Empire. If it is no longer the workshop of the world, it still remains the workshop of a very large part of it.

The prosperity of recent years may, however, prove short-lived, as it has largely been determined by peculiarly favourable circumstances. Britain was less affected by war damage than any other European country, consequently she had a larger share in reconstruction than any other country except the U.S.A. This period was followed almost immediately by a new burst of rearmament which provided for employment, offsetting any setbacks in civilian production. Further, the terms of trade, that is, the ratio of the prices paid for imports to those obtained for exports, were peculiarly favourable over the whole period and still remain so. These conditions may not last much longer, but it does not follow that if wise measures are taken, under different conditions, the British position will necessarily be worse. It only means that it will be impossible to carry on quite in the old way.

The underlying guarantee of continued British prosperity is the fact that the industrial equipment, both material and embodied in human skills, is exceptionally abundant and widely distributed. There is no country that carries such a large proportion (37 per cent) of people employed in manufacture to total employment as Britain (Table XIII). No country has a more skilled, dependable and well organized working class. It is this reserve capacity and the flexible, if somewhat chaotic, structure of British industry that has enabled it in the past to alter its lines of production to suit the changing conditions. The capital charges on British industry are in fact much smaller than in most industrial countries. The policy of allowing machinery to go on working until it has paid off its capital charges has produced this effect, although necessarily the machinery is technically far less efficient. It is nevertheless very profitable on a small turnover. It is largely for reasons of this kind that the productivity per man hour in British industry is less than one-half of that in the United States.

Certainly, in the main lines of production of machinery Britain cannot compete with the United States, but on the other hand, her multiple small works have been able to fill in odd gaps in manufacturing requirements which the United States industry does not find it worth while to do. In this sense Britain occupies the first place of the secondary industrial powers already mentioned (pp. 130 f.) that have specialized in certain new but indispensable lines of production—the small motor car, electrical plant, electronic equipment and now atomic energy equipment

TABLE XIII

INDUSTRIAL EMPLOYMENT IN VARIOUS COUNTRIES

(Millions)

Country and Year	*A Population*	*B Total Economically Active People*	*B as % of A*	*C Population Employed in Manufacturing Industry*	*C as % of B*	*C as % of A*
U.S.A. (1950)	152·8	50·0	33	16·1	32	10
U.K. (1951)	50·2	23·2	46	8·6	37	17
U.S.S.R. est. (1956)	200·2	89·0	45	18·5	21	9
W.Germany (1950)	47·7	22·1	46	6·8	31	14
France (1954)	42·8	19·5	46	5·0	26	12

Sources: Demographic Yearbook, 1957, U.N., New York, 1958.
National Economy of the U.S.S.R., Moscow, 1957.

—besides the maintenance of an unrivalled supply of luxury and prestige consumer goods, ranging from tweeds to whisky.

Another feature almost peculiar to British economy is that, as a result of the popular upsurge after the war, some of the major industries and services of the country have been nationalized.[1] The effect of this conversion, carried out with the utmost caution, with full compensation and the minimum upset to vested interests, has, however, provided for a controlled and planned supply of some basic industrial requirements and at very low cost: coal in the first place, electric power, and much of transport. Though nationalization did not satisfy the dreams of the socialists who first advocated it, at the same time, it did not justify the fears of the capitalists: in fact, it provided them with certain advantages that they would have found very difficult to get from industry in private hands. The price of coal supplied to British industry is effectively subsidized by selling in relation to average instead of to maximum costs. This gives British industries considerable competitive advantage over those on the Continent. Similarly the national control of power supplies

[1] It is true that railways have long been nationalized in many countries, for instance in Germany and France, and mines have in Holland. However, the proportion of industries and services nationalized in Britain is greater than in any other capitalist country.

enables the transition from coal to atomic power to proceed in a smooth and planned way.

Against these favourable features we weigh others which go some way to offset them. Britain, as the first country to industrialize, having now over two hundred years of industrial progress behind it, is apt to be cluttered up by the consequences of the earlier stages of industrialization, and, therefore, to be at a disadvantage against newer industrial countries. British industrial towns, British railway systems, a great deal of the equipment of factories and particularly of their planning and distribution, reflect earlier patterns of production and are not suited to modern ones.

And the antiquities are not all material. Much of the management, particularly the higher management, of British business is still living in a nineteenth-century world. In its concern with the loss of position of prestige of the old world it has not jumped to the possibilities of the new.

In manufacture it has been slow in introducing radically new methods. Apart from the motor industry, which is strongly under American influence, there is little automation. Our iron and steel industry remains conservative. Only in new fields of industry such as electronics and atomic energy—incidentally nationalized—have we shown the enterprise and ingenuity which might be appearing over every field of industry.

In trade British business men are still thinking of a world of special privilege based on the old Empire and the economic weakness of most raw material supplying countries. They are doing little, in some cases less than nothing, to secure in time their position in the great new markets that are already to be found in the Soviet Union and China and will expand with the general industrialization of the world.

Worst of all, the world of banking and big business is clinging to the tradition of monopoly and restriction. It prefers big profits on small turnovers to expanded production at low prices. It prefers a policy of low real wages and unemployment to keep the working class docile, to one with high real wages made profitable by a large and often renewed investment in modern machinery. In our present British economy a nationalized sector of relatively unprofitable industry is assisting a private sector of a more profitable kind. Hence restriction can take the forms of holding back advances both in the public and in the private sphere, a process which has already begun in the cutting down of the capital available for coal, electricity and transport developments.

This is no new tendency. The data on steel production, already given in Figs. 4(*a*) and (*b*) and Table XI (pp. 128 f.), show that in Britain alone, a restrictive policy has been practised to some degree since 1880. This is seen most clearly in Fig. 4(b), where British steel production, in spite of its early start, is passed by every country in turn. If things go on as they are, China's production will have passed Britain's within a dozen

years. The reason for this restriction of output has never been hidden, it is to keep up steel prices and hence profits.

The most open expression of the restrictive policies of British industry is shown by the small proportion of capital formation to national income, which is the lowest of all industrial countries, as can be seen from the data of Table XXI (p. 246). The percentage in Britain is 9, as against 11 for the U.S.A., 16 for France, 18 for Federal Germany and 16 for the U.S.S.R.[1]

The experience we already have of nationalized industries shows that, apart from pressure exerted on them by the government to hold back their development, they suffer from a kind of technical inertia, a tendency to carry on in old ways which were established in the days of private industry, where profit rather than public service was their acknowledged aim. This also affects the character of capital investment, outside the favoured atomic field. In the absence of adequate research, even the small amount of new capital equipment installed follows traditional lines, and few radically new types are being introduced.

The post-war economy of Britain, with the socialist veneer of nationalization covering its unchanged capitalist core, gets the worst of both worlds. Restrictive policies go unchecked in the private sector, shielded as it is from foreign competition by the nationalized industries, while these completely lack the drive to expand and modernize, which only socialism could give.

This attitude, although not universal, is still dominant. It is essentially that of what is now being called *the establishment*. This is a tight nexus, all the stronger for being largely informal and based on personal connections. It comprises big business and banking, higher civil service, military, legal, educational, and church dignitaries, nearly all with a public school and old university background and finding in the Crown a symbol of loyalty. The establishment controls the Press, the radio, and both official and commercial television. It has inevitably millions of adherents who though they gain nothing from it, cling to it and everything it stands for, from the Royal Family downwards, as some kind of security in a changing world. In politics, it is in the first place represented by the Conservative Party, but its influence affects some leaders of the Labour Party as well.

The business side of the establishment is almost unanimously opposed to the whole idea of a new industrial revolution, and is very effectively checking all the practical steps, from capital investment to scientific research, which could lead to it.

The longer such policies are operated the weaker will Britain become, and the smaller her chances of maintaining her place in world economy

[1] Mr. Andrew Shonfield of the *Financial Times* and the *Observer* has argued, on orthodox economic grounds, in his popular book *British Economic Policy Since the War*, London, 1958 that this failure to increase and even to maintain British industrial capital is a prime cause of our recurrent economic difficulties.

which, on account of her exposed position, is more vital to her people than to those of any other country. Just to continue the way things are, with minor adaptations here and there, is to risk a situation in the world of the near future very similar to the fate which befell the old handicraft-based countries after the first Industrial Revolution. India, for instance, was at that time in the forefront of manufactured goods—in the strict sense of manufacture, that is, made by hand. Indian cottons were so popular that their importation into Britain had to be prohibited. Indeed, it was the attempt to imitate them in Lancashire that gave rise to the first stage of the mechanization of spinning and weaving that was to set off the Industrial Revolution. However these inventions so cheapened the cotton piece-goods that they could be sold, not only in all markets previously available to India, but in India itself, to the ruin of the native industry. It was to lead to a general impoverishment which is only now beginning to come to an end. At that time India was suffering under a confusion of feudal rulers, and with various European powers, English, French and Dutch, all striking out for their own advantage. It was, therefore, in no position to take up the Industrial Revolution itself, and clinging to the old methods it simply went downhill.

The difference between these events and those of the present time is that Britain has still a more or less free chance now to decide whether its industries are to continue along the lines of the old Industrial Revolution, or are going to move into the new; and, in particular, whether it is going to make full use of science to transform its own industry, or, rather, wait until other countries transform theirs and try to catch up. The latter would be a fatal course because most of the natural advantages of Britain have already largely disappeared or been superseded; the native minerals have nearly all gone, the coal is becoming increasingly difficult to win, and the exclusive advantages of obtaining raw materials cheaply from imperial tropical dependencies is also imperilled.

In certain respects even the position of Britain as an autonomous industrial country is threatened. It is no longer a centre for the manufacture of heavy contractors' plant, for which it is dependent on the United States. This is a disadvantage that could be remedied, but is likely to be more serious in the future than in the past on account of the demand for this kind of plant for opening up new countries. More serious is the relative backwardness of the machine-tool industry in which Britain has been overtaken by the Soviet Union, particularly in the mass-production of machine tools.

These are technological failings, but they are leading to a situation in which Britain itself is in danger of losing its economic independence. For at an increasing rate since the war, foreign firms are working their way into British industry and setting up factories with or without British partnership. This is occurring largely in the most advanced sectors of industry: oil refining, detergents, pharmaceuticals, motors, electronics, domestic and office equipment, as the familiar names of Hoover,

Ford and Vauxhall, indicate. It is difficult, because of joint ownership, to find the extent of American investment in Britain; the U.S. Department of Commerce put it at $1.599 million in 1956, almost certainly a low figure. It has been growing at a steady rate of 13 per cent per annum, that is, more than doubling every six years, which means that it is rapidly replacing British capital in these vital fields[1].

In this Britain is not alone. The private capital, nearly all American, that is not being invested in industry in underdeveloped countries, is flowing into Britain, France, Italy, and most of all into Germany. This does nothing to reduce the inequalities of the world, for the companies operating with American know-how and providing profits for Americans can do so because they can get first-class labour at British or European wage rates. The productivity is as high as in the States and the profits are accordingly greater. Here, Britain is the most profitable field of investment, the rate in 1953 being 16½ per cent. It is the same method more discreetly worked—of the American oil wells in the Middle East. It is good business, otherwise it would not be worth putting money into it. This loss, however, is less important than the effect of this policy of increasing the dependence of Britain on the United States and consequently tying the country more firmly to the policy of the Cold War.

Another weakness of the British economy, but one common to many capitalist countries, is the insufficient support available for science and engineering, shown by the small number of trained technologists and the small part science plays in ordinary teaching. The realization of this is a relatively recent phenomenon, due almost entirely to the undeniable success of the Soviet Union and the knowledge that their production of trained personnel is thirty times that in Britain, or four and a half times that of the age group (Table XVI, p. 187). Now this disadvantage is probably more serious for Britain than for other countries such as America, which, incidentally, is by no means as badly off in this respect, though still far behind the Soviet Union. For lack of material resources Britain will have to count more on its wits than other countries, and in the modern world wits not sharpened by science are of little value.

Further, the steps taken to improve the technical standard must be taken well in advance. It takes at least ten years to provide a fully-trained technologist, and ten years is already far too long to have to wait to start the change-over of British industry from the old to the new type. The realization of the danger arising from a lag in technical preparation is not a new one. Over ten years ago, at the time of the crisis of 1947, for instance I wrote articles on the need to set up then the basic elements of scientific research and training so as to be ready in 1957.[2] However, with

[1] Mr. Shonfield (see footnote p. 160) welcomes this penetration of British industry by the big American corporations, as a means of easing the balance of payments. This seems to me, however, a poor return for the bartering of the country's independence and making its economy a subsidiary to American Big Business. See also J. H. Dunning, *American Investment in British Manufacturing Industry*, London, 1958.

[2] *The Freedom of Necessity*, *op. cit.*, p. 328

the appearance of Marshall Aid and the general easing of the situation, all such warnings, which in any case were hardly noticed, were soon forgotten and are only now again coming to the fore.

There is another reason for the relative failure of Britain to make full use of science. This is the way in which the effective scientific potential of the country is reduced and its direction distorted by the demands of what is ironically called "defence". The militarization of science is one of the main ways in which mankind is now being cheated of wealth and well-being and kept in a state of permanent danger. I have already discussed some of the aspects of this (pp. 138 ff.), but all the arguments set out there apply to Britain with special force. For Britain spends over 60 per cent of its scientific research budget, more proportionally than any country in the world, on war preparations (Table XIV). Not only

TABLE XIV

EXPENDITURE ON RESEARCH AND DEVELOPMENT, U.K., U.S.A., U.S.S.R., 1955–56

Expenditure	*U.K.* (£ *millions*)	*U.S.A.* ($ *millions*)	*U.S.S.R.* (*Roubles billions*)
TOTAL MILITARY	1,436	41,825	107·4
RESEARCH AND DEVELOPMENT			
Government			
(i) Military	182·5	2,760	..
(ii) Civil	50·5	410	..
Private Industry	63·3	3250	..
Universities & Foundations	3·7	80	..
Total Civil Research	117·5	3,740	16·4
TOTAL RESEARCH AND DEVELOPMENT	300	6,500	..
MILITARY R AND D AS A % OF:			
(i) Total R and D	61	42	..
(ii) Total Military	12·7	6·6	..
CIVIL R AND D AS A % OF TOTAL MILITARY	8·2	9·0	15·2

Sources: Based on *Annual Report of the Advisory Council on Scientific Policy 1956–1957*, H.M.S.O., London, 1957.

Statistical Abstract of the United States 1957, Washington, 1957.

Economic Survey of Europe, 1957, U.N.E.C.E., Geneva, 1958.

F. Korolev, *Education in the U.S.S.R.*, London, 1958.

that, but Britain, of all the industrial countries, can least afford it on account of her precarious economic position, and at the same time stands to gain least and risks most from supporting a policy of nuclear warfare.

The development first of the atom bomb and then of the hydrogen bomb by Britain were gestures aimed at maintaining the traditional "Great Power" parity of Britain as against the United States. It was from the outset a hopeless task in view of the much greater material and industrial sources of the United States; and this was fully brought home by the fiasco of the Suez expedition. From then on it was evident that Britain could not play a great power role, and would be forced either to become a dependent auxiliary to the American military machine, or to abandon the use of force, and particularly the use of atomic power for military ends. For the moment the first alternative has been chosen. The development of a purely British hydrogen bomb to be carried in British jet bombers is being pushed on at great expense. It is excused as an independent contribution to the great deterrent. In fact, despite the great show of patriotism with which it is defended, it is little more than a prestige gesture. The effective role of Britain in a future war is to supply rocket bases for American rockets. But this is unlikely to be a permanent solution unless the bases are actually used, in which case Britain will be the first casualty of the Third World War, and there will be no question about the recovery of British industry.

However, if war can be held off long enough, and time presses, the second alternative, that of becoming a civil rather than a military power, will impose itself for two very cogent reasons. In the first place, if the Cold War goes on and inter-continental ballistic missiles are finally developed in the United States comparable to those already existing in the Soviet Union, the advantage of a forward base for shooting off the shorter-range intermediate rockets, will largely disappear; such bases will be unnecessary as well as dangerous. Thus the policy of bases has only two possible outcomes, either to be an utter waste of money and effort, or to provoke war and lead to the destruction of the British people. These facts are beginning to be understood and popular feeling against turning Britain into a base for American rockets is likely to mount to a much higher level than it has already and secure, the sooner the better, the ending of this suicidal policy.

The second reason is one of economy. The new technical-military developments have altered the burden of demands on production. The role of the old conventional weapons, and with them the land, sea, and air forces that used them, has been much reduced. This was recognized in the Defence White Paper of 1957 and the changes that have subsequently taken place have reduced the strength of the army, navy and air force, although, owing to rising costs and other commitments, the actual saving in money is still not very noticeable. The sum expended in 1957 was £1,529 million, compared with £1,627 million in 1956, a drop

of 7 per cent. The logic of the nuclear rocket, however, is incontrovertible even to the most militarily minded, and it is probable that Britain, even in advance of a general disarmament agreement, will be obliged to convert much military to civil production, a process of which the first dramatic step has been the shutting down of the Saunders-Roe Fighter project.

Any slowing up of military expenditure is a net advantage; it was always extremely wasteful quite apart from its final purpose. It is now recognized for instance that the unregulated development of different types of military aircraft has resulted in the waste of at least £50 million. Even this seems small in comparison to the more than £1,000 million spent on all types now made obsolete by rocket development. Still they made some pretty profits in their time.

This is only one example of the distortion of the economy of Britain through excessive military expenditure. It has now reached the point that in order to preserve the sacred rights of "defence", and waste more money on rockets than has already been wasted on planes, the Conservative Government has instituted severe economy measures of a characteristically restrictive kind. These threaten the very basis of Britain's industrial future, by cutting down capital expenditure in the nationalized industries and elsewhere, and more particularly by cutting down on education and scientific research at a time when the most rapid expansion is absolutely essential for the future.[1]

The consideration of all the negative features of the present position of Britain in the world, while they should serve as a warning, may also be taken as an indication of the country's potential strength and vitality. Once the essentially restrictive policy which is at the root of Britain's backwardness is removed, the positive factors will have a chance to operate. These are indeed considerable, as indicated at the beginning of this chapter.

The two essentials for rapid progress are present, an already equipped and working industrial base which has for long had the capacity for self regeneration, and a uniquely skilled and capable working class. These together with Britain's position in world trade and finance means that the country has a good chance of once again adapting itself to the new situation and playing a notable part in the new industrial revolution. This can no longer be in the nature of things as important as the part it played in the first, but it can still make characteristic and important contributions. What is more to the point, it should suffice to preserve and increase the relatively high standard of living of the British people.

The job of adjusting to the new conditions will require, however, an effort altogether greater in scale and intensity, and even more in careful planning, than has ever before been demanded of the British people.

[1] Mr. Shonfield (*op. cit.*) has argued this case very strongly. Without any wavering from capitalist orthodoxy, he advocates the cutting out of military expenditure as the only way of saving the economic position of the country.

Here we must look in more detail at the special possibilities and opportunities that are open to Britain in its transformation.

The first consideration for the maintenance and expansion of industry is the supply of power. It has been evident for some years that the power base of British economy was going to be insufficient, even considering the production of electrical energy, which accounts for some third of the coal consumption. It appeared there would not be enough for the next decade or so unless some alternative source of power was found. Oil was the first choice, and already much electrical energy is being generated by oil, but this was clearly a very bad choice—all oil has to be imported at a high price, besides the traditional danger for Britain of having oil supplies cut off in times of war.

At this point the prospect of atomic energy opened almost providentially. Proportionally to its energy resources Britain is already planning the largest programme of atomic energy production of any country in the world (Table IV, p. 48). This is planned to produce 5–6 million kilowatts by 1965, and that might have been further increased had it not been for the demands of military production of fissile material.[1] We may hope that a return to international sanity will remove this obstruction and that the rapid development of ever more efficient methods of atomic power production and, what is even more important, a reduction in capital costs may within a few years make atomic power cheaper than coal-generated power.[2] We may hope to go further and cut out the expensive turbo-electric gear by generating electricity directly from nuclear processes, and then move on to the position of using thermo-nuclear energy in which, thanks to the Harwell team, we have already got a lead.

Such prospects should not so dazzle us as to lose sight of Britain's oldest industry—coalmining. Coal will be needed on an increasing scale for several decades and its value as a basic chemical will last for ever. The mines, therefore, must not be neglected, they need more capital and more research and that not so much in the interest of mining more coal as in lessening the risks and hardships of the miners. It may even lead to the supersession of some of the mines themselves through underground gasification.

With ample power supplies assured it will be necessary to look into the position of heavy industry, particularly iron and steel, to see whether here Britain cannot take the lead in a radical modernization (p. 41). We should now be taking stock of the part Britain has to take in the change-over from the old to the new scientific industry. It is no longer sufficient to rely on the natural increase of existing industries, but rather to change the stress on to those that are likely to be more important in the future, and where Britain is likely to show to the greatest advantage.

[1] D. G. Arnott, *Our Nuclear Adventure*, London, 1957, p. 102.

[2] *The Times* 20th March, 1958.

This would appear at the present time to be in the electrical and instrumentation branches of industry as well as in the completely new industry of nuclear engineering.

The special skills embodied in aircraft design, particularly in aircraft engines and rockets, in preparation of materials capable of standing stresses and high temperatures, can be almost immediately transferred into this field. We have already a great advantage in the amount of experimentation on different types of atomic reactors that have already taken place, and a further advancement of this should lead to types that could be readily exported and would perform a very useful function in helping to develop other countries.

It is perhaps in the development of thermo-nuclear energy, although, despite the success of Zeta, this is still a speculative venture, that the greatest effort of the scientists and technologists should be put, because here the rewards are likely to be far greater than in any other field of endeavour. One must apply here, however, a principle put forward by Blackett in relation to operational research for military purposes. It is that the proper distribution of effort between different enterprises, all of which cannot be undertaken at the same time, should be by selecting those which have on the one hand the greatest expected ultimate gain, and on the other the greatest possibility of achievement within a limited time. Ideally the solution is backing only those schemes that have the maximum product of these two quantities, though in practice, as we never quite know either of the variables, this will always be more a matter of judgment than of calculation. On these grounds it would seem best to divide the effort so that the most *research* goes into thermo-nuclear energy where the prospective gain is enormous, though the probability of paying production may be from twenty to fifty years off according to Sir John Cockroft. On the other hand it would be well at the same time to put the greatest *development* still into fissile energy plants of the Calder Hall and newer types, which, though of less spectacular yield, are proved successes already contributing to the power supply of the country.

Though in the actual application of automation Britain lags somewhat behind, this lag could be quickly made up and turned into a lead. It only requires that the ingenuity of the electronics industry, which is well developed in Britain, be turned in this direction and a corresponding willingness on the part of traditional industries to take up the new methods.

Just as the coal base of British industry can now be made a stepping-stone for a new atom-based energy, so the old textile industry of Britain which started the Industrial Revolution, could be the base for the new chemical textile industry, or perhaps, even more radically, for a new fabric industry in which chemical products could be turned directly into cloth or even into garments without the intermediaries of spinning and weaving (p. 271). Such changes, however, run absolutely counter

to the economic habits of British industry, which is notorious, even among other capitalist countries, for its practice of using old machinery long after it has paid off its first cost. Instead of clinging to the old industrial techniques which we were the first to introduce, we should aim at doing precisely the opposite, abandoning them or transforming them and using them as examples to supersede rather than to imitate.

But it would be pointless to change the processes and products of industry without improving at the same time the conditions of life and the surroundings of the men and women who will be working in it. The very necessity of increasing the amenities of towns which were ruined in the early stages of the Industrial Revolution, could give rise to a new attack on the problem of architecture and town planning. Here, all the resources of modern sciences could be used in the choice of new materials and new methods of construction. Some idea of what this might lead to can be seen from the pioneer effort of the new schools, which stand out from all other buildings of the post-war era as the first application of prefabrication methods.

Something must also be done to improve the inadequate and chaotic transport system—the streets, roads and railways of Britain. That we have been able to succeed as well as we have despite such a system shows what advantages could be reaped if transport were completely re-planned. Here it cannot be a question of resorting to the measures, which may well be suitable in countries such as the Soviet Union or America or even Germany, of building enormous autobahns with multiple concrete-bridged fly-overs. Yet we could do much more than we are in road building and street widening if we were not hampered by archaic property restrictions. The best we could do would still require some radically new way to reorganize the traffic on the roads.

The nationalization of transport here gives a possibility not open to most capitalist countries. At present, owing to the country being absolutely small, there is a concentration of vehicles on the roads greater in Britain than anywhere else in the world. This concentration is already leading to an extremely costly slowing down of traffic, not only of passenger but, what is more serious from the economic point of view, of goods traffic. Every method used to reduce this congestion in one place piles it up in another; and the only way the traffic problem can be radically solved is by introducing some measure of control, preferably automatic control, of transport flow. With modern electronic developments this is not a very difficult engineering problem (p. 54); the real difficulty is to persuade a very freedom-loving and anarchic people to accept it, even in their own interests. It may well be that we have to wait until the transport in cities such as London grinds itself to a dead stop for most of the day before anything can be done about it. But it does offer an opportunity of achieving immediate returns without involving heavy capital costs.

In any country other than Britain we would not have concluded the

discussion of industry, much less building and transport, before having considered the elementary question of food and agriculture. This is because by a tradition of a hundred years old a substantial proportion of food has been imported. Even with the greatest effort, however, it may be impossible to maintain indefinitely the old type of balance of trade of Britain, in which the sale of valuable exports covered the import both of food and raw materials for industry. Both of these are likely to increase in cost—that is in the long run, apart from any temporary slump—whereas strong competition, with new countries coming into production, is likely to bring down the prices of manufactured goods.

Here something more can be done to reduce one variable in the trade balance, the amount of food imported. Now it happens for a variety of reasons, due to the war and also to government policy dictated by fears of war, that British agriculture has already undergone a considerable transformation. It is probably today the most mechanized in the world, and possesses, for instance, a number of types of agricultural implements quite unknown in the very heavily mechanized agriculture either of the United States or the Soviet Union. Not only that, but on the biological side the yield of crops is very high and the rearing of livestock most developed.[1] There is also in Britain a development of basic agricultural research which is both the earliest and probably the best in quality of anywhere in the world, though still not on an adequate scale.

If it should prove necessary at any time to diminish food imports without damaging the standard of nutrition of the population, then the way is open to a great reform of British agriculture, eliminating those aspects which are at present holding it back and making use of existing resources for entering into quite new projects. The present means available for agriculture are very much in advance of the pattern of landholding as it exists at present, much of it inherited from early industrial or even from feudal times. With the number of farm workers reduced to a fifth or less of those employed at the beginning of the century—there are only seven hundred thousand in the country altogether—the irrational distribution of land in farms is simply a brake on production. More could be done with even fewer men, without even upsetting the sacred principles of private property in land, by a general redistribution and rationalization of farming areas. Britain has gone so far in agricultural development that the idea of converting the peasant village into the collective farm is already a century or more out-of-date here as there are no more peasants, and farms have been for a long time factories producing food for a more or less distant market. A reasonable structure for British agriculture should provide at the same time for efficient food production and for an interesting and rewarding task for all workers on the land. The time has past when the peasant was the lowest of labourers.

[1] Sir E. J. Russell, *World Population and World Food Supplies*, London, 1954.

Agricultural work, because it demands such a variety of scientific knowledge and practical experience, should rank high among skilled occupations.

There is not much scope for increasing the area of arable land except in so far as we can prevent its still further decrease by irrational extensions of urban areas, most of which have taken up about the best farming land in the country. But much can be done in opening up and improving the rough grazing lands of the West and North and in attempting to reclaim the North British desert of the Highlands, where its apparent disadvantage of heavy rainfall might actually, if appropriate vegetation can be devised to grow there, be turned to advantage. (p. 74)

One possibility, already touched on (p. 76), of particular value to Britain would be the radical utilization of waste farm products such as leaf protein for human or animal nutriment, particularly sown grasses, which are not only the easiest crops to grow over at least half the country, but respond most readily to large applications of fertilizer. Indeed, it may very well be that Britain would be the first place to apply the sequence of semi-agricultural and direct chemical production of food, outlined in Chapter XII. In any case we must realize that there is no danger of absolute starvation or even of seriously lowering the nutritive value of food, although it may be necessary to do without a certain amount of the heavy consumption of meat, which, however appreciated, does seem to be actually injurious to health, at least to adults.

The changes I am recommending, however, are not aimed at avoiding starvation, but rather at altering the balance of imports in order to preserve the capacity of the country to produce manufactured exports sufficiently cheaply. Britain, more than any country in the world, depends on its trade. With every allowance for improvements in agriculture and greater economy in industry it will long remain necessary to base the economy on the sale of manufactured goods abroad. And here it will no longer do to produce the goods and hope they will find a purchaser and little better to engage in expensive advertisement campaigns. The new and changing pattern of the world demands an active and closer relation between maker and user. A manufacturing country like Britain must effectively become one member of a partnership with countries at various stages of economic development and fit its industrial development into their plans. This includes: colonies themselves on the way to independence; former colonies of our own and other empires; and most of all the socialist countries. I need say nothing here about the already established trade with the old Commonwealth countries, with the United States and with countries in Europe.

With regard to former colonies, Britain has maintained and extended her trade but is, nevertheless, falling behind relative to other exporters. This is not due to any technical failure, for British industries can easily make all the goods and machinery needed and at reasonable prices, but rather to restrictive finance. Government and banks are unwilling or,

as they say, unable to provide the necessary long-term loans[1]. They forget that the main reason they cannot do this is because of their huge expenditure on armaments. This is yet another reason why disarmament would benefit the British people.

Even greater benefits would follow from a rapid increase in trade with the socialist countries, particularly the Soviet Union and China. The reason is that the economies of both sectors are largely complementary. It is from the present socialist countries that we may expect to get additional sources of raw materials, and they could take our most well-established lines of engineering products. The damage that has already been done to British industry by the qualitative embargoes placed on countries such as the Soviet Union, Eastern Europe and China is very large indeed and has been recognized to be so by leading business circles in this country, at least to the extent of partially modifying the embargo on China.

Total repeal of the embargo would have results much greater than those predicted by many conservative economists, for, by pointing out that trade with the Soviet Union was never a large part of British trade, they think they have disposed of the matter. They forget, first of all, that trade with the Soviet Union had always been held back on political grounds ever since its foundation forty years ago. Secondly, they fail to notice that the technical and economic developments of the Soviet Union have been so great that we are effectively dealing with a completely new country, capable of disposing of resources many times—probably between ten and thirty times—as great as the old Tsarist Russia. Indeed, in any period of economic difficulty, trade with the socialist part of the world would probably be the salvation of Britain.

Such trade, however, cannot be without its political implications: there is no question of demanding any military alliance in return for trade, but it is absolutely reasonable to expect a cessation of an actively hostile political policy. Trade with China would have the additional advantage of being a market for types of machinery of which the Soviet Union has already enough. The role of Britain may very well be that of urging on its allies, in their common interests, the need to abandon one fundamental objective of the Cold War, the promoting the economic ruin of the socialist countries by the combined effect of blockade and an armaments race (p. 216). It is true that the blockade is increasingly

[1] The amounts that might be made available in the form of long-term loans would depend on the degree of effective reduction of armament expenditure. The figure proposed at the 1957 Labour Party Conference was one per cent of the national income, that is some £200 million per annum, or one-sixth of present arms expenditure. My own view, as expressed in Table XXI (p. 246), is that it would be reasonable ultimately to provide the larger sum of £350 million per annum. I am assuming a cut in armament by two-thirds, which should release £1,050 million. The remainder of the saving would be divided as follows, £250 million going to welfare and £450 million to badly needed capital re-equipment for British industry. Actually, much of the sum allocated to the underdeveloped countries would be spent in re-equipping British industries to provide the production goods to be exported, so that effectively it would add to capital formation in Britain.

ineffective, but it is nevertheless hampering the whole development of the world today and maintaining a permanent state of tension (pp. 22 f.).

Nor is this policy one which can be left over to be adopted at some distant date. One of the results of the earlier stages of the blockade has been to force socialist countries, not only the Soviet Union but also China and Eastern Europe, to build up complete economies, that is, at great expense to create industries to make products which it would have been cheaper to import from Britain and other industrial countries. As this process goes on and as these industries increase their output and lower their costs of production, the need for imports from Britain will progressively decline. The time may not be far off when, in nearly all the field concerned, these markets will cease to exist, and then the openings for British trade will be permanently reduced.

There is little need to fear that in working for an extended trade with the Socialist countries, Britain will have any serious risk of a political or economic rupture with the United States. The danger is rather at the moment that the U.S. will be the first, under the pressure of its own economic difficulties, to break the economic Iron Curtain, leaving her loyal ally to pick up what trade is left over[1]. However, if the worst came to the worst and an American administration was so foolish as to put any restriction on Anglo-American trade it would be unlikely to last long or to have very serious effects while it lasted, at least not to Britain.

Britain's dependence on U.S. trade or on dollars has for so long become an act of faith that few stop to examine what it means. It would certainly not notably affect food for only 7 per cent of our food imports come from the U.S., and only 18 per cent are paid for in dollars, and these are of a kind that could easily be obtained elsewhere. Nor need it affect oil, for this, though largely paid for in dollars, most of it comes from the Middle East and, with a prospective glut of oil, ways would no doubt be found to convert to sterling. In fact, of Britain's total imports from the United States 13 per cent is for cotton and 10 per cent for tobacco. As Britain is primarily a manufacturing country, there need never be any permanent shortage of any product for which raw materials exist. Now, there are no raw materials that come only from dollar countries, so that any shortages which might follow from a U.S. embargo on this country would be short-lived. Indeed, it is the realization of this that would deter the U.S. government from taking any hasty action against Britain, which would only hurt their own business interests.

All these considerations of our future industry, agriculture and trade are necessary, not so much on their own account, but because they are the means of providing the material basis for a better life for the people of Britain. The general lines along which the new powers given by science can help this have already been discussed in other chapters, but

[1] The negotiations now going on for an economic treaty between the U.S. and the U.S.S.R. are already pointing in this way.

the particular application to Britain is a matter for the people themselves to decide. Especially necessary here is an adequate provision for health. The National Health Service was a fine start, but it was more effective in removing the dread of expensive operations and unpaid doctors' bills, than in actually improving health. For that, we need the new hospitals and health centres, promised to us fifteen years ago. Only one new hospital has been built in Britain for the last thirty years, less than in any country in Europe. In education, even greater changes are needed, but these are best discussed in the next chapter. As for culture and sport, and the various occupations of leisure, from gardening to mountain climbing, there is already such a strong drive to cultivate and enjoy them that all that needs to be done is to make the opportunities for them available to all.

This examination of the prospects of Britain in the new world which is just beginning to take shape shows that it is both technically and humanly possible for the country, not only to adapt to the new conditions, but to benefit greatly from them. Britain can find in the new opportunities offered a chance of renewal and expansion of its economy and the prospects of a better life for its people. But it can only do so by participating fully in the transformations of our times. If it chooses, or is persuaded to choose, to continue in the old way, it will not hold its place, but will drop back to a lower rank among the nations and a poorer and more anxious life for its people.

I am confident, on the basis of the whole history and character of the British people, that we will choose the forward path. In it there will be many and great difficulties some of which will be hard to foresee because such an enterprise of this scale has never before been attempted.

The economic task is nothing less than reconstituting British industry as a whole along new lines. Here it is not a question, as in the underdeveloped countries, of creating a new heavy industrial base—this base exists, with a full capacity for self-regeneration. It requires to be made fully effective, and this can only be done if new methods are injected and new capital construction undertaken in time. This in itself means a great economic effort and a jolt to our relatively easy-going, not to say restrictive, ways of this century. It is absolutely impossible to do this without a drastic cut in military expenditure. We need to spend, as indicated in Table XXI (p. 246), at least £450 million of new capital a year on rebuilding and equipping our industries along modern lines, as well as expanding their production in order to co-operate in developing backward countries in the ways already indicated[1].

A policy of economic expansion is, I have argued, of vital necessity

[1] Mr. Shonfield (*op. cit.*) proposes an ambitious Five Year Plan for British industry. This is economically and technically perfectly feasible, but seems to me somewhat naïve financially and politically. This is because he envisages the changes to be carried out by the very men who have prevented any such advances in the past, and without the organized working class support that alone would make them possible.

and urgency for Britain. I believe, however, and the events of the past forty years support me, that it is a policy that is incompatible with the retention of private enterprise. It is not that there is any doubt about the ability of such enterprises to secure profits. British industry is now largely a series of linked monopolies which have managed, particularly in the last ten years or so, to do very well for their shareholders; but this is not the same as, and in some cases it is in direct conflict with, doing well for the country as a whole, either internally or in its economic position in the world.

To quote as old and respectable an authority as Adam Smith, speaking of the capitalists of his time:

> "an order of men, whose interest is never exactly the same with that of the public; who have generally an interest to deceive and even to oppress the public, and who accordingly have, upon many occasions, both deceived and oppressed it."
>
> *Inquiry into the Nature and Causes of the Wealth of Nations*, 1776.

We have passed the era in which private monopoly control of industry is even workable, let alone equitable. It is already unacceptable to the great majority of men and women who actually operate it, and they have only put up with it so far in a spirit of general unwillingness to co-operate more than they absolutely have to in a system which is opposed to their interests. This lack of enthusiasm for work has often been commented on in the capitalist Press, when, in fact, it is in itself a very minor factor in accounting for the backwardness of British industry. The real causes lie in the inefficiency, the lack of capital and the generally restrictive attitude already discussed. I mention it only to contrast it with what the productivity of industry could be if, in addition to remedying these material factors, the workers felt they had a real and personal interest in the production. Already most of the main Trades Unions of the country, including the Confederation of Shipbuilding and Engineering Unions, and the National Federation of Building Trades Operatives, have passed resolutions to secure the immediate nationalization of the key industries of steel, engineering, chemicals, cement and building. This is resisted by the present leaders of the Labour Party, ostensibly for electoral reasons, but in many cases because they still firmly believe in the capitalist system of production.[1] The demand for nationalization, however, is bound to grow with the economic difficulties into which the country is entering and will lead, for the first time, to a British economy which is basically socialist.

[1] The policy document of the Party, *Industry and Society:* "under increasingly professional managements, large firms are as a whole serving the national well. Moreover, we recognize that no organization, public or private, can operate effectively if it is subjected to persistent and detailed interventions from above. We have, therefore, no intention of intervening in the management of any firm which is doing a good job."

This, in my opinion, will be a necessary condition for a general transformation of British industry, but by no means a sufficient one. It can be effective in time only if it is undertaken with enthusiasm and hope. We have in this country already seen that hope arise at least twice, once after the First and once after the Second World War; but because the new change is one which will demand more from, as well as give more to, the people, they must this time be convinced and assured that their hopes will not be deceived as they have been so often in the past. Only a really popular government with the continued support and criticism of the people can carry such a radical and difficult change.

The main drive behind such a government must come from the organized working class, for they have no interest in maintaining the present restrictive policy, and every interest in changing it. Furthermore, they have the greatest chance of securing these aims, for the working class is a greater element of the population in Britain than in any other country. If the working-class is to give its support, it will demand, as, indeed, is already demanding, a far greater say in the running of industry than ever before[1]. This is especially so in the transition to automation which will require rapid and drastic changes in employment and skill. This means that, along with nationalization, it will be necessary to provide for much greater workers' control and direction of management, especially so, as the new type of industry will itself demand from the workers far greater skill, responsibility and intelligence than the old (p. 59). At the same time, this should facilitate the assimilation of interests and active co-operation between the workers in the new industries and the scientists and technologists who will be responsible for its further evolution. A change-over on this scale must inevitably sweep away many vested interests and shake many well-established habits. Because time presses and the whole economic position of the country is in danger, it cannot be undertaken so slowly as to be imperceptible, but must set definite targets to be reached in short periods by which people can judge how things are going. At the same time a long-range plan is also necessary. For there will be inevitable, unforeseen difficulties to be overcome and, to prevent wavering, people must see the line ahead.

Here, I can not enter into a discussion on the conditions in which this change-over will be undertaken, but at least we know that this time it cannot be as a result of another war, because a nuclear war would leave Britain in no position to reconstruct its industry. Any survivors would be hard enough put to it to scratch some wretched living

[1] The *Plan for Engineering*, adopted by the Confederation of Shipbuilding and Engineering Unions in 1951, provides for nationalization of the main sections of the aircraft industry, the main mining machinery firms and shipping, shipbuilding and repair and marine engineering, and varying degrees of public control over other sections of engineering, especially machine tools. At its 1957 Conference the Confederation reaffirmed that ultimate public ownership was in the best interests of the membership.

in the ruins of our cities and industries. Nor would an occasion of an economic disaster be profitable for the change. We should try to see that the transformation of British industry is a deliberate choice in advance of any economic crisis. This may be too much to expect because prosperity, however insecure, does not give much room for radically new enterprise. The best we can reasonably hope for is that the change-over will be initiated in time, when sufficient people have seen the dangers, but before these have become so serious as to damage the economic position of the country irreparably.

In the meanwhile, the most urgent necessity for Britain is the preservation of peace. It is not good enough to go on from day to day being thankful that no bombs have dropped yet: the risk must be removed and the Cold War brought to an end. The British government at the moment is one of the staunchest supporters of the Cold War and is, indeed, the most active ally of the United States. However, this very fact shows that the people of Britain have the power to remove the war danger if they were willing to use it. And this they are showing increasing signs of doing, as witness their massive reaction to the Suez crisis and the present widespread agitation for nuclear disarmament.[1]

This is already a fact of great world importance. The big business interests that have, under the rule of Democrats or Republicans, controlled the policy of the United States ever since the death of Roosevelt, cannot maintain their grip on the capitalist world unless they have the continued support of the British government. But it is not sufficient for them to have that government's nominal support unless they know that it can carry the whole of the country with it. This means, in the present state of political balance, that the policies adopted must have the support of the Labour Party and Trades Union Movement, expressing the will of the organized workers of the country.

Thus, any decision of the Labour Party to draw back from the suicidal logic of the great deterrent, and in favour of disarmament, would break down the whole policy of the Cold War and make possible that of peaceful co-operation which is the only one that offers a serious possibility of ending the present strains and inequalities of the world, of helping the underdeveloped countries to build a decent life for themselves, and of opening a way to peace and prosperity for the whole world.

[1] Organizations pressing for nuclear disarmament include the British Peace Committee, the Campaign for Nuclear Disarmament, the Friends' Peace Committee, the Peace Pledge Union, the United Nations Association. The national conferences of most of the British Trade Unions are also on record for it.

X

EDUCATION AND RESEARCH FOR THE NEW WORLD

In considering how the great changes we have discussed could actually take place and at what speed we might hope to put them through, one most important factor has been left over till now, namely the availability of trained men and women to carry out the changes in the first place, and then to make them work. To many people, and particularly to educated people, this has often been seen as a decisive reason why no such rapid change is possible. Material resources may exist in plenty, it might even be possible, though admittedly much more difficult, to see that the resources were divided in such a way that those who really needed them could use them. But, it is asserted, all this is quite impossible in practice, because people are not actually available to effect the changes. There are only very few competent, trained people in the world, and there never can be many more because the distribution of inherited intelligence is strictly limited. Further, even if there were enough people of potential capacity, there could never be any way of training them because of the lack of teachers and lack of resources for the necessary buildings. I have even heard it argued, at a conference on education in Asia held just after the war, that the effort to produce even a literate population in India, on a scale that the country could afford, would take at least two hundred years, and this explained why, after a mere hundred and fifty years under British administration, so little progress had been made.

Now, fortunately, I am not really obliged to refute such views because the knock-down arguments against them have been given by the actual educational and technological achievements of the Soviet Union and China. It can no longer be seriously asserted that the native ability is just not there, except on the unwelcome assumption that people in such countries as Britain and the United States are hereditarily more stupid than those of Russia and China. It is now only a question of how soon and on what scale it is possible to realize this human potential, and this will be the subject of the present chapter. We do not even need to argue whether it would be worth while to do so, or whether in fact happy ignorance is a preferable state for the majority of mankind, who have after all had to put up with it ever since the beginning of time. For we now know that the provision of a large scientific and technically

trained section of the population is an absolute necessity for the kind of world that we are already entering—the world of atomic power and automation, of scientific agriculture and medicine.

Indeed, we have already passed the point of no return. Our lives and livelihood already depend on the existence of science and technology to the extent that it would mean the death of hundreds of millions and of the lowering of the standard of living of many others if anything were to happen to interrupt the flow of scientific education and discovery. It is true that what we have now is only a very small fraction of what we could have, but we have had enough to feel its loss very acutely should it occur.

Not only that, quite apart from the usefulness of science, the idea that all this knowledge could be made available and is the birthright of every boy and girl in the world has got abroad, and there is an enormous pressure for education in every part of the world, particularly in the underdeveloped countries, such as has never been seen before. Why, therefore, does this case have to be argued in any way, why have we not already got this kind of education in Britain and the older industrial countries, not to mention the colonies, where over 70 per cent of the people are illiterate. The immediate answer is that education there has been for a long time one of the most treasured privileges of the ruling class. It is one that has been shared only to a very limited extent with other classes or peoples, always reluctantly and never on a sufficient scale to endanger their dominance. This policy may not be actually consciously recognized, but these are the assumptions that are built in to the typical educational system of Western Europe and, in a slightly different way, into that of the United States.

All through the Middle Ages in Europe the object of what little education existed was the training of the clergy. This did not only include instruction in their spiritual duties but also in the considerable administrative tasks which they carried out in their own lands and in those of the feudal lords as well. The clergy were, in fact, from the sixth to the twelfth centuries, the only administrative class in Europe. The first break with this monopoly came with the Renaissance, when a rising commercial class challenged this clerical monopoly of education in their own interests and added to studies of philosophy and theology those of the humanities and mathematics. It was Renaissance Humanism that gave us the higher education which effectively we still have. It was intended not so much for the clergy, though they still played their part, as for the nobility, the gentry and the mercantile classes. It was in their interests and with great reluctance that the universities were reorganized and the grammar schools were founded, with their equivalents in other countries, such as the French Lycées and the German Gymnasia.

More popular education was generally frowned on, although religous dissenters used it for promoting conscious opposition to the Churches. Here the pioneer was Comenius, the last bishop of the Moravian Brethren in the seventeenth century, whose enlightened plans for popular

education for girls and boys in subjects of practical interest to them was to inspire generations of educational reformers. In such countries as Scotland, Holland, Prussia and Sweden, the usefulness of a widespread popular education began to be appreciated. Yet it was not until the Industrial Revolution that it became necessary to have at least the three R's—reading, writing and arithmetic—as a necessary qualification for work in factory or office. Even when this was conceded, on as cheap a level as possible, higher education was still carefully guarded. In fact, at the beginning of this century in Britain, it was available to less than 1 per cent of the relevant age groups.

The battle to secure some measure of technical education went on with very slow successes through the later nineteenth and early twentieth century.[1] Even on the eve of the Second World War less than 3 per cent of the age group were receiving higher education in Britain, and of these only 28 per cent were in science and technology. The realization of Soviet successes in technical education began to seep through in the years after the war, and at long last led to some moves in Britain, for example, to the expansion of at least technical education, though the university figure has only risen to $4\frac{1}{2}$ per cent. Even in technical education the class aspect made itself evident in the keeping of it largely out of the universities and in providing technical institutes for part-time instruction of definitely lower than university standard. It is only in the last year or so that it is beginning to be recognized officially that this is still far from enough. So now we have much lip service to the need for increasing our technical education, as shown in the 1956 White Paper on *Technical Education*.[2] Nevertheless, in practice little is being done—indeed less than nothing— because with strictly limited resources the rise in prices is producing a virtual stoppage in educational advance.

An attempt to present a flow sheet of education as it is today in England and Wales is given in Figures 5(b) in comparison with that in the Soviet Union, (a), and a typical underdeveloped country, but one with a long history of high culture, Iran, (c). It shows the so-called educational ladder as something of an obstacle race with far more chance of falling out than of getting to the top.

The story in the United States, with its far greater wealth and its old established tradition of popular education, is different. Even though there some 30 per cent of the age group receive some kind of higher education, less than 10 per cent of the students graduate in scientific and technological subjects. As a result the supply of technical manpower, though better proportionally than Britain, is still far below that of the Soviet Union, as became fully apparent by the demonstration of the sputnik.[3]

[1] D. S. L. Cardwell, *The Organization of Science in England*, London, 1957.

[2] Cmd. 9703, H.M.S.O., London, 1956.

[3] K. Mendelssohn, "The satellite's moral for Britain", *New Scientist*, 17th, October, 1957.

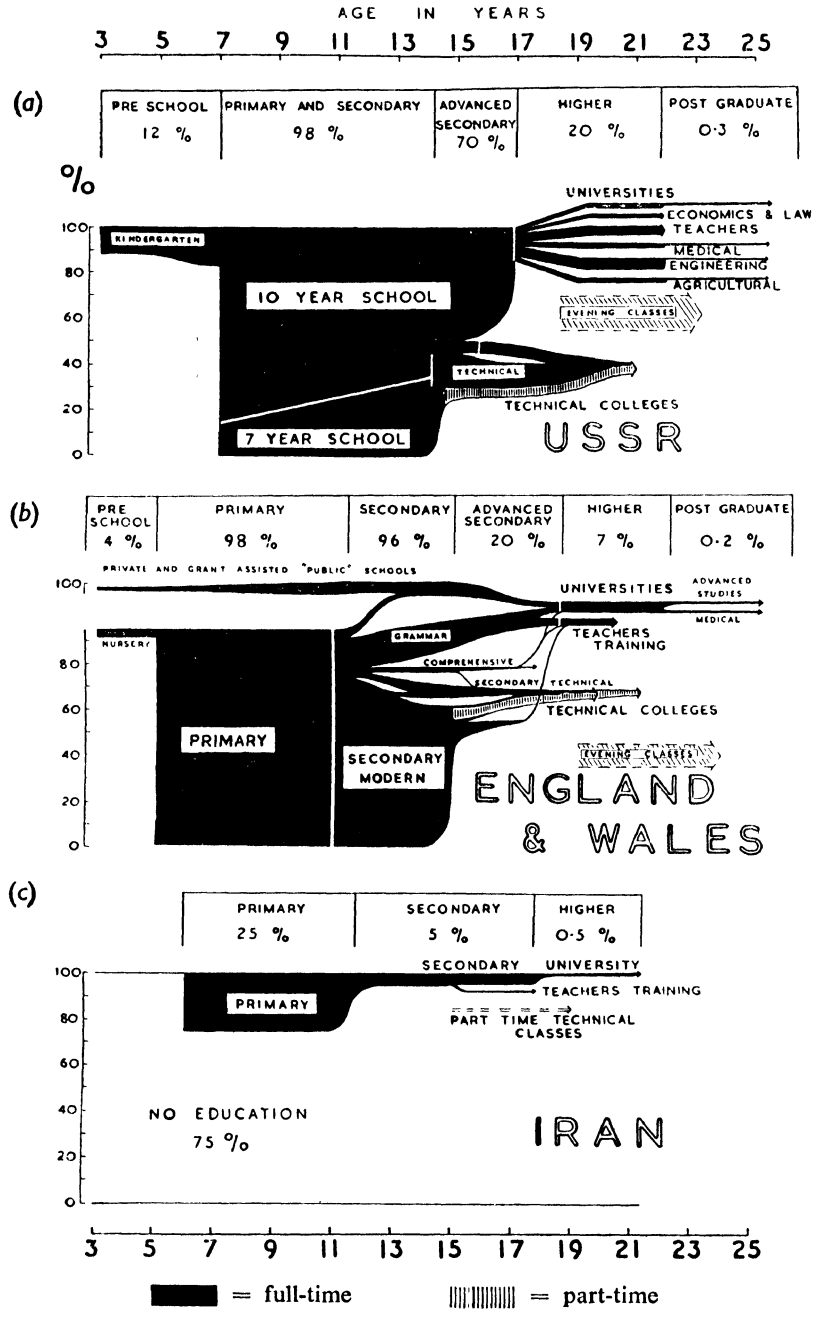


Fig. 5.—Educational Flow Sheets of three typical countries.

The Soviet educational system which is now setting the pace for education throughout the world, was built up with enormous labour and sacrifice during forty very troubled years, not as in Western Europe, on the basis of universal literacy, but from a population largely illiterate, so that the first task was to provide elementary schools for all. Only in 1934 was it possible to build up a secondary school education, which became universal in the cities from seven to seventeen in 1956, and will be universal throughout the country in two years' time. Higher education was divided, in a way more like the German than the Anglo-American system, into a number of separate higher teaching institutions: universities (limited to science and art subjects), engineering of various types, agricultural and medical, economics and other administrative subjects. It was continuously expanded by increasing the size and number of these institutions until at the present time it caters for some quarter of the age group and will cater for as much as 40 per cent in a few years' time.

A similar endeavour has been taken up in China, where even more rapid progress has been registered. Here the first problem of educating some 60 million children is being successfully tackled, though it is straining the intellectual resources of the country. The achievements in the Soviet Union and China show that any part of the world, whether it is an older industrial country with a tradition of class-limited education, or an undeveloped country where there is not even any popular literacy, can expand and transform the whole range of education from kindergarten to university. It also shows that to do this as rapidly as is needed requires a conscious and organized effort far surpassing that which has been put into education heretofore in capitalist countries.

The initial needs of industrial and of underdeveloped countries for education are at the outset very different, though ultimately, once the level of production is everywhere raised—that is within a couple of generations at the most—the same type of education will be necessary for all and will be available to all. For industrial countries where there is already universal elementary education, the main drive must be for improved secondary education on a larger scale and with more emphasis on science and technology, and also for a greatly expanded higher education in order to provide sufficient personnel to deal with the problems of an industry and agriculture based more and more on science.

It is not only a question, however, of training the technicians and

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The data for the flow sheets shown in Fig. 5 are drawn from a great number of official sources, including the U.N.E.S.C.O. *World Survey of Education*, Paris, 1955. They attempt to show, by the thickness of the black or shaded portion at any age, the *proportion* of that age-group enjoying a particular type of education. No account is therefore taken of changes of population, of the post-war "bulge" in Britain, or the far more severe gap, due to the war, of unborn or dead children, amounting to about ten million, in the Soviet Union. They also represent in all cases the educational system as it was in 1955, and take no account of the changes in educational systems which are still going on, particularly in the Soviet Union.

scientists, but also of promoting a general appreciation of science among all the population so as to achieve a high degree of participation in the work of transforming the economy. It would be of little value to change over from a superior class of clergy or manufacturers to one of scientists and engineers. If the new industrial revolution brings real benefits, and the foretaste we have of it is full of promise, it also demands much more understanding than did the old way of living. There will be fewer boring jobs, in fact there need be no boring jobs at all, but more people, in time practically everybody, will have to do far more thinking than has ever been done before.

We have to consider that, in the course of the next half-century or so, we will be moving towards a new equilibrium in the distribution of occupations. A hundred and twenty years ago in Britain, and still over a very large part of the world, 80 per cent or more of the people were occupied in agriculture. In those times and places it was much more important to have practical experience than book learning. Now, in industrial countries, about half the labour force is connected directly or indirectly with industrial production and distribution, the remainder being in administration, education and other services. Only some 10 per cent are occupied in technical jobs and a far smaller number, about one-half per cent, in scientific research. With the advance of automation the proportion of factory workers will drop rapidly, and so will that of many clerical occupations and even of distribution and transport occupations. Although the net result will be a smaller time spent in work of any kind, the numbers of people in highly skilled and scientific

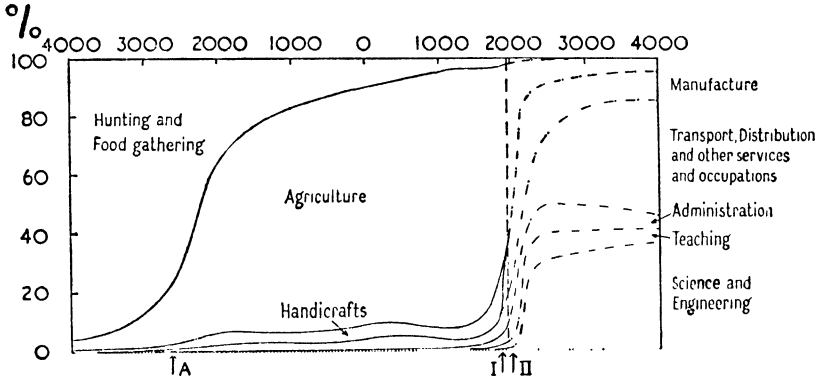
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The three diagrams in Fig. 6 are drawn to illustrate in a semi-quantitative way the changes in the relative *proportions* of the major human occupations, over various periods of elapsed history and their possible extension into the future. They accordingly take no account of the great changes in population which have occurred; any attempt to do so would have made it impossible to see the distinctions in the early periods.

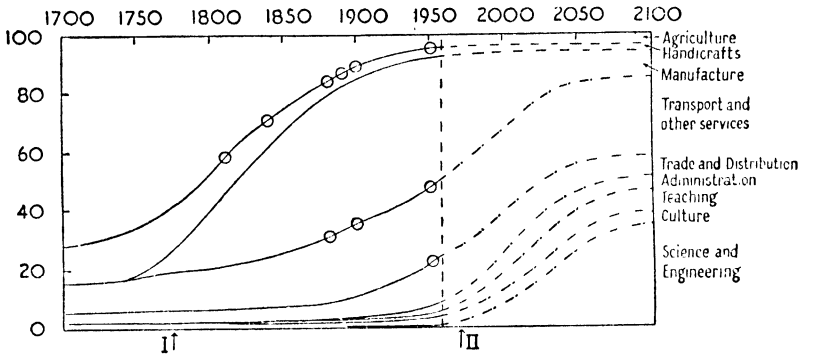
The first diagram (a) dealing with the broad sweep of history is necessarily the most speculative. It is put in to show the 5,000 years during which agriculture has been the dominant human occupation (↑A marks the onset of the agricultural revolution). The decrease of hunting shown is relative rather than absolute. There were probably more hunters and trappers in the nineteenth century—on account of the fur trade—than in the paleolithic. On this time-scale, the First and Second Industrial Revolutions (I ↑ and ↑ II) can hardly be seen as separate; a line situated at the beginning of the nineteenth century marks the transition from handicraft to manufacture.

The second diagram (b) refers specifically to Britain, and is drawn to bring out the transition between the First and Second Industrial Revolutions. The circles on the diagram are derived from very imperfect census returns, but they are sufficient to show that the era of manufacture as the chief human occupation is coming to an end. The lines for the near future are based on recent trends, particularly in the growth of science and engineering, which is doubling every eight years or so, and is likely to go on doing so, at least for another fifty years.

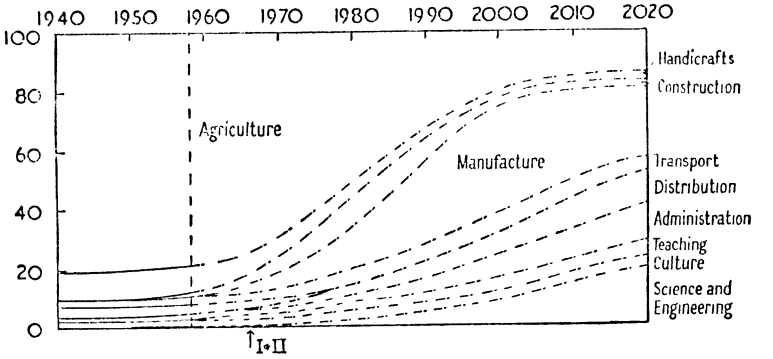
The third diagram (c), on an even larger time-scale, is a frank prediction, along the lines suggested in Chapters VII and XII, of the probable changes in occupations of an underdeveloped country on the way to industrialization. Here the First and Second Industrial Revolutions are entered into at the same time. It is based particularly on the experience of China, which is today at the stage corresponding to 1970 on this diagram.



(a) The world, from the dawn of civilisation to a scientific system of production



(b) Britain through the first and second industrial revolutions



(c) Typical under developed country with first and second industrial revolutions run together

Fig. 6.—Changes in occupation in the past and the future.

occupations will have to increase by many times, especially those needed to advance and maintain the far more complicated equipment of an age of atomic power and automation (p. 59). If it is conceived from the outset as an ordered transformation of industry in a planned and essentially socialist economy, the changeover need not be a painful one. There will be no need to repeat in another form the miseries and injustices which characterized the Industrial Revolution, where an agricultural population were more or less forcibly driven off the land and herded into factories, Nor need it result in a vast industrial unemployment, such as characterized the great depression of the 1930's, though there are signs that something like that is happening in the United States.

In Figure 6 I have sketched an entirely speculative picture of the change-over in the types of employment which may take place in the years to come. This diagram may serve to bring out the difference between the coming change-over and those of the past, such as the Agricultural Revolution, six thousand years ago, and the Industrial Revolution, two hundred years ago. In contrast to them it will be inevitably much more rapid both in the industrial and in the underdeveloped countries. It will not be the kind of imperceptible change that is only noted between generations, but will affect the occupations of those now working. It will, indeed by so rapid that it will be necessary not only to consider a new type of education of the young but the re-education, in fact the continual re-education, of adult workers.

This problem is already making itself felt. As automation makes workers redundant there is an insistent demand that alternative employment should be provided, and if such employment is not available in the old trade then the employees should be trained in a new one in which they will do as well or better for themselves. Moreover, as the types of employment that will come successively into demand in the next few years are all likely to be more interesting and more rewarding than those they replace, there need be little cause for individual complaint. The real danger lies in the changes taking place, as they may well do, in the midst of a slump in the capitalist countries. In that case, many skilled workers may find themselves thrown on the "scrap heap", as the expression used to be in the thirties.

An even more serious difficulty lies in the fact that the new type of industry makes demands of a different kind, or rather it makes the old demands for ingenuity and creativeness, on a much greater scale than ever before. In the past all that workers were required to be was hard working and reliable; skilled workers were praised, and sometimes rewarded for good work. However, from now on for a worker to just

Table XV, based on the best available data, mostly for 1956, attempts to place in perspective the active scientific and technical manpower in different countries. The numbers of scientists, except for the first four countries, are very approximate. In comparing the numbers of scientists and engineers in different countries, the proportion to industrial workers and to the number per tons of steel produced (columns 4 and 5) is what is significant for the degree of industrial development.

TABLE XV

Scientific and Technological Manpower (1956)

Country	*Total Number of Fully Qualified Scientists and Engineers (Thousands)*	*Total Population (Millions)*	*Scientists and Engineers as % of Total Population*	*Industrial Workers per Scientist or Engineer*	*Scientists and Engineers per 1000 Tons Steel Produced*
U.K.	160	50	0·32	70	7
U.S.A.	1,000	168	0·60	22	10
U.S.S.R.	1,000	200	0·50	26	21
France	60	44	0·14	115	5
W. Germany	120	51	0·24	82	5
Other European	400	266	0·11	80	9
China	100	600	0·017	80	20
India	50	380	0·013	100	30
Japan	100	90	0·11	85	9
Others	100	888	0·01	150	30
World Total	3,000	2,737	0·1	45	10

Sources: Based on *Shortages and Surpluses of Highly Qualified Scientists and Engineers*, D.E.E.C., Paris, 1955.

Annual Report of the Advisory Council on Scientific Policy 1956–1957, H.M.S.O., London, 1957.

National Register of Scientific and Technical Personnel in India, New Delhi, 1953.

carry out his set task or even to carry it out well, will not be good enough. Every successful industrial enterprise will, in an age of rapid change, also have to be an operational research laboratory where it is a matter of continually examining the performance of the existing set-up and criticizing it in order to improve it.

Under capitalist conditions the need which already exists for such examination and criticism comes straight up against the real division of interests between the managment and the workers. It is idle to expect any kind of assistance in, still less co-operation with, schemes the result of which is only to make the work more difficult or to lose people their jobs. Management and operational research are seen to be an imposition from above by specialists, and not a real movement by the workers themselves to improve the conditions and at the same time the productivity of their work.

Apart from such generally diffused initiative and creativeness, far more workers than at present will have to be withdrawn from current production to prepare for the jobs of the future in full-scale pilot factories, and others for tasks even more remote to advance the sciences on which those future plants have to be based. This requires, not only a multiplication of scientific research workers, but, as scientific research work is now getting to be a task involving more and more buildings and equipment, it also requires the building up of scientific research into a fairly large industry in its own right—a process which is already occurring to a limited extent in the capitalist industrial countries (pp. 20 ff.), but so far there mainly for military research, particularly in aircraft and rockets.

It is difficult to fix a sequence of targets for the requirements of new categories of workers in scientific and technical research and development. All that we can say at the moment is that in countries like the United States and even now in Britain the numbers are far too small and the maximum rate of increase of some 5 per cent per annum which is officially contemplated will still leave us far behind the already achieved ratios in the Soviet Union (Table XV). Given a real effort, however, these levels could be reached and the proper balance could be achieved within about twenty years. This prediction will seem hopelessly optimistic to those whose conception of educational change is based on an examination of the rates in the past. What they have not realized is that even with a steady increase of entrants of 5 per cent per annum, which will correspond to past achievements in critical periods such as that immediately after the last war, we should still be far behind. If higher rates seem impossible now, it is essential that the reasons for

In Table XV the figures are for total enrolment; it should be borne in mind in comparing them that in the Soviet Union there is a 5–6 year course in scientific and technical institutes whereas in the United States and Britain it is 3–4 years. This, however, has been taken into account in deducing the percentage of the age groups concerned.

TABLE XVI

HIGHER EDUCATION: TOTAL ENROLMENT OF STUDENTS OF SCIENCE AND TECHNOLOGY, INCLUDING MEDICINE AND AGRICULTURE

(Thousands)

Country	1938		1947		1952		1957	
	Number	% of age group	Number	% of age group	Number	% of age group	Number	% of age group
U.S.A.	360	3·7	650	7·4	560	6·4	620	7·0
U.K.	28	1·0	43	1·6	49	1·9	52	2·0
U.S.S.R.	440	3·6	790	5·3	1,070	6·9	1,500	9·0

Sources: Based on *Returns from Universities etc. in Receipt on Treasury Grant* (for various years), H.M.S.O., London.
Scientific Manpower—1956, National Science Foundation, Washington, 1957.
National Economy of the U.S.S.R., Moscow, 1957.

holding back the advance should be examined in more detail in order to find out to what extent they are real reasons and to what extent they simply represent a mixture of economy and complacency, based on a firm belief in the class limitation of education.

We may not agree in every case with the American Senator who remarked—speaking of Sputniks—"There is no problem that cannot be solved by signing a cheque," but at any rate the problem of improving education will not be solved without considerable expense, considerable that is in comparison to what has been spent on education up to now, but very small as compared to other expenses of far less ultimate social importance.

The figures in Table XVII show that this is so, even for the wealthiest countries. It is not that these countries could not afford education, but that they prefer or feel obliged to spend it in other ways. In the United

TABLE XVII

MILITARY, EDUCATIONAL AND WELFARE EXPENDITURE IN THE U.K., U.S.A. AND U.S.S.R, 1957

Type of Expenditure	*U.K.*		*U.S.A.*		*U.S.S.R.*	
	£ *billions*	% *of total*	$ *billions*	% *of total*	*Roubles billions*	% *of total*
Military	1·53	44	44·3	59	96·7	35
Educational	0·68*	20	16·5*	22	67·3	25
Other Welfare	1·25	36	14·0*	19	109·4	40
Total	3·46	100	74·8	100	273·4	100

Note: * These figures have to be estimated as national and local expenditures are involved.

Sources: *Statistical Yearbook, 1957*, U.N., *New York*, 1958.
Statistical Abstract of the United States, 1957, Washington, 1957.
Economic Survey of Europe, 1957, U.N.E.C.E., Geneva, 1958.

States, educational expenditure comes a very poor second to military expenditure, it is 42 per cent of it; Britain is not much better at 44 per cent; while even in the Soviet Union educational expenditure is only 72 per cent of military expenditure. Once there is any serious measure of disarmament, money would no longer limit educational advance in industrial countries, and there would be enough to spare to help badly needed education in the underdeveloped countries.

Money, however, it has been urged, is not the limiting factor even when translated, as it can readily be, into buildings and equipment. Rather, the critics argue, it is that there are not enough people to do the job—there is a shortage of schoolteachers, especially in science, as well as a shortage of professors for the new universities that would be needed. Now we have the examples of other countries to show us that this latter shortage is not a necessary one—there are plenty of young scientists, research workers, junior lecturers today who could quite well be promoted immediately to full professors with proper salaries. In the early nineteenth century many professors were appointed in their twenties. If it were possible to create new universities in the fifteenth and sixteenth centuries it should be even easier to do so today. One may even doubt whether the cry that the sacred standard of education will be lowered would prove to be true. In the enthusiasm generated by a rapid increase in education, it may be that some of the older accepted truths would not be adequately taught or might even be entirely overlooked, but on the other hand the students would have much more opportunity of thinking for themselves and discovering new truths, perhaps better fitted for the new times. We will return later to some considerations of how this change-over could be achieved in detail (pp. 199 ff.).

If the need of the already industrialized countries is essentially for a greater proportion of higher technical and scientific personnel, that of the underdeveloped countries is for general education all along the line, first and foremost for literacy. Luckily, we have had enough experience under extreme conditions in the last few years to realize that the problem of illiteracy is not by any means as difficult as it has been made out to be. It has already been almost solved, and on an enormous scale, within eight years in China. In the more advanced and populous Northern and Eastern provinces, urban illiteracy has been almost abolished, while in the country districts more than fifty million adults are learning to read, and nearly all children are attending elementary school. In the west, and among the non-Chinese nationalities, progress is necessarily slower but there also illiteracy will be wiped out within a decade.[1]

[1] According to the *Hsinhua News Agency*, 9th May and 10th June, 1958: "60 million people are actively taking part in the nation-wide campaign against illiteracy. Illiteracy has in the main been wiped out in 156 counties in various parts of the country. A movement has been started by the masses to set up schools with their own investments, with emphasis on the building of primary schools. So far,

It has needed quite an effort there to achieve the degree of literacy, involving not only trained teachers but a large proportion of the literate people who were used to teach the others and even newly taught illiterates were sent to teach complete illiterates. Inspired by the new pride of liberation and the campaign for universal literacy—an essential first step to reach economic independence—it went with a swing, even though some recognized sadly that this was the end of the privileges of the old class of intellectuals or landlords who had effectively ruled China for three thousand years.[1]

Similar progress is now being made, but rather more slowly, in India and in many other countries. Even where the government is still colonial as in many parts of Africa, so that there is little or no assistance to popular education, the people have taken it into their own hands to be able to anticipate. One of the first acts of the British administration when faced with the Kikuyu uprising a few years ago, was to close down the native schools, which were considered to be nests of disaffection as were the hedge schoolmasters of Ireland two hundred years ago. Now that the country is once again pacified, what is being done for "native" education may be judged by the £2 a head provided for the education of the African children—most of whom, accordingly, get no education at all—compared with the £150 a head provided for the European children.

[1] As an example of a daring break from the past is the planned changeover from the use of the age-old Chinese characters to a Roman script which should be complete in thirty years and may be in much less.

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the 7 provinces of Kiangsu, Chekiang, Honan, Hunan, Fukein, Kiangsi, and Heilungkiang have basically attained compulsory primary school education. Counted by counties and cities, the total number of counties and cities that have instituted compulsory primary school education has reached 1,070 according to incomplete statistics from 23 provinces and autonomous regions. Now 90 per cent to 98 per cent of school age children in these counties and cities are studying in schools.

"The number of new middle schools set up in various parts of the county is also remarkable. More than 130 higher educational institutes have also been set up by 16 provinces and municipalities. Many new scientific research institutes have also been established.

"The total number of peasants in 13 provinces and outskirts of Peking who are now studying in spare-time classes has grown to 46 million. This is nearly one-tenth of the country's total rural population.

"Illiteracy has already disappeared among the overwhelming majority of young and middle-aged peasants in China's northernmost province Heilungkiang.

"In many areas in Hopei Province, over 90 per cent of the remaining illiterate young and middle-aged peasants have been enrolled in spare-time classes. Reports from many parts of the country show that whole peasant families are going to school.

"Today a common watchword among the peasants is 'to make rapid progress both in spring sowing and spare-time study'. They take textbooks and blackboards with them to the fields and construction sites. In Lungki county, Fukien Province, peasants have written newly learned characters on the rocks and trees near the fields in order to memorize them.

"In many areas Secretaries of local committees of the Chinese Communist Party are giving direct guidance in the anti-illiteracy campaign. Visiting groups are sent by peasants to areas which have achieved outstanding successes in order to learn their pioneering experiences".

However, this restriction of education is only a despairing hope of preserving foreign domination through enforced ignorance. The general sentiment of the whole world favours the provision of universal literacy. Something, though pitifully little, has been done also on an international basis under the auspices of UNESCO over various parts of the world, to develop interesting and cheap methods of introducing literacy in such varied countries as Mexico, Morocco, India and Thailand. The real difficulty is to find the money and the political drive. "Operation Literacy" on a world scale would in fact only cost $10,000 million and could be virtually complete within about five years.

Though far less in scale, the task of providing middle and higher education is likely to be more difficult and to take longer. This for instance has proved the main bottleneck in Chinese education, because the number of people capable of being trained for scientific and technical jobs depends on the output of the secondary schools and this in turn on the output of the primary schools from five years back. The effect of new Primary Schools, therefore, does not make itself felt for some years. As, meanwhile, the country could not wait for adequate supplies of technicians, recourse was made to education of a semi-adult type. Young workers were taken into special schools attached to the universities and given the necessary training in literacy and elementary subjects to fit them to enter the universities after two years' study. This is not claimed as the equivalent of a proper secondary education, but, given the needs of the time, it did do the job and produced the thousands of geologists and engineers necessary for the first and vital stages of the transformation of the agriculture and industry of that vast country.

Such crash methods may be necessary in other undeveloped countries In any case it would be wrong to hold up the development for lack of suitably trained native personnel. Although foreign advisers can be used and indeed can perform an essential task in underdeveloped countries, they can never be there in adequate numbers, nor can they function as teachers as well as executives unless they are surrounded and backed up by persons with adequate training to appreciate the points they are making who will be ready to take over from them within a few years in their jobs of training new workers and advancing the level of technique (pp. 123 f.)

The objective of the industrialization of a former colonial or other technically backward country is not to make it an imitation of an older industrial country. It is a task undertaken by the people of that country in order to produce their own kind of industrial culture and to stand on their own feet, not only technically but also scientifically. This, in fact, has happened in certain cases even before the liberation or the industrialization of the country, notably in India, where a few devoted men, overcoming great difficulties in absorbing a foreign culture through a foreign language, did make a name for their country in the fields of abstract science.

These achievements are no longer enough. What is wanted now are scientists who can appreciate the particular needs and particular genius of their own country and do there with and for their own people what no foreign scientist could do. On account of the international character of science, it is essential for the self-respect of the newly industrial countries to share fully in international scientific life. At first, perhaps, they need to absorb existing knowledge and then, as soon as possible, to make their original contribution. But this need not involve any great delay because scientists mature early. It only requires the establishing of the institutes for fundamental and applied science from the very beginning of reconstruction. Indeed, this was the policy Lenin was already applying in Russia right from the darkest days of 1918. One of the more far-sighted tasks carried out by the new Indian government just after the liberation, was the setting up of an active Department of Scientific and Industrial research, with twelve major research institutes. This has been criticized on the grounds that it was too early to withdraw scientists from the task of teaching to that of research but the error, in my opinion, was on the right side and it should be corrected, not by slowing down the growth of the research institutes, but by the acceleration of that of the science departments of the universities, particularly on the practical side.

This production of technicians in adequate number is only the first charge on higher education in rapidly developing countries. It is equally essential that the basis should be laid, as early as possible, for fundamental science both in university teaching and in research. It is true that in the first five years of the Chinese Republic, as was also the case in the early years of the Soviet Union, trained research workers were needed more for teaching than research, but this was admitted to be a temporary phase and is now practically over. The beginning of genuine research, without which no effective university teaching can take place, has already been organized on an adequate scale through the reorganized Academia Sinica.

Naturally, in the building up of science in underdeveloped countries, it will be desirable to keep as much foreign contact as possible both by the visits and residence of foreign scientists in the underdeveloped countries, and by the taking up and training of their scientists in more well-established scientific centres abroad. Indeed, this has been done in India where most students go to Britain, and in China where most go to the Soviet Union. These national limitations are due to the political division of the world and it would be well if they were completely wiped out and students could go to the places where their interests are best served. It is in such studies that permanent links are set up which should go far to weld the whole body of science together as a common human enterprise.

Once the necessity of raising the educational level and producing an adequate number of highly trained people in all countries is understood

and admitted, we can consider the real difficulties in the way and how to overcome them. For although actual practice has now demonstrated in many countries the task to be a possible one, it has also revealed great difficulties and many shortcomings, the lessons of which should be learnt in making any further efforts in the same direction. The general state of economic and political stress under which the major transformations have occurred in the last few years, have in themselves prevented the problem being considered sufficiently clearly and dispassionately to avoid repeating many of those mistakes. We should now, in the countries that still have to carry out this revolution in education, be able to think more logically so as to avoid them.

In Britain, for instance, the principle of an equal educational opportunity for all children was supposed to be embodied in the Education Act of 1944. Its object, according to the White Paper on "Educational Reconstruction",[1] was ". . . to secure for children a happier childhood and a better start in life; to ensure a fuller measure of education and opportunity for young people and to provide means for all of developing the various talents with which they are endowed and so enriching the inheritance of the country whose citizens they are. . . ." This was to have been achieved by compulsory education up to 16 years of age, followed by the alternative of a full-time common secondary school or a part time people's college. What we actually got was compulsory education to 15, and an effectively class-segregated secondary education. Nevertheless, the only possible source of supply for the far greater numbers who will need to receive higher education for a modern scientific-industrial state is the whole population without discrimination. To remove that discrimination is a very difficult task which is as much political as educational.

We must start from recognizing the fact, given the marked class distinction in capitalist industrial societies, that boys and girls from different kinds of homes have different abilities. In tasks mainly of an academic or literary character they will receive very considerable and almost automatic training in middle- and upper-class homes, and none or little in working-class homes. Selection for higher education in the past was based quite frankly on class and wealth—a few of the poor managed to get up through genius, luck or favour—but it was recognized in all countries of Europe that there existed a more or less hereditary professional class or intelligentsia. Similar and much more venerable intelligentsia were to be found among the Brahmins of India and the Mandarins of China. It was from this educated class that candidates for all senior administrative and educational posts would normally be drawn. The distinction was not so clear in the United States where originally money, and the skill to make it, counted for much more and class for much less, and where all kinds of more or less

[1] Cmd. 6458, H.M.S.O., 1943.

legitimate methods of enrichment existed for enterprising people with or without education.[1]

In Britain, the number of students, in all subjects, receiving higher education are 85,000 or 4½ per cent of the corresponding age group. But this 4½ per cent represents 7 per cent of the boys and 2 per cent of the girls of the corresponding age groups and that in fact we have potentially available to us in this country, and to a large extent in most of the old industrial countries, another half of the population, the women, to put into the occupations requiring higher education. In Britain the selection for further education by wealth was replaced on paper in 1944 by selection through intelligence tests—the controversial eleven-plus examination. This examination effectively settles the educational fate of every boy and girl before they reach the age of twelve; for by controlling the entry to the Grammar Schools, it effectively bars the way to higher education for all who fail—unless their parents can find enough money to send them to the private and exclusive "Public Schools".

Moreover, as the selection had to be made to provide for a number of places not markedly more than those available simply to moderately wealthy parents—the children of the really wealthy going then, as they still do, to "public schools"—opportunities for education did not get much wider than they had been before. Nor did the children chosen for higher education come from a markedly different type of homes. This was largely because, without any necessary intention, the tests discriminate in favour of children from professional and lower middle-class homes against those of the manual workers. In fact, owing to the loopholes offered for paid students, practically none of the children of the professional or other classes went to the secondary modern schools in which were lumped some 80 per cent of the children of the country, and from which it is practically impossible to go to the universities.[2] Nominally those going to grammar schools were those deemed to be capable of profiting by higher education though, in fact, for one reason or another, mostly financial, only some 20 per cent of them do so, the rest falling out on the way. It is the limitation of this selective process that has made many people say that there just are not enough people with ability in the country. However, some of the comprehensive schools set up by certain progressive educational authorities did not make these distinctions. Experience there showed that the selection at eleven-plus was by no means even correlated with this type of academic performance. Those who failed the eleven-plus in

[1] More recently even there class distinctions in education are appearing, see C. W. Mills, *The Power Élite*, New York, 1956, and W. H. Whyte, Jr., *The Organization Man*, New York, 1956.

[2] In England and Wales, of 325,650 children leaving Secondary Modern Schools in 1956, only 14, or 0·004 per cent, went to University. Of 88,496 leaving Secondary Grammar Schools, 10,527, or 12 per cent, went to University.

such schools often did as well as, if not better, than those that passed it.[1] In other words, there are more young people of promise to be found among the rejected 80 per cent than among the successful 20 per cent.

I have discussed these questions in some detail as they indicate there is something wrong with the tests rather than the children. The same principle applies logically to the whole educational system. We cannot expect to make a big quantitative change in education, to start educating 20 per cent or 25 per cent of the population up to the age of 25, without expecting a considerable change in the content and quality of the education. In fact the methods of education both in secondary and higher education in capitalist countries such as Britain are necessarily doubly at fault because they were aimed originally—and still are largely —at producing administrative officials, business men, or mere gentlemen of leisure required for a culture that is fast disappearing and, secondly, because they were developed for children from the homes of gentlefolk with their habits of leisured life and their opportunities of culture.

A study of the time-table of our grammar schools, with its weight in favour of languages, English and history as against science and mathematics, shows it to be only one step removed from the old grammar school, the object of which was to introduce the pupils to the necessary Latin and Greek to make them pass as cultured gentlemen, and from which we have only begun to escape in the last fifty years. The new change required will probably be greater than that.

It is the inability of so many children from working-class homes to fit in with this kind of education that makes so many schoolteachers and even education authorities maintain that they are not suited to higher education at all and these are repeating in a modern form the words of Dogberry: "To be a well-favour'd man is the gift of fortune but to write and read comes by nature."[2] These schoolmasters would rather think badly of the abilities of the majority of children than of the skill of their profession. The tragedy is that this is all done with the greatest of goodwill and even of devotion to teaching. The only trouble is that the teachers are so busy teaching that they have no time, and accordingly they have had no training and little incentive, for thinking how teaching needs to be done under the new circumstances of the time which demands education of the mass rather than of a selected *élite*.

The fundamental principle is that we must take all the children as we find them, at least for another generation. If most of them do not fit into the present educational scheme, it is no use blaming the children, there must be something wrong with the teaching. This something has to be found out by adequate study and research, including the experiment of trying out new teaching methods and rapidly discarding the

[1] B. Simon, *Intelligence Testing and the Comprehensive School*, London, 1953.

[2] *Much Ado About Nothing*, Act III, Scene III.

old objectives of purely literary education. Now we may hope that some of this constructive experimenting will go on in education but it will be useless to expect any overall change unless its results can be applied on a larger scale than at present. This would involve quite considerable financial provision, ultimately, for a complete internal reconstruction of our educational system.

These difficulties are not by any means peculiar to British education —in different forms they occur everywhere. In the United States the voluntary and almost casual aspects of education, together with the extremely low pay and lower consideration given to teachers, raises the problem in a different form: how to produce courses which will teach something and at the same time amuse the children sufficiently to attend to them.[1]

In Continental Europe, including the Soviet Union, the problem is rather a different one, that of finding a system of teaching which can be followed without absolutely exhausting the pupils. What was done in the Soviet Union, after a short period of radical educational reform undertaken without proper preparation, was an attempt to impose on a far larger and less well prepared group of children the whole syllabus of the old high schools, together with a lot of new material needed to fit the children for a scientific and industrial world. That has been an enormous teaching load on masters as well as on pupils, and it says something for the toughness of both that they have managed so well for such a long time without breaking down. However, this evil is now recognized and is being put right[2] and, there again, we will probably have something to learn from it.

One fundamental question that must be discussed is that of specialization and the stage at which it should be introduced. The British tradition has been geared to preparation for universities, even though only 4 per cent of the children can expect to go there. The demands of examinations and scholarship competitions push specialization still further back into the schools, so that, for instance, the great division between the sciences and the humanities reaches back to the age of fourteen and even earlier. In the Soviet Union, on the other hand, all schools are comprehensive in respect to subjects up to the age of seventeen. At this age, however, absolute specialization sets in. The young student is accepted, not only for a particular university or technical, medical or agricultural school, but also for the particular kind of faculty—for example, physics or electrical engineering—in which he will study during the whole five years of his higher educational career.

Some degree of specialization there must be, but it would seem particularly dangerous in the new age to attempt any specialization in

[1] *Scientific Manpower—1956*, Washington, 1957. *Message from the President of United States to Congress on emergency action in education*, 27th January, 1958.

[2] "The Overloaded Syllabus" *S.C.R. Soviet Education Bulletin* (1957), Vol. 4, No. 2.

the direction of science and technology which prevents the children getting an adequate picture of their literary culture or of the political and economic system of their country and of the world. I would, myself, favour a continuation of more general education right into the university level. However, this seems a council of perfection because, as already indicated in relation to the Soviet Union, the amount required to be learned even in the specialities is now so increased. Consequently, to demand at the same time the doubling of the work, by joining the humanities to the sciences, is to ask for more than the human brain can cope with.

At least this would be the case if we continued to construe humanities and science in the way we do now. The present syllabus is, in fact, a kind of geological record of the education of the past in which stratum upon stratum is laid down one after the other. We can discern, even today, the old Classical of Greece and Rome, the Mediæval Scholastic, the Renaissance Humanist, the Eighteenth Century Enlightenment, the factual Gradgrind and, rather unconsolidated at the top, various efforts at a child-directed project education of our own time. To get the whole of this into a student's head requires massive compression involving considerable distortion. What we really need now is a literal metamorphic process, a general scrambling of education and a concerted attempt to think out anew, not only how to teach, but what to teach.

As a result, a lot might go out: overconcern with the technicalities of language, which children learn from each other in foreign visits much better than from a teacher; a lot of dull facts in science. But, also, much would have to come in, particularly the knowledge of the structure of the administrative, economic and political world, into which the child will be going when his education is over.

There is, indeed, another reason for change, which did not exist in any of the previous reforms of education, though Comenius with his "people's schools" foreshadowed it. If we have to teach, not a selected few but everybody up to the ages of eighteen or twenty-three, we might reasonably expect that the character and methods of education would have to be radically revised. One object would be to ensure that no one was left behind because he was too slow—he may not be stupid but only thoughtful, or was held back because he was too quick—more could be given to interest him.

However, we must face the fact that with a rapidly growing civilization, the young will year by year have more to know and, also, will be required, by the new demands made on them, to know more. Some way of ensuring this must be found. One which will certainly have to be used in any case is the lengthening of the period of education. It is not so long since it was considered that children who could read, write and figure by the age of ten, were then fitted to go out and earn their living in the world. Now in Britain we have had the battles which have at long

last succeeded in raising the school-leaving age from fourteen to fifteen but still the implementation of the 1944 Act to raise it to sixteen has not been achieved. British universities still stick to their three-year courses, while for many years back those in the Soviet Union have been five and are now lengthening to five and a half, which means that, normally, higher education does not end at twenty-one but at twenty-four.

This is one of the necessary features of a world on a higher technical level. The fact that fewer people will be required to work in the productive machinery of society, also implies that they should have longer time to learn how to work it, and that something like a third of a human life span should be taken up with education. This is, incidentally, in line with the whole trend of human evolution from the animal stage —one of the characteristics of human beings as distinguished from other species of animals is their much longer period before reaching maturity. No doubt we will, before very many years have passed, reach a stage where learning as such continues during the whole of a life span, but, after childhood, is not separated, as it is today, from active work.

However, lengthening the period of learning is by itself no real solution. Something must be done at the same time to simplify and reduce the amount of learning at every stage, along the lines already indicated. In fact, we will have to carry out a fundamental transition in the objectives of teaching. In the past, and with some reason, teaching was considered to be the passing on of known and established truths from one generation to the next—a process in strict traditional sequence from the practice of the wise men in the past and their initiation ceremonies.

But clearly, in a civilization where the whole basis of knowledge is expected to change several times in a generation, the passing on of established knowledge becomes palpably inadequate and, also, from its ever increasing bulk, impossible. It is lucky if most of what is taught is true, or supposed to be true, at the time it is taught. It is certain that it will no longer be considered true by the time those who are taught it are half-way through their lives. What is needed, therefore, is a different and lightened content of education. The emphasis will be on discovery rather than knowledge. It will be, not so much the passing on of established truths, as showing the way to criticize and discover new truths; in other words, the active part of the scientific method.

It must also contain some of the passive part of science, that is, the testing of the validity of truths more or less intelligently guessed at in the first place. We must come to admit openly that the great and growing accumulation of scientific knowledge cannot be taught or learned as a whole, and that knowledge of a part alone breeds a blind specialization. It would be better to learn how to find things out, either from reference to the existing storehouse—which we may hope will

be better arranged in the future than it is now—or by directly interrogating nature by experiment. Indeed, as we shall see later, the long term objective of education is likely to change still further away from the mere transmission of traditional knowledge—few claimed to teach wisdom—to a preparation for research. For in some degree or other we may find a great proportion, if not all, of the population of the future will be devoting their time to it.

To change over from an educational transmission to an educational creation is a major change and will require much time, thought and experimentation to establish. But we must now recognize that as an aim and not try and continue the older methods, which are already too much of a burden. These remarks apply primarily to teaching in the field of science; in the field of humanities the problem is somewhat different and much easier. The individual achievements of the men of the past are not superseded in these fields; the same pictures, the same poems, please successive generations. Poetry and art in previous times are well within our appreciation today; but here again the problem is not to present the child with everything that has been done in the past or, what is far worse, a crabbed summary of it, but to show him enough to make him want to see more if his inclination lies in that way. Bernard Shaw used to say that basic education consisted of "reading, writing and knowing enough arithmetic to give correct change" and that everything else one had to learn for oneself: and this might not be a bad precept for the new education.

One major problem remains to be discussed, that of adjusting educational output to the needs of the community. This is likely to be a task of peculiar difficulty in a period which we are now entering. In the past—even fifty years ago—it was sufficient to produce about the same number of people, or perhaps a steady increase in the number, entering each profession. Maladjustments were dealt with as they arose. If too many were trained for the law, they could always go into politics, and those with more adventurous spirits could go into new fields such as navigation or electrical engineering, for which only a short apprenticeship was then necessary. Now, however, when we expect changes of a radical kind to occur with a frequency of two or three times in a generation, such forward estimates of the numbers required in each profession would be quite useless and, indeed, certain to be falsified by events.

Just after the last war, official inquiries were made in Britain by a Committee set up by the Advisory Council on Scientific Policy—the Barlow Committee—as to the number of scientists that would be required by the country as a whole in five or ten years hence. They recommended a doubling by 1955 which was very nearly achieved. Some years later answers were collected from industrialists and on the strength of them it would appear that there would be no exceptional demand and, as a result, action to increase the number of scientists was to that extent discouraged. When the time actually came it was

found that the industrialists required far more scientists than they had put down for. They simply did not know, nor had they, indeed, any reason to know their future requirements as they were operating to no plan of production. And most were not imaginative enough to realize that times were changing.

If we cannot forecast, we must adapt the kind of education to a future in which types of employment change rapidly. In other words, we must provide a flexible type of education which trains the young people to take up new openings in life as the old ones fade out. Up to now such changes have been somewhat rare misfortunes, but in the future they will be the rule. Such things have happened before and in other places, notably in the early days of the United States, where everyone was, as a matter of course, expected to take up half a dozen employments before they were thirty. So in a more sophisticated and scientific era, this flexibility in education will need to rest on certain common and basic sciences, certain intellectual techniques of mathematics or experimental techniques such as those of physics. Beyond that, what is most required is a general intelligence and a capacity to seize the main principles of the job in hand rapidly and without too much attachment to previous habits. Transferring jobs will also need to be helped by special re-training courses, and this will probably be a feature of education which will grow in importance: possibly as much as one year in six of an adult working life will be taken up in attending courses, changing over from one occupation to another, or catching up with the new knowledge in the application already chosen.

At any given time, however, we should be able to see roughly how the new entrants to the various types of industry will be going: in other words, we ought to have some kind of flow-sheet of employment in the economy, in which the rough proportions of entrants are matched to requirements. Any reasonable estimate for Britain would have to approach the proportions already reached in the Soviet Union (Table XVI, p. 187, and Fig. 5, p. 180). This would mean training between two and ten times the number that we do now of young men and women in the different sciences and technologies.

How to reach these figures and by what stages is another problem in its own right. It is first necessary to decide that the system of education and training must be changed in a certain direction and by an approximate amount. Then it is necessary to find out how rapidly this can be done without dislocating the system itself. That is, we must find out how many people can be set aside for the rather heavy demands of teachers which will be needed in the transition period that will precede any steady state such as I have sketched. Here we have the experience of other countries to go on—I have already mentioned that of China and of the Soviet Union.

Personally, apart from the difficulty of shaking teachers out of their usual routine, I see nothing impossible in such a shift-over. In fact,

however much it may shock the teaching profession, I am proposing nothing nearly as drastic as the shake-up of employment that we have already experienced twice in the wars of the present century. There, some thousands of highly trained people were removed from one day to the next, from occupations where they had often been working for a score of years, into something completely unfamiliar, often without suffering anything more than a general sense of relief and excitement. In fact for many it was a much more serious shock to have to go back to the old routine at the end of the war. Operation "Educational Reform" will be part of the general set of ordered transformations of the new industrial revolution and should be carried out with the same intelligent enthusiasm. It remains in any case an absolutely necessary reform without which a country like Britain is doomed to backwardness and decay.

Although we may not know now what the long-term requirements for scientists and technicians are at different levels, we at least know the minimum required for the present transformation of industry in already advanced industrial countries. This represents something of the order of 10 per cent of the age-group: this is the figure which has already been reached for some years in the Soviet Union and is already being passed there. Now other countries are far short of this, Britain by a factor of five, the United States by a factor of three, other industrial countries like France and Italy by even larger factors.

It would not be right to conclude a chapter on Education without dealing with its most advanced part, scientific research itself, where the teachers are the unknown elements of nature and human art. As already mentioned, research will inevitably play a larger part in the life of the future, and occupy the time and attention of a far larger number of people. This has often been given as a reason why it would be impossible to advance at a rate much greater than the present, because,whatever may be claimed about the possibility of training good technicians, good teachers, or even good routine scientists is not supposed to apply to research. In its fundamental sense, in the discovering of new things, research is supposed to be an operation requiring peculiar mental capacities, those of so-called scientific genius.

Even though we may have some doubts whether this potential quality —genius—is as rare in all populations as has been claimed, it should be quite evident from what I have said about the deficiencies of the educational ladder, that there are many candidates who never get to a place where they can see whether they have got genius or not. In other words, we could, even in a country so well developed scientifically as Britain, multiply at least by five the provision of minds of the first category. But Britain is only a small country in a world in which there has been very little educational opportunity, and the same proportion taken over the whole world would increase the contribution to genius by

a factor of more like a thousand. Such a factor, even if it should take a generation or two to reach, should provide us with enough native originality.

Personally, I think the prospects are even brighter. Genius, they say, is born and not trained, and this may indeed be true for the geniuses that have survived in the last centuries; from any study of their lives it can be realized how little they owed to their teachers, if they had any, and how much they have had to suffer from the obstruction of their contemporaries. But I think we should distinguish the kind of battling genius who got through in old times, from those who can in fact be capable of generating new ideas if given a favourable upbringing and circumstances. We have some indication of this from the number of men of the first rank and a few geniuses who have risen from families where it was, to say the least of it, peculiarly easy to be brilliant, for instance in the families of the Darwins and the Huxleys, the Galtons and the Sidgwicks. The alternative explanation that these are examples of hereditary genius, if only the rather unexacting kind listed by Galton in his *Hereditary Genius*.[1] But before we accept the hereditary theory unreservedly, it is worth while making the experiment of providing good conditions of education and upbringing in the hope of multiplying the supply of geniuses at least of the second and even of the first rank. What these conditions are we simply do not know at present but we might well find out by research.

One may at least suspect that a good deal of genius is latent and is actually depressed or repressed by educational methods. There is some evidence for this from statistics of so-called intelligence tests, which show that the scores of people who have been college-trained fall off more sharply in the higher intelligence reaches than those who have had no education at all; in other words, there seems to be some evidence of a dis-education going on.[2] In view of some of our experience of educational methods this is hardly surprising. The kind of dis-education particularly unfavourable to genius is dogmatic teaching: if all attempts to think for oneself are censored or even not encouraged, the possibility of making new co mbinations of ideas—which is the essence of genius—may be so effectively repressed as to disappear. More than this, we may be missing a positive contribution to creative thought simply because we never bother to train for it at all.

Some ingenious American psychologists[3] have thought of how to deal with the very awkward problem which occurs in industrial research laboratories when the young men, so well trained and qualified, fail, after they are employed for a few years, to produce any new ideas at

[1] See also *Science in History, op. cit.*, p. 748.

[2] I have done my best to trace the original reference for this statement, so far without success, and I would welcome any evidence for or against it.

[3] M. J. Stein, "Creativity and the Scientist", *The Direction of Research Establishments*, H.M.S.O., London, 1957.

all. Here a course has been suggested in "creativity" and, considering the almost unlimited capacity of human beings, not to speak of animals, of responding to training, it seems as if this can be just as well trained in creativity as in anything else. Naturally, there would be some dangers in overdoing it, particularly as there is no necessary correlation between having a new idea and having an idea which is actually true or useful. But still, all that could be sorted out later. The point I want to make is that the objects of education should be first to detect, secondly to bring out and thirdly to train the capacities of creative thought.

When we have done all these things and searched the world for possible candidates for creative thinking, we will really be able to say we have reached the limit of the rate of educational advance. It is very likely that that limit will be so high that it will not be for lack of geniuses but for lack of people who can carry out their ideas, that the whole process of social advance will settle down to a steady speed, which will, in any case, be far greater than any we have experience in the past.

If new ideas come from individual human minds, what is done with them is much more a matter of organization; and here we want to overhaul radically our whole system of scientific research organization. What has happened in fact in the last two centuries is the multiplication, at the fantastic rates of first doubling every twenty and then every ten, now almost every five years, of this new human occupation, while retaining roughly the same organization simply increased in size. I have already discussed (pp. 89 f.) the character and shortcomings of that organization in different parts of the world, in particular the chaotic character of the exchange of information in science. Further, the material conditions of scientists, in most quarters of the world, leave much to be desired; in only very few countries do they receive salaries at all compatible with the work they do and consequently they are discouraged from entering the profession and depressed when they are in it.[1] Even in the exercise of their work they lack the proper equipment, and to an even greater extent the proper technical help. It is probable that the efficiency of scientific work, judged in the ratio of what is produced to what could be produced by the same people in the same time, given good conditions and organization, is very low indeed; and this is especially important just at a period when we are starting to produce scientists in large numbers and there is still an acute shortage of them. We should first be making the best of the people we have already.

This inefficiency is particularly great in the fields of industrial and governmental research where the principles of sound administration are directed inevitably against scientific advance. Either the pursuit of profit or the maintenance of strict routine are fatal to fresh scientific

[1] World Federation of Scientific Workers, West European Conference, Paris, February, 1957, *Report* (in preparation).

thought: the former by diverting it from some particular long research not likely to yield immediate returns, and pushing it into something of less scientific interest but greater immediate profitability; the latter by restraining it by keeping it on the prescribed programme, just when interesting side-lines are opening. These dangers have been recognized though hardly remedied: a point already mentioned is the tendency of research workers in industry and also in government service of losing interest about the time they reach the age of thirty. It is a fairly natural response to a situation where the greatest advancement is to be got by not, as it is said, "causing trouble", that is, by not having too many ideas interfering with the normal run of things. An employment in which the less you do the better off you are, hardly encourages a ferocious search after truth.

To alter this requires more than altering the conditions of scientific research—it really requires altering the whole of the running of industry and administration and of the position of science in it. As long as that position is as inferior as it is at present, as long as the scientist is a kind of paid slave asked to produce ideas and solutions for enterprises and policies in which he is not consulted, it will be impossible to get the best out of him. I had plenty of experience of this during the war, and it was not until the scientist was "on top" and not "on tap", to reverse an Air Marshal's dictum, that things really got done.

The key position which science is acquiring in our society will sooner or later impose such a relation, but it can impose it usefully only if the administrators working with the professed scientists are also sufficiently scientists themselves to understand what the matter is about. Further, the scientists must understand their social responsibilities and stick up for them, individually and collectively, more than most have done so far.

For the full utilization of science, the whole of human enterprise must be run as scientific research is, ideally, by teams of people consciously interested in the aims of the enterprise and able and willing to work together creatively to further it, without personal animosities and jealousies.[1] The interests of the advancement of science and the well-being of society are one and the same.

[1] "In science men have learned consciously to subordinate themselves to a common purpose without losing the individuality of their achievement. Each one knows that his work depends on that of his predecessors and colleagues, and that it can only reach its fruition through the work of his successors. In science men collaborate not because they are forced to by superior authority or because they blindly follow some chosen leader, but because they realize that only in this willing collaboration can each man find his goal. Not orders, but advice, determines action. Each man knows that only by advice, honestly and disinterestedly given, can his work succeed, because such advice expresses as near as may be the inexorable logic of the material world, stubborn fact. Facts cannot be forced to our desires, and freedom comes by admitting this necessity and not by pretending to ignore it.

"These are things that have been learned painfully and incompletely in the pursuit of science. Only in the wider tasks of humanity will their full use be found." J. D. Bernal, *The Social Function of Science*, London, 1938, pp. 415f.

XI

THE POLITICAL PROBLEMS OF A DIVIDED WORLD

In the earlier chapters I have tried to show what the new advances in science and technology could mean to mankind if they were applied; later, I have also tried to show that the resources in materials and men are sufficient to achieve such a change-over within a few decades—a generation or two at the most. If it only depended on its technical possibility we should now be well advanced in this transformation and the present age would be one of the happiest and most optimistic periods in the history of the world. But it is only too sadly evident that this is not happening. In contrast we are living through some of the most anxious, as well as the most horrible, periods in recorded history.

In my lifetime there have been two murderous and unnecessary major wars and almost innumerable minor ones, causing death and destruction over almost every territory of the inhabited world. Such wars are going on today, notably in Algeria and Malaya, and we think of them as less only in comparison with a third and greater world war which, we are afraid, may break out at any moment and for which the weapons are literally flying over our heads in the form of hydrogen bombs in aeroplanes or are standing ready as ballistic missiles to be fired.

Underlying the wars and preparation for war are deep divisions which split mankind. There are the differences between the states with different economic systems, capitalist or socialist; there is the long struggle between imperial powers and colonial peoples, and as well many old-standing national disputes. So far from wanting to join together in a common enterprise for the benefit of all, many statesmen are more concerned with preparing to kill others in the name of the defence of their culture or their standards of living.

If this were the whole picture it would be a very gloomy and desperate one indeed, but we also know that this is only one side of the picture: that underneath these divergences does lie a deep and common wish of the peoples of the world for peace and for a return to the possibility of enjoying the good things of life. At the moment these are, admittedly, wistful hopes: people would like them to be true but they feel there is

very little they can do to realize them. Many feel, or are made to feel, that they are in the hands of forces greater than themselves. They fear that they may be driven once again to war, as they have already been driven twice before in living memory. Already, even if much against their will, they are lending their strength to prepare even further wars, which may possibly this time lead to the total destruction of humanity.

This tragic folly is made all the greater by the fact that the objects for which the peoples are allegedly striving—the natural resources, the wealth, the standard of living, the way of life which they are defending —are all immeasurably small compared with the rewards that could be won if the peoples of the world got together to use the new means which science has now made available to all mankind. It is not enough to state the absolute pointlessness of the present tensions; they must be examined and brought home to people before they can be resolved. For thus, people can be made to realize that it is far from true that in these matters they have no power. Their lack of power is simply a measure of their lack of knowledge and their failure to work together to achieve their common aims.

In this chapter I want to examine, as realistically as possible, the actual divisions and differences that exist in the world and show how far they hold back useful changes and how far they in their turn can be removed. There is no place here to follow these back to their historic and social origins, though this is needed for their fuller understanding.[1]

We are here concerned rather with the immediate issues of war or peace within the next few months or years, and hence we must deal with symptoms rather than causes. The dangers that hang over us, the differences that divide us, the hindrances to our winning of the good things that we could get through science, are all connected with the great international conflict of our time which bears the name of the *Cold War*. This chapter will, therefore, largely be taken up with discussing the Cold War. This is not because I believe that all the difficulties of the world would be resolved if the Cold War were to disappear, but because it represents a pressing danger and because the great constructive tasks of humanity can only be undertaken lamely, if at all, as long as it hangs over us.

The present state of the world is critical in the true sense of the word, like the crisis of an illness. All the peoples of the world anxiously await a decision as to whether the present state of Cold War is going to lead to collapse and to nuclear war—the death of humanity—or whether it will pass away and the world will recover in a genuine peace. Only a few political and military fanatics—unfortunately in high places—think of it as a permanent feature set to go on for centuries. Most people cannot see how the strain can be endured for much longer. Now divisions of the world as deep, if not as all-inclusive, have existed as long as history. We have only to think of the divisions between Christen-

[1] I have attempted to do so in *Science in History*, *op. cit.*

dom and Islam, in which there was hostility and war on and off for at least a thousand years. Neither side ultimately defeated the other; indeed both survived and both flourished for much of the time.

The essential difference between this and the present situation is not so much that victory is impossible—the absolute victory of the Allies in the two world wars looks strange when we consider the state of Germany today—it is rather that *war itself is impossible* without destroying not only the combatants but most of the rest of the human race as well. *The catastrophic character of nuclear warfare is the absolutely new factor in human history.* It obliges us to attempt to settle international and ideological differences without war, and that is a lesson that is very hard to learn and carries terrible penalties if it is not learned well.

The simple solution that would appeal to the ordinary person is "If we can't fight it out, why not stop quarrelling and make friends?" After all, duelling was ultimately prohibited, and the honour of gentlemen did not notably suffer as a consequence. However, the present situation is evidence enough that this solution is considered unthinkable by some all-powerful statesmen. The only solution they have been able to think of, is to remain in a position of threatening their enemy with complete annihilation, claiming that this deters him from doing the same to them, an act which they know he is perfectly equipped to do. I have already discussed the military absurdity, danger and criminality of this policy of Cold War based on deterrents and negotiation from strength (pp. 18 ff.). Here I must look closer into its political antecedents and possible consequences.

In principle the Cold War is very easy to understand. It reflects, in terms of tensions between governments, the hundred-year-old political struggle between Socialism and Capitalism, with the Soviet Union as the champion of Socialism and the United States as that of Capitalism. It changes nothing to call the protagonists by different names—such as the Free World against Totalitarian Dictatorship, or Western Christian Civilization against Atheist Materialism, or even Anglo-American Imperialism against Popular Democracy. No one has any doubt on which side the millionaires are to be found or from what class came the people who actually fought for the revolutions that established the Soviet and Chinese governments in power.

The Cold War is, indeed, no new conflict. The name may be new, but in fact it has been going on for just over forty years—ever since the Bolsheviks took power in 1917. The only difference between the phase before the Second World War and the one we are now in has been that in the first the danger of Bolshevism was considered as a limited and to a certain degree a secondary danger that could be boxed up by the celebrated Cordon Sanitaire of Eastern Europe. The capitalist Powers indeed felt strong enough to get on with their own mutual rivalries which culminated with the Second World War. Since the end of the war it has been recognized that the Soviet Union offers the major

challenge to the whole system of capitalism. In essence that challenge is a political and economic one, a clash of two opposed systems of government. However, it is usually seen and represented in the oversimplified form of a direct military challenge which, as will be discussed below, is very wide of the mark.

To picture the world situation solely in terms of the Cold War would be a mistake. It is true we have two groups of countries, the so-called Military Blocs, associated by a complicated network of alliances and dominated respectively by the United States and the Soviet Union. However, for many years now the first group by no means includes all the non-socialist states or what is called the "Free World". There is now a third, neutral and uncommitted group of powers in Europe, Asia and Africa, without alliances but largely under the moral leadership of India, which adhere to the five principles—the Panchashila—of the Bandung Conference,[1] supporting a policy of peace and non-interference. These include most of the underdeveloped areas of the world, and their peoples have accordingly the greatest interest in securing peace and general disarmament.

Further, the Cold War is a war between governments and not between peoples. However much their governments are committed to this policy, there are a growing number of people in all countries who would like the Cold War ended. Most perhaps do so because they hate and fear the idea of the outbreak of a nuclear war, but there is a conscious minority in some countries, and a majority in others, who are coming to understand the way in which the Cold War is impoverishing or thwarting their desires for a better life.

Nor are these people in different countries any longer isolated from each other. Thanks to the cultural and political stirring of our times —even the wars, revolutions and political struggles have played their part—people in different countries are more aware of each other. They see in others' problems the likeness of their own and they respond to events in distant countries in a way inconceivable even twenty years ago. This is specially so for the peoples of the former colonial countries who have gained their freedom and have, so to speak, discovered the world. They are now seeking to change it for the better, as witness the great effect of Indian opinion on world politics in recent years. It is on these forces—on the feelings and the wills of men and women throughout the world—that we must in the last resort depend for the break-up of the present deadlock and for the creation of a new and effective unity.

These pacific interventions of governments and peoples may have done something to prevent the outbreak of a Third World War (p. 19). But they have not stopped the Cold War: we still have in many parts of the world conflicts between countries, and even civil struggles, into

[1] They are: mutual respect for territorial integrity and sovereignty; non-aggression; non-interference in each other's internal affairs; equality and mutual benefit; peaceful coexistence.

which the great rival powers are inevitably drawn and every one of which, whether it be in Korea, Egypt, Hungary or Indonesia, threatens to start a chain reaction leading to a general war.

The Cold War and the polarization of military and political forces that it represents remains the central danger and the greatest obstacle to progress. It must be brought to an end. To understand how it can be swept away it is, however, necessary to look more closely into its many somewhat confusing aspects. In the first place, while there is no doubt that fundamental conflict between two opposing groups exists, the attitude of the protagonists towards the conflict itself is markedly different. It is only on the side of the U.S.A. and its allies that we find expressions of the necessity to maintain the Cold War, if necessarily indefinitely:

"There is thus no military reason why a world conflagration should not be prevented for another generation or more through the balancing fears of mutual annihilation. In fact, there is no reason why all this should not go on almost indefinitely."

Report on Defence: Britain's Contribution to Peace and Security, H.M.S.O., London, 1958.

On the Soviet side there is, and has been for many years, a persistent demand for a rapid ending of the Cold War and instead the establishment of a state of peaceful co-existence:

"We have always supported the peaceful coexistence of states belonging to different social systems, the peaceful coexistence of socialist and capitalist countries . . .

"We live on the same planet with you, and there is enough room on it for all, but distances on this planet, thanks to development of intercontinental missiles, and other achievements of science and engineering, have considerably diminished before the eyes of our generation. Therefor it is more important than ever that we be reasonable and learn to live together as good neighbours.

"Naturally there exist and will continue to exist contradictions between the world of socialism and the world of capitalism. . . . However, if people all over the world consciously make every effort to prevent a new war, they will be able to impart to the struggle between the system of socialism and the system of capitalism, the form of peaceful competition, first and foremost, economic competition, that is a competition in peaceful production, in improving the living standards of the entire population."

(Mr. Khrushchev in an interview with James Reston of the *New York Times*, October, 1957).

Thus there seems to be, besides the main conflict of the Cold War itself, another dispute as to whether it should be ended or not. But in this dispute the alignment of forces is by no means the same. In nearly all the countries which are neutral in the main conflict, public opinion favours an easing of the Cold War which threatens them almost as

much as the potential combatants. Some of their leaders, notably Mr. Nehru, have used all their influence to bring about a general pacification. Nor are such voices limited to neutrals. Several important public figures in Western Europe and America have urged the same course.

At the World Assembly for Peace at Helsinki in 1955 Jean-Paul Sartre made a penetrating and prophetic analysis of the dangers of the Cold War, not only in respect to the threat it represented to peace, but also to the prosperity and liberty of peoples throughout the world:

". . . One of the greatest contradictions of our time is that the Cold War—of which one of the obvious causes is the very existence of thermo-nuclear bombs—has separated the world into blocs, placed governments on opposing sides and everywhere maintained abstract and dangerous divisions which even go so far as cutting countries in two . . .

"Indeed it must be understood that the Cold War is not a matter of a mere exchange of insults, in the manner of Homer's heroes, nor even a matter of *tension*. It is a definite structure of international relations which has had its repercussions even on the internal structure of nations. The progressive deterioration of relations between America and the U.S.S.R., together with the impoverishment of Europe after the Second World War, had given rise to the integration of nations into each of the two blocs.

"I know the desire for peace of the U.S.S.R. and the People's Democracies; the austerity and even severity of their political systems, for which they could have been reproached, are primarily the result of the Cold War. Those countries threatened with encirclement cannot secure their defence without a tightening up both internally and externally. In the same way, if I do not forget that certain capitalist interests are at the bottom of present tension and that certain American groups are interested in maintaining it; neither do I forget that the American people and even its rulers have demonstrated for more than a century and a half a real love of peace and a profound horror of war. It is neither the American people nor their institutions which must be held responsible for McCarthyism, it is the Cold War and the terror it engenders. The Cold War is a complete entity, a political and social system."

Bertrand Russell, himself no friend of Communism, has maintained in his campaign against nuclear war that this issue transcends all the political differences of the world today:

"We are all in peril, in deadly peril, ourselves, our children, our grandchildren—not our great grandchildren unless we are successful, for, if we fail, we shall have none. In comparison with this peril, all other questions are insignificant. What will it matter who was right and who was wrong when no human beings have survived? I am not suggesting that the debate between Communism and anti-Communism should cease. What I am suggesting is that the debate should not be conducted in military terms."

"Bertrand Russell Replies" *New Statesman*, 5th April, 1958, p. 426.

Though it is difficult to find any outright condemnation of the Cold War by political and cultural figures in the United States, there have been pleas for the mitigation of some of its most important features. Mr. Kennan, the former U.S. Ambassador to Moscow, in his celebrated 1957 Reith Lectures[1] advocated a degree of withdrawal of forces from a zone in Central Europe:

"Is there, then, any reasonably hopeful alternative to the unpromising path along which we are now advancing? I must confess that I see only one. This is precisely the opposite of the attempt to incorporate the tactical atomic weapon into the defence of Western Europe. It is, again, the possibility of separating geographically the forces of the great nuclear powers, of excluding them as direct factors in the future development of political relationships on the continent, and of inducing the continental peoples, by the same token, to accept a higher level of responsibility for the defence of the continent than they have recently borne.

"... If they could be induced to refrain from doing this (building their defence establishments around the atomic weapon), and if there could be a general withdrawal of American, British, and Russian armed power from the heart of the continent, there would be at least a chance that Europe's fortunes might be worked out, and the competition between two political philosophies carried forward in a manner disastrous neither to the respective peoples themselves nor to the cause of world peace. I would not know where else this chance is to be looked for."

In the *New York Times*, 26th February, 1958, Mr. Stassen, former adviser to President Eisenhower on disarmament matters, stated his belief in the possibility of a provisional disarmament agreements:

"I believe that a trial agreement for two years between the United States and the Soviet Union on a first-step limitation of armaments and the suspension of nuclear explosions under a rigid reciprocal system of inspection can be negotiated within the next six to nine months.

"I am convinced that such a first step, calling for equal sacrifices by both sides and affecting both evenly, could pave the way for a longer and more lasting control and limitation of armaments while at the same time lessening the dangers of war."

In view of this world-wide expression of opinion against the continuance of the Cold War, it is necessary to consider how, in fact, it has been so stubbornly maintained. This is not a simple matter for, in fact, the Cold War is supported for a number of very different reasons. Among these we must distinguish those put forward as propaganda rallying points, and those that cover, if they do not always clearly express, some real interest. These two categories are not exclusive. The interests of a very few may well be served by actions undertaken by millions of idealistically minded people.

The Cold War, for instance, is still felt by many people to be the

[1] Published as *Russia, the Atom and the West*, London, 1958.

great Crusade of our times, undertaken with the motive of liberating all the peoples under Communist dictatorship, or at least those of Eastern Europe and China. Among the supporters of the Crusade are to be found people of a whole range of opinions. There are old supporters of the Anti-Comintern Axis, Conservatives, who have always seen Communism as the main danger to property and sound government; Liberals, who see in the rule of the Communist Party a threat to parliamentary democracy and private enterprise, as well as some Social Democrats who consider that the nature of the socialist experiment in Russia and in China damages their chances of co-operation with capitalism. United against Soviet Communism, they agree on nothing else, and the degree to which they would push the Crusade varies from instant preventive war, through internal subversion to an indefinite maintenance of a strangling blockade against the Communist countries.

Behind this massive front of political hostility represented by the world Crusade against Communism lie the interests that have supported similar movements for forty years. The success of such a Crusade, some may reflect, would also secure the domination of the U.S. trusts over the resources and markets of the whole world, instead of merely over those of the "Free World". Although the desire for the Crusade still exists, it has lost much of its attraction now that it is apparent that it is very unlikely to succeed. With the growth in strength of the Soviet Union, not only "unconditional surrender" but even "negotiation from strength" is still a long way off.

There remains the argument for the Cold War which always had a wider if less idealistic appeal, the argument of fear. Its protagonists stress less the crusade than the counter-crusade, the need to resist the advance of the armies of militant Communism over the whole world. It was against these that Churchill at Fulton in 1946 invoked the atomic deterrent. They never had much difficulty in persuading themselves and many others that the Soviets would be as foolish as they were wicked, and would instantly move their hordes into Europe unless held back by the "umbrella" of the atom bomb. The object of the Soviet Union is in this view identical with the spreading of "International Communism" by force of arms all over the world. It was on this theory that the military blocs and alliances culminating in N.A.T.O. and the Baghdad Pact were set up and their ratification extracted from somewhat reluctant parliaments in Europe and Asia. There was little sign of reluctance from the United States of America.

Now there never has been any evidence either in actions or speeches from the Soviet Union in favour of this theory. The occupation by Soviet forces of the Baltic Republics and portions of Poland behind the Curzon line either restored territory that had been Russian before the First World War, or served to unite the Ukranian and White Russian populations. These moves—incidentally ratified in the Yalta Agreement—were then and since considered to be essentially defensive

in nature. Former Ambassador Kennan—no friend of the Soviet Union—stated in his 1957 Reith Lectures[1], that the major danger was not one of a military onslaught:

"But the threat has not been one of all-out military attack. It has been a combined political and military threat, but more political than military—a threat intimately associated with the weaknesses of our Western civilization itself—looking to these weaknesses, in fact, rather than to the strength of the Soviet arms, to constitute the main instruments of our undoing . . .

"Now in connexion with this design, armed force has, to be sure, been cultivated on a major scale by the Soviet Government. It has been cultivated partly as a precaution, partly as a psychological weapon, partly because it was always envisaged that the Soviet armed forces might some day be called upon to play a subsidiary role in the final phases of the demise of Western capitalism. But it has never—at least not until very recently—never been looked to as the major instrument by which our undoing was to be accomplished."

Even when Soviet troops in Hungary were called on to support the Kadar government, their action, however it may be judged on political grounds, cannot be considered a case of Soviet military aggression. In the circumstances of the Cold War, the maintenance intact of the positions of the Warsaw Pact countries was considered essential from the point of view of joint military defence. Indeed, the whole Hungarian tragedy must be considered as a direct consequence of the Cold War itself. If it had not been for the state of strain in Europe, the economic difficulties in Hungary would not have been so serious as to cause the widespread dissatisfaction they did. Nor in the absence of continued provocation from abroad, and the reaction to it in security measures inside the country, would the outbreak have been so violent when it occurred.

However, it is quite useless in the face of the steady pressure of propaganda in America and Western Europe to expect these considerations to carry weight or even to be known at all. What is more relevant here is that quite outside military and political circles, there are millions of people in Europe and America who believe in the Soviet military threat and who find in it a justification of the Cold War and nuclear weapons. Any sceptics are usually answered by allusions to speeches of Lenin predicting that a head-on clash between socialist and capitalist countries was inevitable[2].

[1] *Op. cit.*, pp. 17f

[2] The most quoted of these is from Lenin's report to the Eighth Congress of the Russian Communist Party, in March 1919:

"We are living not only in a State, but also in a system of States, and the existence of the Soviet Republic side by side with imperialist States for a long time is unthinkable. In the end either one or the other will conquer. But before this end comes, a number of the most terrible conflicts between the Soviet Republic and bourgeois States is inevitable".

(*continued on next page*)

On reflection, even those who have little knowledge of the internal history of the Soviet Union can see that there are at least three strong reasons which make the idea of Soviet world conquest by arms a very improbable one. Firstly, the Russian people have suffered more than any other from the effects of wars and invasions.[1] Secondly, they are engaged on an immense task of reconstruction which takes up all their forces. Thirdly, while even without nuclear weapons world conquest would have been a most doubtful venture at best and expose them to heavier losses than in the last war, such an attempt with nuclear weapons on both sides would, whatever the outcome, have meant utter devastation of their own country. Those who know the Soviet Union, including many of its enemies, realize that the whole idea of aggressive conquest is foreign both to the deepest feelings of the peoples of the Union and to the whole theory of communist revolution as worked out by Marx and Lenin.

On the other hand the people of the Soviet Union are firmly convinced that there are important people in the United States and other capitalist countries who have formed a plan to attack, defeat and destroy their country mainly by the use of atom and hydrogen bombs. They gather this, not only from the bellicose speeches of United States and British generals and politicians, but even more from the fact of bases placed all round their country filled with bombers instantly ready to set off to destroy their cities and industries. We know that very few of the people who have voted for these measures and supplied the money for them did so out of any intention of attacking the Soviet Union but they have been told to protect themselves against any attack emanating from there through the policy of "containment" or "deterrence". They are not fully reassured by the repeated statements from the Soviet Union that they have no intention of attacking the West, even when that is backed up by unilateral actions in demobilizing some 2·4 millions of their forces and the stopping of nuclear tests. They have been prevented from knowing how strongly the Soviet peoples hate war, and they have been persuaded that the Soviet Government is mad enough to risk wantonly the destruction of all that has been built up with such infinite pains in the last forty years.

[1] The population of the Soviet Union is some 25 million people less than it would have been had the Second World War not occurred. Over 15 million people were killed, and births were reduced by nearly 10 million.

As this speech was made during a short lull in the wars of intervention against the young Soviet Union, and when nearly all its territory was occupied by foreign troops, the reference to terrible conflicts seems little more than a description, or at most an only too well justified prediction of the Nazi attack of 1941. In the context, its purely defensive character is evident. There is no evidence from any Soviet speech of any belief in the desirability or possibility of the military conquest of the capitalist world by "International Communism".

See also A. Rothstein, *Peaceful Coexistence*, London, 1955, chapter 6.

On all sides the fear of nuclear war grows and justifiably so for as the bombs accumulate there is more and more to be afraid of all over the world. But among the supporters of the Cold War, it is taking an increasingly pathological form. If they cannot win the atomic war or even escape the consequences of starting one, they embrace it willingly. Lord ————'s phrase "I would prefer to be Atomized than Communized", has found an echo in many a Conservative breast. Bertrand Russell in answer agreed with his lordship as a personal expression of opinion: he would also rather be atomized than communized, but he did not see the justification for atomizing all the peoples of the world who might not make the same choice.

These gloomy and indeed suicidal thoughts are more prevalent in the advance bastions of American forces than in their homeland. In the United States there has been no such official admission as is found in the British White Paper of 1957 that there is no defence against nuclear weapons and that only retaliation remains. Internally, the American policy of building up a Cold War front and including practically all available countries into military alliances, is represented as the most effective means of preserving the American way of life—that is, preserving the very inequalities which are maintaining and increasing the tensions of the world today. With somewhat less conviction than in the past and with more tact in its presentation, this is justified to the citizens of the United States on grounds of the innate superiority of the white races or of Western civilization, and backed by the fear of being subjugated by Russian reds or by oriental hordes.

Thus popular arguments and prejudices are still not lacking, especially in the United States, for keeping on with the Cold War. They would not, however, be sustained with all the power of Press and propaganda if there did not exist very real and practical reasons which make that policy a very profitable one and hold out hopes for far greater profits to come.

The Cold War itself has now become a large vested interest. The demands for new types of weapons, as the older ones are used up in wars, or become obsolete in peace, is a perennial source of profit to the big monopoly corporations (pp. 139 ff.). But never since the beginning of imperialism has this source been so profitable or so necessary to them. Cold War armament production is now a built-in feature of the economy of the United States. It is only slightly less so for Britain and France, and may soon be for Federal Germany (Table II, p. 21). The first rumour of an easing of the situation or a serious risk of disarmament, causes immediate losses on the Stock Exchange. And it is not only the capitalists who are keeping the Cold War going: workers are led to believe that the continuation of full employment depends on arms production (p. 150). As they are carefully not shown any alternative in renewed world trade, large numbers, especially in the United States, are deluded into thinking that their livelihood and the sacred American

Standard of Life depends on the indefinite continuation of the Cold War.

The arms race has a further advantage in the opinion of Western statesmen, particularly in the United States. It may itself be a decisive weapon in winning the Cold War. Continually stepped-up rearmament strengthens the United States economy. The material resources for doing this exist, even if it involves serious inroads on the resources of their partners in the defence against Communism (p. 149). But, they argue, the enemy are in no such state: their resources are far more limited, they are trying to put through great schemes of civil construction and industrialization, especially in China. The diversion of productive capacity to armament manufacture hurts Soviet industry as much as it helps that of the United States.

Their statesmen and business men have thus every incentive to press on with the Cold War: they need it, and they nourish some hopes that it may help them to win without having to fire a single nuclear rocket. For they know that the Soviet and Chinese standard of life is not helped, as their profits have been, by arms production. It is held down by it, and may, they hope, be pressed still lower. At the worst this will weaken the Soviet Union and make it a less formidable rival in the world; at best it may force a breakdown of the régime and compel it to surrender or bring in once more a capitalist government. They are counting on the existence of strains in the Soviet Union, and even more in its allies, which can become intolerable under the combined effect of economic blockade and pressure for ever greater arms production. They can count also on a well subsidized service of spies and agents[1] using every method of propaganda to cause division and stir up elements hostile to the régime.

It is a gambler's logic, where the player with the longest purse can, by continually raising the stakes, force his opponent to give in without even having to show his strength. In fact, for some reasons which I will discuss later (pp. 235 ff.), it does not look as if it will work out like that, but what matters here is that this policy still commands official support in the United States and is one of the greatest obstacles to any reduction of international tension.

Meanwhile the bad effects of this policy are not confined to those at whom they are aimed, but spread all over the world, and affect particularly those countries like India that are trying to industrialize with quite

[1] James Reston, in an article in the *New York Times* as far back as 11th January, 1953, explained this aspect of the Cold War:

"The agencies now engaged directly or indirectly in open propaganda, such as the Voice of America, and in 'black propaganda'—the use of spies, the financing of anti-Communist undercover activities, etc.—are the State and Defence Departments, the Central Intelligence Agency, and to a limited extent, the Mutual Security Administration. The work of these agencies in the field of psychological warfare is co-ordinated by the Psychological Strategy Board, which works under the National Security Council."

inadequate resources. The concentration on military production has drastically limited the amount of capital available for these countries and has delayed accordingly their abilities to raise their standards of living. Indeed, we might reasonably charge up as indirect casualties of the Cold War, the tens of millions of men, women and children in Asia and Africa now dead, who would be alive today if the resources wasted on that struggle had been used for their welfare. This is in addition to the direct casualties of the "minor" wars that have already occurred and are still occurring, to the millions killed in struggles either caused by or prolonged and intensified by the Cold War. Indeed we might well draw up, year by year with a cumulative total, what is effectively the casualty list of the Cold War. It would by now be some 110 million people, of which 10 million, civilians rather than soldiers, were killed directly or indirectly in the wars, and 100 million died unnecessary deaths. What could have been done to save them by providing them with food and medicine was not done, because the countries that could have done so were too busy piling up defensive weapons. A graphic picture of this kind of murder is the life table shown on p. 98. We now know that people of all countries could have the same expectation of life as in the richest today.

Everywhere in the world, therefore, the Cold War has proved a curse and it is one whose effects are likely to grow worse the longer it is maintained. It is a fantastic situation in which one half of the world is trying actively to prevent the development of the other half and preventing its own development at the same time. It is intolerable that this situation is allowed to continue.

I have here brought out, as briefly as I can, both the ostensible and the real reasons for the continuation of the Cold War. In doing so I have by implication brought out some of those which lead not only the Soviet Union and its allies, but also increasing numbers of people in other parts of the world, to want to stop it as soon as possible.

Soviet economy is not geared to profit and faces no risk of unemployment. It therefore lacks an incentive to maintaining or increasing armaments. On the contrary, occupied with a terrific task of industrial construction and raising the standard of living, the Soviet government and the Soviet peoples grudge every rouble spent on armaments and every man kept from the farm or the factory by military service. The people can take the strain—they have shown that often enough in the last forty years—but they do not want it to last a moment longer than it need. They fear the senseless destruction of war which they have felt already more than any people in the world, and want to be able to live without the fear of it. They have, therefore, as much vested interest in ending the Cold War as American business men have in continuing it. But here the Soviet people are not alone. Hundreds of millions of people in every country, many of them inside the United States, also want an end to the Cold War and are making their wishes more and

more evident. Hence the demand for Summit negotiations which has been forced by popular pressure on unwilling governments.

In principle, therefore, it is admitted, at least officially, by all sides that the Cold War is bad and ought to be brought to an end. The politicians who still really support it, but can no longer openly defend it, are now driven to their second line of argument. They admit that the Cold War ought to be brought to an end, that there should be a relaxation of tension, settlement of disputed points, disarmament, and, with the greatest reluctance, even abandonment of nuclear weapons. At the same time they point to one convincing reason after another to show why none of these things can happen now or, indeed, in any foreseeable time.

We must, however, briefly examine these arguments because until they are refuted and withdrawn it will be impossible to make peace. Some are very familiar, they are repeated in the speeches of every Western statesman; others are merely hinted at and refer to the real reasons for maintaining the Cold War already discussed here. Still others—the most decisive ones—are carefully concealed from the public.

The first group of arguments are military and turn on the technical impossibility of any disarmament agreement. Because nuclear weapons, it is claimed, are easy to conceal from the most pertinacious inspection, they can never be given up, and hence it is hardly worth considering any other forms of disarmament. This argument depends on the well-propagated assertion that the Communists cannot be trusted one inch. Mr. Dulles has held on as long as he could to the argument that negotiations are useless because Communists do not abide by the agreements they sign, an argument which taken literally would doom us to a perpetual Cold War.[1] As a matter of historic fact there have been very few peace negotiations in history in which the opponents trusted each other. They thought it worth while to negotiate because the situation had reached such a point that even a bad and insecure peace was better than a ruinous war; and they reached agreements which they could rely on because they knew it was to the interests of both sides to keep them. At its lowest, the present situation is no worse than that.

The argument, based on mistrust, is given a peculiarly hypocritical turn by Mr. Dulles who always insists on his superior Christian virtue (p. 14). The NATO powers have steadfastly refused to make any statement repudiating the use of nuclear weapons. The reason given for this is that they, as Christian and democratic powers, would be obliged to stick to any agreement they made, whereas the Communists being totalitarians and materialists, would be free to break their word

[1] The justification he quotes is that they did not operate the agreement reached in Geneva in 1955 for the unification of Germany with free elections. In fact, there never was such an agreement, nor could there be as long as the United States insisted on including the re-united Germany in N.A.T.O. and thus bringing nuclear arms within easy range of the Soviet Union. All Mr. Dulles really demonstrates by this allegation is his own dishonest wishful thinking.

whenever they chose. Uncommitted peoples read such fine sentiments in the light of the military preparations that are going on all round them, and conclude merely that the Western powers refuse to agree not to use nuclear weapons simply because they have every intention of using them, and indeed are building the whole of their strategy and tactics on their use (pp. 13 ff.).

Another military argument is that the Western powers must stick to the nuclear deterrent because otherwise they would be overwhelmed by the superior conventional forces of the Communist bloc. This argument has had a long run and is still constantly used to convince the public by politicians who must themselves know that it is a dishonest one. For, in the first place, in 1954 the total manpower of NATO forces —the last year for which figures have been given—was 6·7 million men, and since the rearming of West Germany is now likely to be greater. At that time, the NATO estimate of the Warsaw Pact forces was stated as "over six million".[1] Since then 2·4 million of these have been demobilized. Consequently, the NATO powers have a present manpower advantage of at least four to three over the Warsaw powers.

In the second place, it was the NATO powers and not the Soviet Union that, in the last resort, demanded the retention of large manpower totals, mainly for the conventional forces. In the discussion at the United Nations Disarmament Sub-Committee the substance of the Anglo-French plan of 1954 was accepted by the Soviet Union in May 1955. This provided for reducing armaments by stages, beginning with conventional forces. Here, the Soviet Government proposed a ceiling of 1 to 1·5 million men each at the third and last foreseeable stage for the Soviet Union and the United States. This was objected to by the latter as too *low*, and a compromise was reached at 1·7 million men each. Thus, it is the Soviet Union and not the United States that has demanded the drastic cutting of conventional forces. Mr. Khrushchev has gone even further and suggested the complete disbandment of all military forces, keeping only a small militia for the preservation of internal order.[2]

The idea that nuclear disarmament will leave the field free for Soviet conventional forces is one, however, that will be very hard to remove, as the facts just cited are very little known and never publicized. In Britain in these last months, millions have been so stirred on moral grounds about the absolute wickedness of nuclear weapons as to demand their unilateral and unconditional abolition by their own government. Many of these are actually doing so in the firm belief that atomic disarmament is equivalent to complete surrender to communist occupation of the country, which, in the event, should be opposed only by means of passive resistance. For lack of information on the actual disarmament situation, they have been made to face an entirely unreal

[1] Lord Ismay, *NATO, the First Five Years, 1949–1954*, Paris, 1954.

[2] Interview with the *New York Times*, published 10th October, 1957.

choice between annihilation and slavery and, as a consequence, to present the advocates of the Cold War with a telling charge of unpatriotic defeatism which greatly weakens the appeal of the opponents of nuclear weapons. The real choice is rather between annihilation and living in the same world with the communists, and here only the most convinced anti-communists would choose the former alternative.

Debates on the whole question of disarmament have now become so widespread that these facts must soon come to light. Already, people in the uncommitted world, and now even in the N.A.T.O. countries are beginning to conclude that it is the Soviets that want disarmament and the Western powers that are holding back on it, especially in regard to their principal weapon, the Great Deterrent.[1] In the complicated exchange of open letters and diplomatic notes about a possible Summit meeting, it is also becoming evident that this will be agreed to, if at all, only very reluctantly by the United States, though its allies' governments, under popular pressure, have had to put up some show of wanting one.

At the time of writing, June 1958, there is, however, little sign of real progress. The only exception is the agreement between the U.S.A. and the U.S.S.R to hold a meeting of scientific experts to consider the possibility of control of nuclear tests. Ever since the unilateral stopping of tests by the Soviet Union, there has been an increasing popular pressure for the general stopping of tests. If this point is once ceded, it may be difficult to resist going further and accepting nuclear disarmament itself, and all it implies.

A telling argument against any agreement to disarm and end the Cold War actually stems from this very realization that the Soviet Union is in favour of it. For those who think that Communists are enemies and always will be, the mere fact that they want negotiations indicates that they expect to get some advantage from them, counting presumably on the unsuspecting virtue of the Western powers. "If it is an advantage to them, it must be," they argue, "of disadvantage to us. If we cannot see how, it only shows how diabolically clever they are." They never think of the easy answer to this—of proposing themselves to end the Cold War, and thus compelling the Soviets by the same logic to fight to retain it. But then there is the danger that they would not play fair and would agree instead. These are the same obsessed people, unfortunately very influential, who would rather blow up the whole world than live in it alongside the Communists.

The concealed reasons against having any negotiations derive from the real advantages to some groups—politicians, business men and military staffs—of preserving the Cold War indefinitely. They fear, and with some justification, that for their Heads of State to negotiate with

[1] ". . . since May 1955 the Russians have made considerable efforts to reach agreement, including the acceptance, in principle, of a large measure of international inspection and control; while the Western Governments have withdrawn the reasonable 'comprehensive' proposal for a first-stage disarmament agreement which they had previously urged." P. Noel-Baker, *The Arms Race*, London, 1958.

Communist powers, even without reaching an agreement, is very dangerous. It might make the peoples of their countries believe that the Communist leaders were not untouchable villains but people like themselves. Worse still it might appear that these leaders really wanted peace, and once that idea got abroad it might prove too popular and make it very difficult to keep up the attitude of fear, hatred and suspicion, which is necessary to make the people put up with the sacrifices and continuous strain and terror of the Cold War. This almost happened at the Geneva meeting of Heads of States in 1955. It needed all the efforts of the Western Foreign Ministers, headed by Mr Dulles, to get back to normal in 1956. Now once again in the spring of 1958 the Western Powers have agreed most ungraciously to diplomatic steps leading to a Foreign Ministers' Meeting to prepare one of Heads of States. All this may take quite a time (pp. 293, 295).

Meanwhile it is, indeed, becoming increasingly difficult to resist popular pressure from all parts of the world in favour of ending the Cold War. It arises not only from fear of the bomb—though this is often the aspect which has moved people into action—but because of the growing realization of people all over the world, in the industrial as well as the underdeveloped countries, that their present hardships will never be lightened as long as this threat remains, and may well—even short of war—become even more difficult to bear. What is more, the very hope that the newly liberated peoples had of winning prosperity and dignity by their own efforts is being destroyed as a consequence of the Cold War, which on one hand obliges them to waste much of their meagre resources on arms, and on the other denies them the capital to develop their industry, thus dooming them to a life of increasing backwardness and misery (p. 20).

One fundamental reason for condemning the state of the Cold War is its hopelessness, a hopelessness shared by its most fervent advocates. The best hope they offer is a negative one—the destruction of communist states and communism throughout the world. If this cannot be done by nuclear war, then it will be by internal dissension produced by the strains of the Cold War itself. But having done this and restored the rule of capitalism throughout the world, what is there for most of the world to look forward to. Even for the United States and a few other favoured countries, the only prospect held out is of carrying on as before 1917, without the fear that their system may be upset by military force, as they often claim but do not really believe, or by foreign subversion. But this world-wide capitalist system was precisely that which broke down in the first world war and gave rise in 1917 to the first socialist government. Nothing has happened since to alter it so fundamentally as to remove the internal strains that led to these events. Therefore, all that could be hoped for is a repetition, but now in a more deadly form, of wars between capitalist states, as happened in 1914 and 1939. Actually, the strains of the world as a whole in such a case would be much greater, because in

1914 the colonies were still safely under direct government of the old imperial powers and the prospects of their independence and industrialization were so remote as to be unthought of.

Now, even under the conditions of a complete victory for the West in the Cold War, the most the countries in the "free world" and "liberated areas" might expect is what they have actually been getting in Central and South America, where under the Monroe doctrine the United States is politically as well as economically supreme.

Actually, the prospect for the underdeveloped countries is likely to be far worse. With the destruction of the only socialist governments of the world, there would be no longer the restraint on imperialist exploitation and oppression which their presence exercised particularly during the last fifteen years. For though Soviet arms had nothing to do with it and Soviet political influence very little, the liberation of so many colonial countries in recent years has gone through relatively easily because of the fear the imperialist powers had of their peoples going over to communism. The people and even the governments of these countries know this perfectly well and even when they dare not, for political or economic reasons, openly support the Soviet Union, they resist being drawn into the Cold War and work for its relaxation.

Until the advocates of the Cold War can think up some better prospect to hold out they are unlikely to get support except from those who stand directly to gain from it or those who can be persuaded that bad as their present situation is it would be worse under communism. That is why the Cold War has generally been propagated in its negative aspect, "Preserve the American way of life" "Preserve Civilization", as if this preservation, if it could happen in a world changing as rapidly as ours, was the final goal to which all previous history had led.

These widespread feelings that the Cold War must be ended and peace secured are now finding means of common expression in innumerable meetings and international organizations, but most consciously in the movement of the World Council of Peace that has for these last nine years acted as a kind of Parliament of Man, attempting, and with some success, to influence governments to halt their conflicts, to negotiate, to disarm, and to ban all nuclear weapons.[1]

Sooner or later—let us hope before an incident in any part of the world sparks off another great war—this popular pressure will bring about negotiations, an ending or at least some relaxation of the Cold War and some measure of disarmament. There is even the hope, though it seems a danger to some, that once this process starts it may well prove to be a chain reaction and pass rapidly through the stages of relaxation, disengagement and disarmament to peaceful coexistence, even perhaps to

[1] This was the first international body to call for the banning of nuclear weapons in its Stockholm Appeal of 1950. See also *World Assembly for Peace, Helsinki, June 1955*, Vienna, 1955, and *Bulletin of the World Council of Peace*, Vienna (in progress).

international co-operation. The idea of "One World" launched in the dark days of the war when the United States and the Soviet Union were fighting side by side, may yet return. But though we may hope, we must not rely on this occurring so quickly all by itself, but rather step up the pressure of public opinion to keep the process going in the same direction and not allow any lapses back to Cold War conditions.

We must be prepared to accept for some time to come a situation where many of the present conditions are preserved, but also one in which violent hostility between rival social systems and military preparations for war between them are replaced by mutual acceptance of each other's existence, and in which the struggle between them is fought out by means of peaceful economic competition. This kind of competition, unlike war, is likely to bring out the best of both; in so far, for instance, as the Soviet Union can effectively help to build up heavy industry and create general prosperity in countries such as India or Egypt, this is a direct challenge to America and Britain to do likewise each in their own way in other underdeveloped countries, or to compete directly in the same countries, as they are doing in India, to see which way it works out best. If war and suspicion are eliminated, then the most rewarding economy will prove its superiority (pp. 290 f.).

Naturally the Communists think that their system is the most rewarding, and they are willing to take on others in the demonstration. Supporters of capitalism, though as confident of the superiority of their system in principle, seem slightly more doubtful about demonstrating it in practice under such conditions and with a certain amount of reason. There can be no doubt at the present moment that, with their far greater facilities for financing capital investments, they could do more in a purely material way than the Soviet Union in helping underdeveloped countries. The only trouble is they do not particularly want to, for it seems to them that they could only do so at the expense of their own profits. However, rather than see the whole system go under in economic competition, capitalist governments may be willing to forgo them. Nor would it be hard to manage; the device of long-term government-supported loans might secure profits to firms at the expense of a few years of deficit budgeting, always resorted to in times of slump with success.

If they decided to do this they might find that they did not lose so much in the bargain as they thought. There is a tendency of many well-meaning people in Britain and America to suggest that their countries should sacrifice a part of their national income to help the underdeveloped countries. I think the motive is admirable but that the whole idea is wrongly conceived. As indicated earlier (p. 124) economic development in these countries will not only be of great material advantage to the industrial countries, provided they adapt themselves to the changing needs of the underdeveloped countries, but also this provides far the best and most effective way by which the industrial

countries can soften the impact and shorten the duration of over-production crises due to the capitalist nature of their own economy.

I am not suggesting here that the ending of the Cold War will in itself lead to the solution of such deep-rooted instabilities of capitalism. Nor am I attempting to discuss, for reasons already given in the Preface (p. ix), the origin of these instabilities or the ways in which they can be resolved. This is not because I consider them unresolvable, but only because I believe that they will take time to solve and that before this is done it is absolutely necessary to hold off nuclear war. If the capitalist system is to be reformed, the pressure must come from within, from the peoples of the capitalist countries themselves, and this pressure is necessarily least effective under the conditions of arms race and whipped-up hostility to socialist countries. The ending of the Cold War and its replacement by a period, short or long, of more or less friendly competition will offer the only conditions in which the internal economic and political problems of the nations of today may find their solution.

The ultimate decisions between the systems may come soon or may be put off for many years. In a world at peace this decision will be made according to their relative performance in providing lasting welfare for their peoples, and this will, in the last resort, have to be judged by results. But as long as both systems are working together in a competition to see which can do best, both for their own peoples and for the peoples of the rest of the world, the danger that arises from the division of the world will be to that extent mitigated. The essential thing is to prevent war. If that can be done, the steps to the development of a world without war can be envisaged to lead forward at different rates, according to the degree to which not only active war but Cold War is given up. How this might be done will be shown in the next chapter.

XII

THE TIME-TABLE OF TRANSFORMATION

IT is only after considering both the possibilities and the difficulties that face the transformation of the economy of our present-day world that we are really in a position to deal with the questions asked at the outset of this book: How and where can we expect this transformation to start and proceed—how fast will it move? Can we provide anything like a reasonable time-table for the development of the changes?

These are the main questions I am trying to answer in this chapter. But at the outset I would like to make it clear that I am not doing this as an exercise in prophecy; partly because I know that all prophecy is dangerous, but more particularly because this kind of prophecy is the most dangerous of all. For here we are dealing with two sets of more or less unpredictable unknowns interacting with each other—politics and scientific discovery. Even in science we do not like to make the kind of prophecy that involves rates of change. The science of thermodynamics, when indicating which are the unstable and which are the stable arrangements of material systems, postulates that the unstable will of themselves turn into the stable, but it cannot say at what rate they will do so, because this depends on a number of other factors, some facilitating like catalysts and some hindering like poisons, and these have to be stipulated before the programme of the course of events can be constructed.

The predictions I wish to discuss now are therefore not intended to be compared, after a gap of ten, twenty, or thirty years, with what has actually happened by then, although this might be a quite amusing demonstration of human fallibility. They are rather to show people now what is the most or the least they might expect in different political circumstances. I am not even attempting the difficult task of predicting the political changes. Instead, I will try to examine what might happen to the development of world economy in certain different political conditions. In other words, I am trying to estimate the effect on world economy of different degrees of slackening of the Cold War. For simplicity I am taking only three of these. The first is the condition of no slackening—the *continuation of the Cold War* more or less as it is. The second might be called *a truce in the Cold War*, in which rivalry between the systems still exists, but where economic competition takes the place

of the arms race. The third condition is one where even this rivalry is replaced by *active co-operation* in the economic sphere between different countries making use of international agencies but without the formation of any world state. These are obviously somewhat arbitrary divisions put up simply to clarify the picture; in actuality they might well merge into each other.

The unpredictability of scientific discovery will have to look after itself. It is, for instance, quite likely that the production of thermo-nuclear energy, already achieved both practically as the hydrogen bomb, and on a small scale in the controlled reaction in the laboratory, will in the course of the next five years or less, become a practical industrial possibility; that within twenty years we may be drawing an unlimited amount of energy from this source. However, it may turn out that the technical or scientific difficulties are too great, and we will have to forego this source of energy for a much longer period. Similarly, some new antibiotic against virus diseases or against cancer may be discovered, or some perfectly safe, simple, and cheap method of birth control, all of which may have considerable effects on social evolution.

But by and large the old fable of the farmer and his sons is true; there may be treasures hidden in the field, but they will not be found without digging. And new advantageous scientific discoveries will be turned to practical use in the next few years in the measure that money and effort are spent on scientific research to good purpose, that is, not spent on scientific research for making bigger and better bombs or the means to throw them further or more accurately. By and large, therefore, we may expect a faster or slower tempo of scientific discovery, and then, with a time lag, of technical advance, according to where more or less effort is put into the whole of science, from science teaching in schools up to fundamental research.

In the world in its present chaotic state, neither completely unplanned nor completely planned in any part, what actually happens will be the result partly of things sought after, and partly of unforeseen consequences of actions taken for some other purpose. There again it is impossible to make any kind of precise prediction, except that by and large casual and unplanned actions will not lead as rapidly forward as planned ones, even with our very imperfect knowledge of how to plan. It is relatively easy for a group of trained engineers and economists, working together, to draw up a practical plan for the transformation of the industry of any country or region, either from the present industrial state to an advanced automatized state, or from a primitive economic state to a modern one. But, as the first planners were to find out in the time of the Soviet industrialization in 1928, there is a great difference between a paper plan and the plan that is actually carried out. The real miracle of Soviet planning was that in practice the difference was not so great as might have been expected, but that was only due to the great popular drive behind the plan, and the determination of the Communist

Party to let nothing interfere with it. It was literally a life and death business.

From then on, however, most national economic plans have had to take into account not only the capacities and resources of the countries themselves, in so far as they may be known, but also the degree of help, technical or economic, that can be expected from abroad. The change-over from an internally-financed plan to an internationally-assisted plan cannot be settled inside the country itself, but it turns essentially on the quantity of capital provided from abroad and on the conditions on which it is offered. This in the present world is as much a political as an economic question, some aspects of which we have already considered.

It is also quite impracticable to talk about planning without some idea of the internal social system under which the plan is to be made. Although the original Industrial Revolution was brought about without much conscious planning except in detail, the scale of enterprises and the interests of governments in them grew all through the nineteenth century. By the time of the First World War, monopolist corporations could plan on a large scale, but only within restricted fields and in rivalry with each other. Complete state planning could only occur when the whole economy came under working control, as in the Soviet Union in 1917, but even there ten years had to pass before the First Five Year Plan was successfully launched. This proved to be the prototype of many further plans, and not only in the Soviet Union, but also in China and in other countries, non-socialist as well as socialist. The Five Year Plans of India, for instance, are set in the framework of a capitalist economy, and have accordingly considerably less scope and a smaller degree of governmental control.

National economic planning, as we now know from experience, is by no means a simple business of setting up, as in an architect's plan, a desirable state of affairs and then ordering its realization. It is more like a military plan, where not only the intentions of the general but also those of his opponent must be taken into account as well as all kinds of unforeseen circumstances. Nevertheless, both military and economic plans are carried out, and sometimes successfully. Both depend for that success on proceeding consciously and in due order.

In an international economic plan, even under the best conditions of co-operation, this consideration of order and of proceeding by carefully considered phases would be absolutely necessary. It should be emphasized that international planning, with which this chapter will be mainly concerned, is not conceived as superseding national plans, but rather as means of helping such plans to more rapid and effective fruition. As already argued, the motive power for economic improvement must come from the people of the countries themselves who will have to do most of the work and expect to reap most of the benefits (pp. 115 f.). Any idea of some superior authority, even international and democratic in

character, planning for people in different countries of the world is completely foreign to the ideas expressed in this book.

The *operation* of changing from a pre-scientific to a scientific economy, like a military or any other planned operation, requires correct and deliberate phasing. What we might hope to do here is to outline the kind of phases we might expect the different countries of the world to go through, and to make some kind of provision, phase by phase, for the requirements of the next ones. We must also not treat them as a sequence of phases of indeterminate length, but have some idea of the time each phase would take.

This need for conscious foresight is now becoming really important in a way in which it never was in the past. No one knows quite how long the Old Stone Age lasted, but to judge from the uniformity of its products over a period of time of the order of 50,000 years, its evolution was pretty slow. Generation after generation of men found things much the same as they had been in their father's time. In the later and more stirring times in our own Middle Ages, changes began to be just perceptible between one generation and another. The old generation went so far as to disapprove of what the new generation was trying to do. Even then in some respects people could count on future events, and even plan far longer ahead than we would dare to do now: a noble family might build a policy of aggrandisement by marriage which could be carried out successfully—as was that of the Hapsburgs—for about five or six centuries. In contrast today those who have lived twenty years have seen enough drastic changes to last a lifetime, and are likely to see as many more.

It is under such conditions of rapid change that it becomes necessary to foresee the effect of changes, not merely on future generations but on the present one, that is, on people already adult, who will have to learn new skills. We need, also, to consider the training of young people to cope with jobs the very nature of which is not known at the time when they are at school. Such a rate of change makes planning very difficult, for although some things in our modern world change rapidly, others require even longer preparation than they did in the past. The scale of human operations in making dams, and reservoirs today, and the even greater works of the future, is now becoming so large that it requires a large time scale as well. Such works need to be thought of and planned, perhaps fifty years ahead, and that even in capitalist countries. Planning is an element in modern civilization that cannot be avoided. It is our business to see that it is done as comprehensively and as flexibly as possible.

The fact that speeds of advance in different parts of the world are widely different is another feature of our age that makes for even great complexity and puts even more demands on our capacity to plan. We have already seen in whole regions of the world that there is virtually no advance at all, indeed some have fallen back. Between them and the

most advanced industrial states there are a number of grades, corresponding only partially to the stages through which countries passed in the early ages of industrialization (pp. 105 ff.). I say partially because one of the hopeful features of modern science is that it is possible, through its aid, to skip whole phases of industrial development. On the advent of atomic power, for instance, it may be possible for newly industrialized countries to avoid the coal-based stage, with all its ugliness, completely. Nevertheless, in considering the advance of the world as a whole, we have to take into account not only the actual economic state of each country, but also its capacity for development. As we have seen in our own time, really rapid economic advance is possible for an underdeveloped country only when it is free from both foreign and native capitalism. At any give time, some countries will be well advanced in industrialization, others will be beginning it, still others will not even have begun. For optimal advance on a world scale, it would be necessary to work the plans of the different countries together into some kind of harmony, so that their economic products could be exchanged at each stage to mutual benefit. Thus, in a way that I have already indicated in part, the more advanced countries can help the less advanced and help themselves at the same time.

It will not be necessary here to discuss the normal course of the industrialization of backward countries or the further advance of the industrial ones. This has already been done in earlier chapters (VII–IX). What I will try to do here is rather to consider the total strategy of world development, indicating the parts played by different sectors, under the different overall limiting conditions.

In the process of industrialization of a large underdeveloped country or region, there is always one decisive point marking the change-over from secondary industry to the setting up of a self-regenerating heavy industrial base—the establishment of the complex of power, steel, engineering and chemical industry, implying production on a scale of millions of tons per annum. Of all the underdeveloped countries in the world, only Brazil, Mexico, and Chile with a total population of 97 millions are even approaching this phase. In 1956 their steel production was 1·4, 0·6 and 0·4 million tons respectively.[1]

Until any country has reached at least this phase of industrial development, its advance is necessarily slow and its economy remains dependent on those of already industrialized countries. In the "Free World" there is little or no incentive from outside to help industrialization, and insufficient capital accumulation in the country to start it from the inside. Consequently, industrialization may take long to get started, and develop slowly when it does. This has been, for example, the case for India, the second largest country in the world, which still has an industry smaller than that of Belgium, with one-thirteenth of the population.

[1] The Soviet Republics of Central Asia and Transcaucasia have already reached similar levels of steel production (p. 123 *n.*).

TABLE XVIII—THE CONDITIONS OF ADVANCE

		I CONTINUATION OF 'COLD WAR'	II TRUCE IN 'COLD WAR'	III INTERNATIONAL CO-OPERATION
ARMAMENTS		Arms race continues. Nuclear tests continue. Production of more and larger nuclear weapons. Build up of sites for intermediate and inter-continental ballistic rockets. Increased risk of outbreak of nuclear war through technical misunderstandings and irresponsible decisions. Dissemination of nuclear weapons to many countries not now possessing them. Growing armament costs. Depletion of scientific and technical manpower.	Arms race stopped. Nuclear tests suspended. Agreement not to use nuclear weapons but stocks left undestroyed. Standstill on development of ballistic missiles. Large reduction in conventional armaments. Conversion of many arms factories to civil uses. Many scientists and engineers released from defence services and industries. Funds made available for capital investments and improved standards of living.	Disarmament agreement in operation. Elimination of nuclear weapons. Cessation of military research liberates scientists and technologists. Reduction of all conventional forces and weapons to minimal levels. Setting up of permanent system of control of armaments and for settlement of disputes. Nearly all sums previously used for armaments now available for civil purposes.
INTERNATIONAL RELATIONS	Political	Tension maintained by recurrent crises. No resolution of existing disputes. Dangers of disputes triggering off war.	Tension reduced. Existing disputes resolved by negotiation and compromise on general basis of status quo.	Tension replaced by co-operation, each country determining freely its own internal social system. No abandonment of national independence but greater activity of U.N. agencies.
	Economic	Continuation of embargo on production goods exports to socialist countries. Reduction of capital available for neutral underdeveloped countries.	Freedom of trade in all goods. Currency agreements to facilitate exchange. Great increase in capital available to underdeveloped countries. Active competition in economic assistance.	Planned international trade to secure maximum benefits for all. Co-ordination of development plans of each country with agreed quotas of capital assistance from industrial countries.
	Cultural	Hindered movements across frontiers; passports and visa refusals. Scientific secrecy and security checks.	Restoration of freedom of movement of persons and information across frontiers. Abolition of scientific secrecy.	Greatly enhanced cultural exchanges. World organization of scientific research and communication.

CONSEQUENCES	Capitalist Countries	Inflationary pressure and exchange difficulties. Dangers of restricted markets and slumps. Reduction of capital formation. Threats to wages, employment, social welfare and civil liberties.	After a brief period of transition to civil industry, increased production of capital goods, machinery and vehicles. Later expansion of consumer goods industry. Increased capital formation and greater sums available for social welfare and education.	(Capitalist economies may have disappeared at this stage). Production planned in relation to internal needs and requirements of industrializing countries. Economic progress with less fear of slumps. Rapid advance of automation and atomic industry.
	Socialist Countries	Economic progress continues but rate affected to a lessening extent by import restrictions.	Economic progress accelerated, more effort available for consumer goods. Greater imports from capitalist countries. Greater exports to underveloped countries. Freer foreign contacts.	Fully balanced economic progress possible on account of removal of external risks.
	Underdeveloped countries	Colonial wars likely to continue and get worse. Economic conditions unlikely to improve in most cases and may markedly worsen. Absence of capital for industrial development. Any new industrial centres formed will be largely on the initiative of the Soviet Union.	Rapid granting of independence to all colonial territories. Economic conditions improve. Long term loans available from both capitalist and socialist countries. Possibility of forming new industrial centres in all continents.	Economic advance now possible at highest rate determined by internal factors only. Capital available through international agencies to meet requirements. Rapid industrialization. Some ten new industrial centres could be started in first decade, twenty in next and more as required.
GENERAL		Growth of internal and international tensions. Mounting danger of war and revolution.	Relaxation of internal and international tensions. Competition between social systems by raising internal standards of living, educational and scientific achievements and assistance to underdeveloped countries.	Rapid completion of second industrial revolution on world basis. Evening-up of standards of living all over the world. Flourishing of science and culture.

Now that it is free from the direct imperial control of Britain, India is industrializing, and doing so for heavy industry in a socialist form (p. 116 f.). Despite the present restricted conditions of world economy, it will be impossible to prevent other countries also reaching the point when they become self-sufficient, both technically and in capital formation.

Consequently the speed of industrialization throughout the world can be assessed by the sequence of dates at which each new country or region passes into the first phase of industrialization. We must then consider to what extent general world conditions hasten or slow down the rate at which new countries start their industrialization. Under the worst conditions—short of war—it may happen that no underdeveloped country becomes industrialized. None did so in fact in the capitalist-dominated world during the first half of this century. It was only through socialism, and in the face of strong capitalist opposition, that the Soviet Union itself managed to acquire an industrial base. Indeed, according to orthodox capitalist economies, there is no reason why any more industrial bases should be set up. But this restriction cannot be maintained, as China and India are showing, the process of industrialization is likely to go on at an accelerated pace. Even under ideal conditions it would be impossible to start such an industrialization everywhere at the same time. But we might expect the first one or two to appear within twenty years, and after that an increasing number in each decade, until the process slowed down as the world became completely industrialized, and ready for the next stage of further scientific advance.

Here in this chapter we have to consider in more detail the likely effect of different world political conditions already referred to which were summarized for simplicity under the three headings of I. Continuation of "Cold War", II. Truce in "Cold War", and III. International Co-operation. A synoptic picture of what these three conditions might mean are shown in Table XVIII. They are discussed in more detail in the following paragraphs.

The first of these, and the only one with which we are already familiar, is *the continuation of the Cold War* at more or less its present degree of intensity. This means, by and large, the continuation of the arms race, limited only by the capacity of the countries on either side, particularly the weaker ones, to bear this strain. It also implies maintenance of the general territorial *status quo* in most regions of the world.

This might be broken here and there by limited, local wars of the type of Korea and Viet Nam which, unless they are to invoke a general world war, are bound to end in negotiated armistices with no great advantage to either side. Whether even this could happen, with the openly proclaimed Western strategic policy of "limited nuclear warfare, now built in to their armed forces" (pp. 13 ff.), is far less certain. Atom bombs in Manchuria or Syria would have probably set going a chain reaction of reprisals which would have ended within a few weeks or days

in a general war (pp. 13 ff.). But here by definition, and unfortunately only by definition, we are not considering such eventualities, and hope that somehow or other it will be possible to maintain the precarious, ill-tempered and dangerous peace.

In their gloomy moments American and British statesmen have talked of the Cold War as a permanent feature of our civilization, which will go on for a century or so (p. 209). But we may hope that this prospect is no more real than Hitler's boasted thousand years of Nazi rule. However, as we are dealing here with the short-term period of a generation or so, the possibility of a continued Cold War must be considered as one of our limiting conditions; it is certainly the most limiting.

Because we are unfortunately so familiar with Cold War conditions, it is hardly worth doing more than list its major economic features as far as they affect any possibility of progressive changes in world affairs. It involves a state of permanent strain—this is really its essence—not only of military and political strain, but also economic strain which has shown itself in recurring crises of a special type. They were characterized not so much by lack of employment as by shortage of foreign exchange. This in turn was due to the inability of countries—other than the United States—to carry the ordinary burden of their economic life and indulge at the same time in making what is considered their necessary contribution to the common defence. We are in the middle of one of these in Britain as I write. This may have passed, or another may have come, by the time this book is finished. Nor is it impossible that the old, cyclical production crises of capitalism before the war, which have since then been partly held back by the arms race, may return once again (pp. 293 f.).

Bad as these minor crises are in the industrial countries themselves, as tending to destroy the advantages brought by improvement of technique and full employment, they are far worse in the under-developed countries, where falling world prices result in extending misery and some degree of famine. A major slump in the United States would produce catastrophic results in these countries.

For the last few decades the real standard of living over most under-developed countries is falling slowly, but with an increasing pace (p. 64). The peoples of these countries feel the injustice of enduring greater poverty while the means to end it are withheld from them and this provides much of the motive power for the anti-colonialism which is at present the most dynamic of world movements, and, because of its very nature, is wedded to change rather than the maintenance of a *status quo*. It is in such countries as Algeria, where conditions are so bad that it seems that nothing could be worse, that freedom from Imperialism seems worth fighting and dying for. In the older European capitalist countries the atmosphere generated by the Cold War is one of general cynicism and discouragement, now also tinged with fear. There is a

tendency to turn away from politics to concern with purely personal and family life, without hopes of any amelioration of general conditions.

It is perhaps this absence of hope more than any other psychological fact that stifles any serious effort on the part of public opinion to change the economic conditions. People may know that what stands in the way of better times is the persistence of the Cold War, but they feel that there is just nothing they can do about it. Nevertheless a point will come in one country after another when the strain will get too great and people will be shaken out of their political apathy and take some action. Whether the action will be wise or not depends on how far in the interval they have come to understand the political and economic forces in the world they are living in.

In the United States itself conditions are again different. Here the problem is one of a production—or rather of a productive capacity—greater than can be absorbed by the amount of consuming power set free in the economic process. It is a more classical boom and bust situation in which slump has been held off, in so far as it can be, by recurring crises of alleged national dangers, requiring enormous new armament expenditure such as that set off by the Sputniks.

As these conditions are the ones that we actually live under, the simplest way of predicting what this means for the development of a new economy in the world is to look at what it has meant in the last ten years. For like causes will produce like effects, at least up to the point when the whole system becomes unstable, either in the direction of war or of major economic crises. Unless and until either of these happens, what we will see therefore is what we have already seen only more so.

Many industrialized countries and particularly the United States will see a rapid advance in technique and science but one polarized increasingly to military uses. Automation in limited fields of industry will grow rapidly, though in a spasmodic manner, enabling goods such as cars, washing machines and refrigerators to be turned out faster and with smaller labour costs, thus increasing the tendency to unemployment and slump (p. 58). Science will continue to advance but as long as it remains so largely tied to military uses its benefits will not be fully felt. However, because not enough people know about science anyway nor are they brought up to be interested in it, they do not know what they are missing.

Agricultural production in the United States may well increase still further than the 50 per cent it has gained in the last twenty years (for details see Table V, p. 62). But there is already great difficulty of disposing of the food produced, however wastefully it is used, and it would be immoral to give too much of it away to people in the rest of the world who want it but are unable to pay for it. In consequence, the policy of restricting cultivation and destroying or dumping surpluses is likely to continue. Wealth will accumulate further in the hands of the

rich, though the twelve million families, out of 43 million, who earned less than $3,000 in 1955 are likely to earn still less in the next few years, while the number of such families is likely to increase. But the more the wealthy get, the less secure they feel and may be persuaded by a well-designed campaign of advertising terror to put up ever more money for "defense" by means of nuclear bombs. In this time of strain the mood of the great mass of the people, the 60 million American workers, is uncertain but there are signs that if unemployment rises still further there will be a turn towards Rooseveltian liberalism.

Meanwhile the European industrial countries, as already indicated, are in a state of increasing financial strain. The increase of production, which was reasonably large for a capitalist country, running at a rate of about 5 per cent or more per annum for the years 1950–55, has turned into a decrease, except in Germany which is a few years behind the others in its development and may be expected to slow down in its turn. The social gains of the period of the Welfare State and full employment now seem to be in danger and here a general discouragement and cynicism is beginning to turn, even in Germany, to active resentment against the policy of the Cold War.

On the other side of the world, in the Soviet Union, it is now evident that there are at least six large and well distributed bases of heavy industry. Heavy industry will continue to grow at rates of some 15 per cent per annum as compared to the 32 per cent maximum or the 7 per cent average of the United States. But at the same time, for political as much as for economic reasons, it will be combined with an ever faster drive in consumption-good industries. This was always desirable, and now the country feels strong enough to undertake it. The leeway to be made up in the form of improving food, clothing and housing is such that there is no fear of running the industry into over production. Rather, it will still be a long haul, estimated by Mr. Khrushchev as at least fifteen years, before they reach the same standards of physical consumption as the Americans have today, due in part to the burden of rearmament expenditure and in part to the closing of new markets both for consumer goods and productive machinery.[1]

In the Soviet Union, quite unlike the United States where it is a stimulus, military expenditure is an absolute drag and is holding back the rate at which these good things might be provided. This is a fact well known to the rulers of the United States and indeed used by them as one of their major levers in foreign policy (p. 216). The change towards better conditions of living will not, by any means, prevent the rapid transformation of industry along the lines of the new Scientific Revolution (pp. 144 ff.). For the last few years it has been evident abroad that the pace of the transformation of industry is being set in the Soviet Union. In the use of atomic energy, it is surpassed only by Britain; in automation, it is leading the world, as it is also in mechanical engineering,

[1] *Soviet News*, 7th February, 1958.

aviation engineering, and rocketry, where Soviet advances have completely upset the military balance of power in the world.

The policy of full utilization of the human resources of the country, particularly by scientific and technical education, on a scale never before attempted elsewhere is already paying dividends (pp. 181 ff.). In the long run it is bound not only to give an immense and growing advantage to the Soviet Union and other socialist states but also prove a powerful transforming factor for the whole world.

The prospects in Eastern Europe which was for long considered by the advocates of the Cold War policy of "containment plus" as the weakest sector of the whole socialist world, have definitely improved since the bad days of 1956. The attempt of the separate countries, even small ones like Hungary, to set up major industrial bases of their own at heavy cost to the standard of life (p. 131) has been abandoned and in its place has come schemes of mutual trade between the countries in the area[1] and also with the Soviet from which has come in recent years considerable economic aid. The severity of the Western blockade, which is also a major economic cause of distress, has also been mitigated, and in the case of Poland credits are being actually provided from the United States. All this is an indication that the early Cold War policy of relying entirely on sharpening internal discontent by propaganda and agents, so as to provoke political disintegration, has been modified. Instead, more stress is being laid on weakening the hold of the Soviet Union by demonstrations of superior benevolence. This may to some extent remove the danger of the area being made the focus of a new world war. However, it has for the last ten years suffered more than any other from the Cold War, and can never fully recover in a Cold War atmosphere.

In China, on the other hand, the difficulties are of a more elementary and physical nature. Here an enormous population of over 600 million, with an ancient and high culture, has been kept by the backward looking feudal-imperial governments—interfered with by foreign colonial powers—from developing its own resources, which it clearly could have done at least as early as Japan. It is now at last embarking on stages of industrialization. How this is being done has already been described (pp. 116 ff.). Here it is sufficient to say that already China's future as a major economic power is assured through her great resources, the energy

[1] This is useful because the industries and agricultural products are largely complementary. Czechoslovakia is the most industrialized and can supply agricultural and other machinery as well as consumer goods like glass and footwear. Poland has large coal supplies and a strong textile industry. Hungary has aluminium ore and a good electrical industry. Rumania has oil and could, with mechanization and fertiliser, produce agricultural surpluses. Slightly outside the area but now developing trade with it is Eastern Germany with its brown coal and fine mechanical and optical industry and Yugoslavia with considerable agricultural and mineral resources. Between them they comprise all that is necessary to maintain a major heavy industrial base and associated industries. In this case, however, it need not be concentrated as in the past near the Silesian coalfields but could be of the modern scattered type (p. 131).

and enthusiasm of her own people, the leadership of an experienced Communist Party, and the technical advice and aid from the Soviet Union. The great advances of the last ten years have been made in the face of maximum Cold War hostility from the United States and what amounted to its active war of intervention in Korea. Were this hostility to be relaxed, the advance of China could be even more rapid, to the benefit not only of her people, but all those of Asia.

When we turn to other underdeveloped countries lying outside the orbit of the socialist states, the outlook is far more grim. So far, only in India has there been a full-scale attempt to industrialize. This has been on the general lines of the Soviet Union's First Five Year Plan, but without any fundamental change in the social system—that is, by a method of nationalization with compensation and building up to state-owned industries. This policy, though violently opposed by capitalist interests both inside and outside the country, has won the imagination of millions of Indians and particularly of the engineers and scientists who have to carry it through. Where the conditions of the Cold War block them is in limiting the supply of capital. Adequate quantities could only flow as the result of considerable disarmament.

I have no doubt that the industrialization of India will go through, but certainly it will go through much more slowly under present conditions than its protagonists hoped, or than it could go, given a relaxation of the Cold War.

The other countries of Asia have not been able to reach by any means the same stage of internally-directed industrialization as India. None of them were as technically advanced as India nor are they for the most part either large enough or possessed of suitable raw materials to attempt to become autonomous industrial centres in the sense discussed in earlier chapters. Egypt—now the United Arab Republic—and Indonesia although rich agriculturally, are known so far to have few exploitable mineral raw materials, though more may well be found. This situation would change radically if means were found to introduce atomic energy, where the full value of large and industrious populations could be turned to account. But this is still some twenty years ahead.

In both these countries the national liberation movements are having to resist the last efforts of the colonial powers. While foreign administration has ended, it is still necessary to break out of an effective economic blockade and refusal of credit—for example, the classical case of the Aswan dam. In many of the other countries where there are immediately available resources, in the oil countries of the Middle East, the direct or indirect grip of the oil companies is sufficient to prevent the real wealth of the country falling into the hands of the majority of its inhabitants. The same conditions hold for other oil-less countries of the SEATO and Baghdad pact areas, such as Thailand or Pakistan. There is little possibility of industrialization or any relief of the grinding poverty of the largely peasant population until they have shaken free of capitalist

interests. How difficult this is to do was shown by the case of Iran, where a promising beginning of getting rid of the Anglo-Iranian Company was cynically turned into selling the country to the American oil interests.

These countries are now enjoying benefits of the Good Neighbour policy, by which the United States has kept the whole of Latin America under its tutelage for the last forty years and to prevent the development of any independent industrial centre in that continent. This means American consumer goods and various degrees of luxury for the landlords and *bourgeoisie*, and continued poverty under primitive, but now slightly more sanitary conditions, for the rest of the population. The relatively small working class is occupied in producing raw materials such as oil or cash crops for export—in other words, we have a new colonialism. However, it is less likely to be accepted even for a shorter time than the old one, and we may expect and indeed are already having plenty of examples of local revolt against these conditions. They cannot always be put down by reliable politicians or by troops armed with American small arms. Nor are these good regions in

TABLE XIX

DISTRIBUTION OF FOREIGN AID

Billions of U.S. Dollars

(*a*) U.S. MUTUAL SECURITY PROGRAMME

	Military	*Non-Military*	*Total*
1950	·05	3·4	3·5
1951	·9	2·8	3·7
1952	2·4	2·1	4·5
1953	4·0	1·8	5·7
1954	3·6	1·2	4·9
1955	2·3	2·0	4·3
1956	2·6	1·6	4·2
1957	3·5	·5	4·0
Total for 8 Years	19·35	15·4	34·8

(*b*) U.S.S.R. FOREIGN AID

	Military	*Non-Military*	*Total*
1956	0·2	0·7	0·9

Source: *Statistical Abstract of the United States 1957*, Washington, 1957.

The Sino-Soviet Economic Offensive in the Less Developed Countries, U.S. Department of State, Washington, 1958.

Economic Survey of Europe in 1957, U.N., Geneva, 1958.

which atomic bombs can be used with effect to prevent internal subversion according to the Eisenhower doctrine (pp. 295 f.).

Most of these countries have been for many years recipients of aid from NATO powers which comes overwhelmingly from the U.S.A. The main funds for this are provided by the U.S. Mutual Security programme. The official figures given in Table XIX(a) shows an unmistakable trend from civil to military aid. The latter, because of the demands it makes on the manpower and resources of the countries it is given to, is not so much aid as imposition, and is usually on a scale which may dwarf the good effect of the civil aid. In contrast, aid from the Soviet Union, Table XIX(b) is on a much smaller scale, though the preponderating civil aid is comparable to that from the United States.

More details as to the distribution of aid from both capitalist and socialist countries are shown in Table XX. The former, (a), shows total aid in loans and gifts to twelve underdeveloped countries arranged in order of the aid received per inhabitant, with the further addition of India. It includes multilateral aid through U.N. agencies, which can be seen to be a relatively small contribution. In most cases—all, except for three ex-colonial or protected countries—the largest contributor in the U.S.A.

In Table XIX(b), the corresponding figures are given for aid from socialist to underdeveloped countries. The figures, derived from U.N. sources, are admittedly incomplete and consequently only indicate the lower limit (>) of the aid received. Here the major contributor is the Soviet Union. What the figures do not show is the difference in the character of the aid given by capitalist and socialist countries. In samples where this is stated, it would appear that the capitalist aid is mostly in the form of food and consumer goods, while that from socialist countries is mainly in the form of producer goods. For completeness, aid to the socialist countries of Mongolia, N. Korea, N. Vietnam and China has been included in this table, but the policy of rapid industrialization and agricultural reform followed in these countries put them effectively in a different category from those that remain within the orbit of the "Free World".

Bad as the conditions of the free countries of Asia and Africa are, they are far worse in the remainder of the old colonial system—in Malaya, in Kenya, the Portuguese colonies, in Algeria, in Madagascar—in all of which there is actual revolt, either smouldering or active, and where impoverishment is made worse by the presence of foreign colonists or administrators living on a far higher standard than the so-called "natives" and monopolizing all the best land, plantations and mines where the said natives have to do all the work.

How this will break down—whether by the costly methods of prolonged warfare as in Indo-China, or by the astute giving in at the right moment as practised by the British in India and Ghana—remains to be seen. But from our point of view of changing things we can see that

TABLE XX

International Economic Aid in Loans and Gifts To Underdeveloped Countries: January 1954–December 1956

(Millions U.S. Dollars)

(*a*) Aid from Capitalist Countries

Recipient Country	*Total Aid Received*	*Largest Bilateral*		*Multilateral Aid*	*Aid Per Inhabitant (Dollars)*
		Contribution	*Contributing Country*		
Israel	141	140	USA	1	83
Jordan	113	85	UK	2	81
Libya	60	26	USA	2	55
Laos	70	66	USA	—	50
S. Korea	675	595	USA	78	31
Tunisia	105	104	France	—	28
Taiwan	218	216	USA	2	25
Morocco	151	150	France	—	18
Bolivia	48	45	USA	3	15
Vietnam	353	341	USA	—	13
Brazil	293	239	USA	51	5
Pakistan	309	222	USA	39	4
India	245	200	USA	16	0·6

(*b*) Aid from Socialist Countries

Recipient Country	*Total Aid Received*	*Contribution of U.S.S.R.*	*Contributing Countries other than U.S.S.R.*	*Aid Per Inhabitant (Dollars)*
Mongolia	> 50	> 50	Czechoslovakia	>50
North Korea*	415	250	Czechoslovakia, E. Germany, Poland, Hungary, Rumania	50
North Vietnam	>100	100	..	>10
Afghanistan	>106	106	Czechoslovakia	> 9
U. Arab Republic	>231	>175	Czechoslovakia	> 8·5
China	>855	>855	..	> 1·5
Indonesia	>100	100	Czechoslovakia	> 1·2
India	>240	240	..	> 0·7
Burma	7	7	..	> 0·4

Sources: *Statistical Yearbook, 1957*, U.N., New York, 1958.
Economic Survey of Europe in 1957, U.N., Geneva, 1958.

Notes: *Mostly 1953–54.

these countries have not even reached the point at which improvement can begin. They have first to gain their independence.

By and large, the only hope for all the underdeveloped countries, ex-colonial or colonial, embracing nearly half the population of the world and at present outside the orbit of socialism, is breaking away from the control, direct or indirect, of the capitalist powers, and this is going to be extremely hard to achieve in the conditions of the Cold War. Nevertheless, the whole of this region, from the Phillippines to South America across Asia and Africa, is in a ferment. The popular movements in these countries are themselves becoming linked with the major conflict of the Cold War, notably in the Middle East, so that the danger always remains that they themselves may give rise to the critical hostilities to set off a Third World War. If this does not happen it will be necessary, in any settlement which puts an end to the Cold War, to make them effectively free or at any rate to leave them equally open to assistance from both parts of the world. Despite increasing injustice and repression, such as occurs in South Africa and Algeria, the peoples, by actions ranging from boycotts to insurrection, are forcing concessions and rapidly moving towards liberation. However, as we shall see in the next section, it is possible that they may find sufficient resources through the very competition between the capitalist and socialist systems to effect their own economic as well as their political liberation.

The conditions of the Cold War offer only the feeblest prospects for any progressive and certainly for any rapid improvement of the conditions of the worlds as a whole. What we may expect while it lasts—and let us hope it will be a very short time—will be a continuation of the economic tendencies already evident in the "Free World". If there is a slump as well conditions will be far worse.

To sum up: the disparities of standards of living, themselves one of the major causes of conflict in the world, will certainly not be reduced as long as the Cold War lasts. In fact it is one of the objects of the Cold War to increase them. The same threat hangs over the countries of Western Europe, who will have in addition a heavier armaments burden to bear. At the other end of the scale the economies of the underdeveloped section of the Free World have very poor and fluctuating prospects. None are likely to advance rapidly and many may face still further impoverishment.

However, the other object of the Cold War, the weakening of the socialist countries and particularly of the Soviet Union and China is plainly not going to be achieved. Hampered as it has been by blockade and the necessity for large military expenditure, economic development is sure to go forward, and at a continually faster rate.

Thus the Cold War may well have a result precisely the opposite of what was intended, by increasing the relative strength of the Socialist part of the world and increasing its attractiveness in the eyes of the peoples of Asia and Africa. No one in the socialist world would,

however, approve this way of securing an advantage simply as a result of general improverishment, and one carrying with it the horrible danger of another nuclear war. On reflection, it will be to the advantage of all to end this tragic state of affairs, which offers no hope for the future, and uses most of the available surplus of the industrial forces of mankind to hinder rather than help its advancement.

We pass now to the second condition, that of some kind of *Truce in the Cold War*. Here it is more difficult to define what we mean or even to picture it, for unlike the Cold War we have no direct experience of it. For the purpose of argument, however, one could postulate some kind of intermediate condition, in which the major blocs into which the world is at present divided still remain essentially intact. Territorially, there would be a general *status quo* as far as governments of different countries in the world were concerned, even in the disputed areas. It would not, however, necessarily exclude the reunification of Germany, Viet Nam and Korea and even some adjustments of the frontiers of Israel providing a tolerable life for the Palestinian refugees. But by and large I am considering a condition in which no great changes in régime or in territory are being made.

The major change postulated would be the definite stopping of the armaments race and some degree of disarmament. This might be one of the stages of the plans which have been agreed in principle over and over again at the U.N. Disarmament Sub-Committee but never yet accepted in practice. It would include the drastic reduction of conventional weapons and forces, something which is likely to happen in any case because they are now practically obsolete except for dealing with unarmed colonial peoples. It would also imply some prohibition, with inspection, of the manufacture and use of nuclear weapons, though not yet necessarily a destruction of stocks. With this could go a general relaxation in international tension, because such a degree of disarmament would hardly take place without it. This would mean some lessening of the acute hostility between the major antagonists of the Cold War, the United States of America and the Soviet Union, and this not merely in the comparatively easy fields of literary and artistic interchanges, but in the hard field of economics and trade. It would require the abolition of the restrictions on exports to the Soviet Union and China, and even the possibility of some long-term loans at low-interest rates to those countries for the purposes of industrialization.[1]

[1] Concrete proposals for such loans were made on 3rd June, 1958 by Mr. Khrushchev in a letter to President Eisenhower in connection with the new Soviet plan to set up a large plastics and artificial fibre industry to advance the standard of living of the Soviet people.

The scale of the enterprise is indicated in the following quotations:

"In the opinion of the Soviet government, co-operation between our countries in the manufacture of synthetic materials and of articles made from them could develop in the following ways:

"Purchases by the Soviet Union from the United States of industrial equipment, including complete sets of equipment for factories and works . . ."

The essential economic difference here would be that by reducing armaments and stopping the arms race a great deal more capital would be available for export, not only from capitalist but also from Socialist countries, and this capital would tend to flow to the less industrialized countries of Asia, Africa and South America. Under the conditions we have postulated this will be no longer the kind of export of capital which existed in the past—one directed mainly at the rapid exploitation of mines and plantations. For once the Soviet Union was relieved of the necessity of military production and was able to export capital in its own way on an ever increasing scale, there would be a competitive attraction for the U.S. to open up industrial rather than merely extractive forms of capital exports.

This would give rise to the possibility of an agreed, or at least a competitive, financing of national construction plans, such as the five year plans of India and others, which would grow up very rapidly in countries such as Egypt and Indonesia. In this the United States and the Soviet Union would take part, together with a number of other countries, such as Germany, probably coming in on a smaller scale. The conditions would be settled according to the most favourable offer, and the influence of bids from the Soviet Union would tend to make them much easier for the new countries to industrialize (pp. 123 f.). The American investor—or rather the U.S. Government, because we have not postulated any change in the desire of the American investor to make the most of his money—would have to advance capital on fairly easy terms. In parallel to this export of capital would go a reorientation of industry in the industrial countries of the world, capitalist and socialist alike, which would transfer to civil industry the potential now locked up in military industry. Much of this would be for industries making production goods, constructional and electrical plant, vehicles and agricultural implements, which are of just the character needed by the underdeveloped countries. It would represent a substantial addition to the productive capacity of the industrial countries, of the order of several tens of billions of dollars a year.

An attempt to estimate more precisely the supply of capital available from the industrialized countries and the requirements for it of underdeveloped regions of the world has been made in Table XXI. It is based essentially on the U.N. estimate of the needs of economic development of these countries in a way set out in the explanatory notes to the table.

"The Soviet government believes that the purchases of equipment and various materials in the United States, given a corresponding agreement by the parties, could be valued at several thousand million dollars in the next few years."

"This leads to the question of the possibility of instalment payments and the extending of long-term credits on normal terms.

"The development of trade may naturally be started on a basis of reciprocal deliveries. But, due to the considerations mentioned above, credits and instalment payments could create conditions for considerably larger immediate Soviet orders and purchases in the United States."

It will be seen from the schemes proposed that a *reduction of military expenditure to one-third* of its present value would provide not only all the funds necessary to industrialize *all the underdeveloped countries of the world within ten to twenty years*, but that there would also be plenty left for further improvements in the levels of production and the standard of living in the industrial countries. In conditions such as envisaged here we might expect industrialization to proceed at a rate which, though it would still fall short of what could be done under the best conditions, would be much greater than that achieved under the most favourable conditions today. A number of new industrial centres might be set up—one for instance in the Middle East, one in North Africa, two more in West and Central Africa respectively, as well as five in Central and South America. Some idea of what their distribution might be is given in Map I, which shows major and minor industrial centres as they are today, together with what might be done to enlarge the latter and to create new centres where the density of population and the availability of raw materials, chiefly mineral, might seem to justify it. In all, such proposals would mean the enlargement of 11 existing centres, and the creation of 14 new major and 30 new minor industrial centres. The actual locations of such centres can be a matter only of intelligent guessing. They are set down here to give only an impression of the scale and extension that would be involved in industrializing the whole world.

With industrialization, there would necessarily be the improvements in health and education already discussed in previous chapters (VI and X). At the same time, a world-wide attempt would be made to increase food production through the extension and intensification of agriculture, as discussed in Chapter V. What this would mean in terms of utilization of the world's land surface is shown in Map II, which should be looked at in conjunction with Table VIII (p. 69), for the areas of land available for food production. These are shown in a graduated series of stages of land utilization, each one requiring more capital expenditure than the previous one. A truce in the Cold War would permit at least the extension of agriculture to the limit of what is possible with existing methods,

[continued on page 250

In Table XXI an attempt is made to balance the capital available from five industrialized countries, four capitalist and one socialist, with that required by the five underdeveloped regions of the world. On the first, left side of the table, the situation as it has existed in the last few years is set out. With respect to the industrial countries this is derived from the last available United Nations figures, mainly for 1956. (*Statistical Yearbook 1957, op. cit.* and *Monthly Bulletin of Statistics*, U.N., New York, February, 1958). All figures are in $ billions—the Rouble being taken, as before, as 4 to the dollar. For the underdeveloped regions I have based my estimates on the U.N. Committee of Experts report, *Measures for the Economic Development of Underdeveloped Countries*, New York, 1951, but with the figures expressed in 1956 prices. This is probably not far wrong for regional incomes, which have about kept pace with population. The estimates made by this Committee were admittedly extremely rough, but they represent the best figures I can find on the capital needs of the underdeveloped regions. They were calculated on a

formula based on population and aimed at raising the standard of living by 2 per cent per annum. As this is hardly greater than the normal increase in population, it is plainly insufficient to provide for any major change in their economies. The estimate of foreign credits required annually is $16·2 billion in all. Small as it is, this sum, on this reckoning, is more than 13 times that actually made available to these regions annually in international loans or gifts from governments. These figures have also been derived mainly from United Nations sources (for details see Table XX, p. 240). They do not include private loans, for instance from oil companies, but nor do they include the profits transferred from these regions by foreign mining, oil or industrial companies, nor do they allow in any way for changes in the terms of trade. The losses due to the fall of raw material prices in the last year was actually greater than the total assistance of the past three years.

The second, right part of the table, represents an estimate, which I have made, of a possible redistribution of available funds which would be provided by a reduction of the armament expenditures of the main industrial countries to one third of their present rate. I have divided this between additions to capital formation funds, available for welfare services or tax reduction, and those available for aid to underdeveloped countries. The last of these has been adjusted to meet their needs for accelerated development, as set out in the lower right-hand part of the table. The distribution between capital formation and welfare has been slightly adjusted to provide more capital for the countries that have been investing least, notably Britain (p. 160).

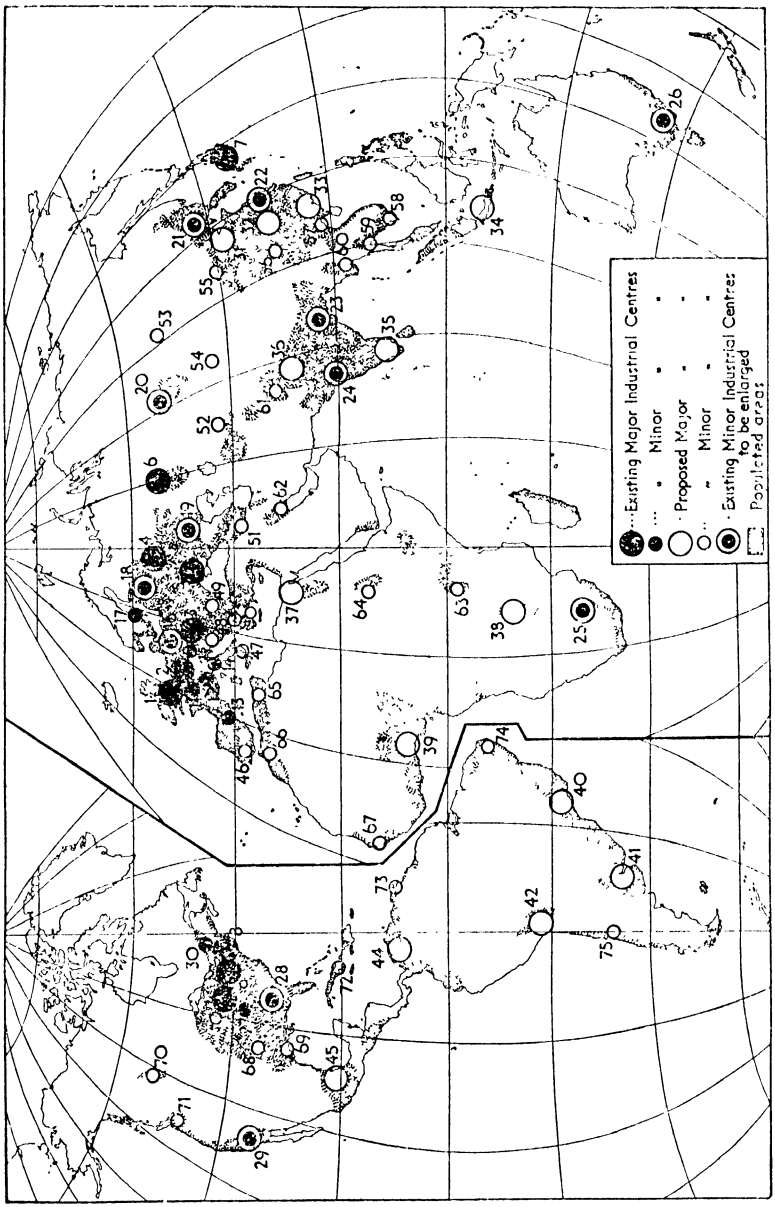
In the lower right-hand section of the table a re-estimate is made of the need and the provision of capital for the underdeveloped regions. The figure for investment required is set at 50 per cent more than the U.N. estimate. This would nominally provide an annual increase in standard of living of 3 per cent, which would be still too low. However, the calculations of the U.N. experts were based on the more expensive types of capital imports (pp. 121 f.), whereas the experience of China has shown that far more can be done for the same money by investing only in essential equipment (pp. 123 f.). Consequently, the amount of money budgeted for in the table should provide, if wisely invested, for a 10 per cent per annum raising of the standard of living. At the same time, the regional savings estimated in the U.N. report were based on actual savings in an economy in which property is so unequally distributed and the spending habits of the rich such that much is wasted or sent abroad. With a strictly economical government control of investment, it is probable that between 15 and 10 per cent per annum could be provided from local savings. These figures, which are shown in the second column, have been adjusted, to a certain degree, according to the immediately available natural wealth of the regions. Indeed, it is certain that already the profits from the oil from Latin America as a whole, as well as those from the Middle East would, if they were not sent abroad, suffice to finance, without recourse to outside funds, the whole of the industrialization of these regions.

The total foreign credits required, $20·5 billion, estimated in this way are not much greater than the U.N. figure, though seventeen times that provided at the present time. If anything, they are an overestimate. The actual time for which sums of this order would be required by any country are of the order of ten years, after which it should be largely able to finance its own further development through its internal industrial capacity and trade, as China is already largely doing.

As not all countries in any region will be starting their industrialization at the same time, the demands of some would be rising as others were tapering off. Although the total external cost of industrializing the underdeveloped regions of the world would still be of the order of $100 billion—about a two-year's world arms bill—it might have to be spread over twenty years. Consequently the sum required per year would only be about half the figure given in the table, or $10 billion a year, an expense which shared amongst the industrial powers would hardly be felt.

TABLE XXI—Capital Available and Economic Needs of Underdeveloped Countries

PRESENT POSITION (1956)							*PROPOSED TRANSITIONAL ARRANGEMENTS*			
Country or Region	*Population (millions)*	*National Income (Billions U.S. Dollars)*		*Capital Formation*	*Military Expenditure*	*Credits and Gifts to Under-Developed Countries (Average 1954–6)*	*Military Expenditure Reduced to one third*	*Capital Formation*	*Credits Available for Under-Developed Countries*	*Funds Available for Welfare or Tax Reduction*
U.S.A.	168	342		38·4	44·3	0·54	14·8	43·0	11·5	13·9
U.K.	51	50		4·7	4·5	0·03	1·5	6·0	1·0	0·7
France	44	34		5·4	3·7	0·10	1·2	5·8	0·9	1·2
Federal Germany	51	38		6·9	2·8	—	0·9	6·9	0·8	1·1
U.S.S.R.	200	275		45·0	24·2	0·53	8·0	47·9	6·3	7·4
TOTAL	514	739		100·4	79·5	1·20	26·5	107·7	20·5	24·3
		Regional Income	*Investment Required*	*Regional Savings*	*Foreign Credits Required*	*Foreign Credits Received*	*Investment Required*	*Regional Savings*	*Foreign Credits Available*	
Latin America	189	28	2·9	2·3	0·6	0·07	4·4	4·2	0·2	
Africa (Except Egypt)	197	15	2·7	0·8	1·9	0·17	4·1	1·5	2·6	
Middle East (Including Egypt)	96	11	1·5	0·6	0·9	0·16	2·2	1·3	0·9	
South Central Asia	506	28	6·2	1·4	4·8	0·23	9·3	2·8	6·5	
Eastern Asia	745	30	8·9	0·9	8·0	0·57	13·3	3·0	10·3	
TOTAL	1,732	112	22·2	6·0	16·2	1·20	33·3	12·8	20·5	



Map I.—Existing and Proposed Industrial Centres (*For Key see overleaf*)

KEY TO MAP 1

Major existing industrial centres

1. Britain
2. N. W. Europe: Ruhr, Benelux, Lorraine and N. France
3. Central Europe: Silesia, Poland, Czechoslovakia, Hungary
4. Moscow
5. Ukraine: Donbas
6. Urals
7. Japan
8. Eastern United States
9. Pennsylvania
10. Chicago, Detroit

Minor existing industrial centres

11. Paris
12. Lyons, Clermont-Ferrand
13. Catalan-Basque
14. N. Italy
15. Bavaria
16. Berlin*
17. Sweden
18. Baltic*: Leningrad, Riga
19. Stalingrad*
20. Altai*: Novosibirsk
21. Manchuria*
22. E. China*: Shanghai
23. E. India*: Calcutta, Bihar
24. W. India*: Bombay, Ahmadabad
25. S. Africa*: Johannesburg, Rand
26. Australia*: Sydney
27. Mississippi: St. Louis
28. Alabama*
29. California*: Los Angeles
30. Canada: Montreal

Proposed major new industrial centres

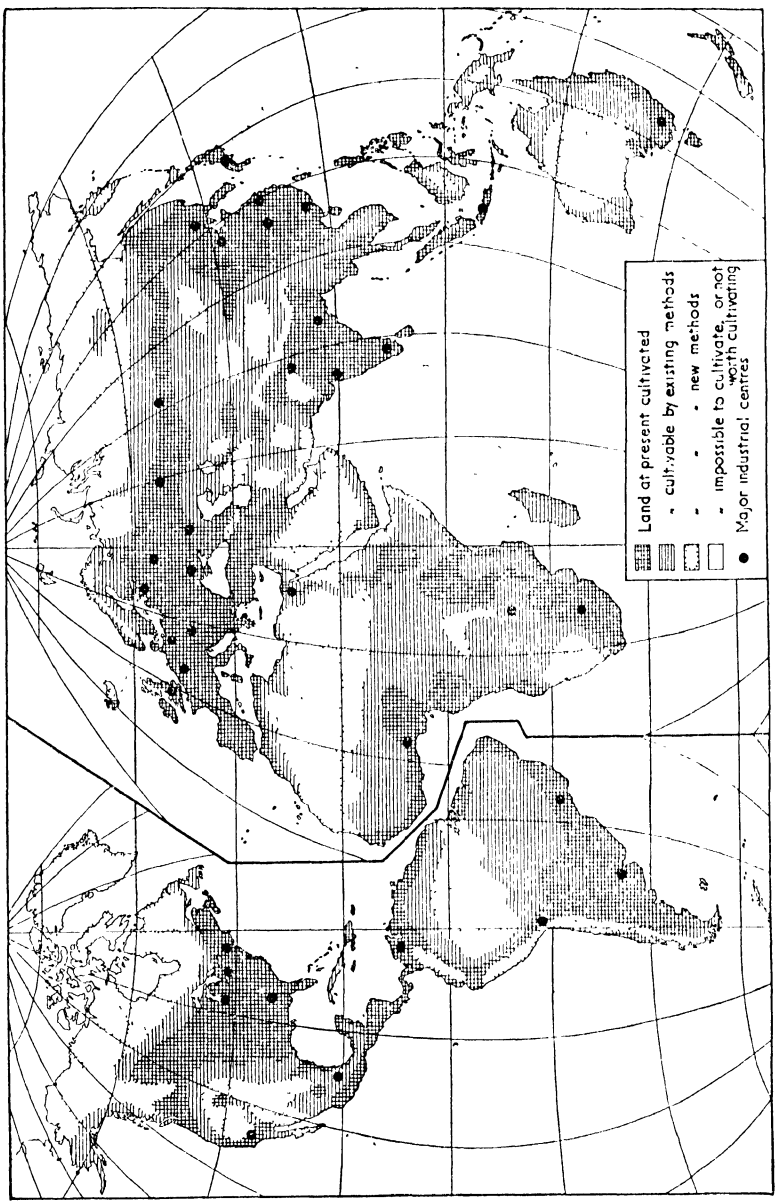
31. N. China†: Pekin, Tientsin
32. Central China†: Wuhan
33. S. China†: Canton
34. Indonesia: Java, Sumatra
35. S. India: Bangalore, Madras
36. N. India: Delhi
37. United Arab Republic: Cairo
38. S. Central Africa: Katanga
39. W. Africa: Ghana
40. Brazil: Minor Geraes
41. Argentine-Uruguay: Buenos Aires.
42. Andean: Bolivia
44. Carribean: Venezuela, Colombia
45. Mexico

Proposed minor industrial centres

46. S. Spain: Andalusia
47. S. Italy: Sicily
48. Yugoslavia†
49. Rumania†
50. Aegean: Greek-Turkish
51. Caucasus†: Georgian-Ammenian
52. Central Asia†: Tashkent
53. E. Siberia†: Irkutsk
54. Sinkiang
55. Inner Mongolia†: Paotow
56. W. China†: Szechuan
57. N. Vietnam†: Saigon
58. S. Vietnam: Hanoi
59. Thailand: Bangkok
60. Burma: Rangoon
61. Pakistan: Lucknow
62. Persian Gulf: Basra, Abadan
63. Uganda-Ruanda
64. Sudan: Khartoum
65. Algeria
66. Morocco
67. W. Africa: Dakar
68. Oklahoma
69. Gulf of Mexico
70. Alberta
71. Vancouver-Seattle
72. Cuba, Haiti
73. Trinidad
74. Brazil: Bahia
75. Chile

* To become major industrial centres
† Already being constructed

Map I attempts to show what the process of levelling up the standards of living throughout the world would mean in terms of the enlarging of industrial centres and the building of new centres (pp. 126 f., 130 f.). The location of the centres named in the key is intended to give only a very rough indication of the area in which they would be placed. Thus the Eastern Indian centre, 23, would comprise engineering in Calcutta and Steel in Bihar. On this scale, the whole of Britain counts as only one industrial centre. In some cases a centre would serve more than one existing state or territory. Thus the Katanga centre, 38, would serve both the Congo and Northern Rhodesia.



Map II.—Present and Potential Land Use.

including the use of ample machinery and fertilizer and some extension of irrigation.

For this process of simultaneous transformation of the industrialized and the underdeveloped countries to proceed smoothly would demand certain political conditions which go beyond the purely negative ones of abandoning the Cold War and accepting some degree of disarmament. These conditions, however, are by no means impracticable, because in one form or another they have already been reached at different times in different parts of the world. Indeed it is difficult to conceive that relaxation of the Cold War could occur and the abandonment of the arms race take place unless, even before or immediately after these steps were taken, there were changes in the internal balance of political power in at least the major countries in the capitalist world. Powerful capitalist and industrial interests are tied up both with arms production and with conservative political parties. It will need a great intensification of popular pressure to secure, in the face of this opposition, even the negotiating and signing of a disarmament agreement. It can only be implemented in the face of subsequent obstruction by bringing into office governments of a more liberal or socialist character than are in power in the capitalist world today. Such governments, relying on the support of the majority of the people and particularly of the working class, would be pledged to the ending of the arms race and to the furthering of international co-operation.

The kind of situation that one might conceive, for instance, is a government in the United States of the character of the Roosevelt administration of the thirties and forties, an administration which was very popular except in certain business circles. The crack used to have it "that everyone in the United States is against President Roosevelt except, unfortunately, the voters". In Britain a Labour Government seems indicated for the same purpose, in France some form of Popular Front coalition, in Germany a Social Democratic government. Most of the parties which would compose such governments are not yet pledged to changing the economic system, though they are to a greater or less degree in favour of modifying it in the direction of a welfare state. On the other side of the "Iron Curtain" there can be no doubt

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Map II is intended to show the major types of actual and possible agricultural uses of the land surfaces of the world. It should be studied in conjunction with Table VIII (p. 69) and Chapters V and XIII. Owing to the small scale, only the largest mountains and desert areas can be indicated, so that the actual cultivable surface will always be less, sometimes much less, than indicated here. In comparing the table and the map, the category of land marked on the map "Land at Present Cultivated" includes the same category in the table, together with that referred to as "Additional Land Available With Existing Methods". The category on the map marked "Cultivable by Existing Methods" corresponds to that on the Table "Additional Land Available With Capital Expenditure"—mainly dry plans, dissected plateaux, forests—which would require expensive irrigation and drainage schemes. The category of "Land Cultivable by New Methods"—mainly mountains, semi-deserts, and tropical rain forests— is the same in map and table.

that this major change in the world strategic position, the abandonment of war as an instrument of policy, would inevitably lead to further measures of political and cultural relaxation—a process which has been going on somewhat slowly for the last five years.

For most countries to reach the second stage, therefore, is not by any means a political impossibility, though the power of vested interests to hinder it, especially through their control of all the machinery of propaganda, will certainly make it a very difficult transition to effect in certain countries. In the underdeveloped countries it means that either coalition governments of the type in Indonesia or Laos, or *bourgeois* governments with a socialist tinge, such as those in India, would have to replace those almost purely military dictatorships which, supported by United States' money, exist at present in the Middle East, in Africa and in parts of South America. But again this change is in line with the general trend and development in those countries, and need not involve anything in the nature of civil war. Indeed, in this stage, a prolonged civil war would be especially perilous. Wherever it occurs the contending parties are likely to have the support of one or other of the present blocs and this is liable to lead by a chain reaction to a world war. We were very close to this in July, 1958 (pp. 295 f.).

Great as the advantages of a relaxation in the Cold War would be, it does not afford a complete or even a very secure solution to the problems of the present-day world. It is evident that certain advantages may be gained from the peaceful as against the military competition between the present power blocs. This is particularly so for the underdeveloped countries who may be chosen as recipients of rival favours, rather than of rival threats. But this kind of development makes planning, particularly long-range planning, extremely difficult. The amount of capital available at any time for an underdeveloped country is only too likely to depend on temporary political considerations. This would be a very insecure foundation; for planning, particularly heavy industrial planning, is extremely difficult to carry out on a year-to-year basis. It would be far preferable if agreement could be reached to channel all such assistance through a neutral or collective body, such as a United Nations organization like SUNFED (p. 115).

To the extent this was done, we should be passing into the third stage of international co-operation in transforming the world. Until this stage is reached there is always the possibility of slipping back to the previous Cold War position. Those who remember the "One World" policy of Wendell Wilkie in 1942–43, and how quickly it turned into the Cold War, can feel no security in such temporary arrangements, which would be at the mercy of internal political development in the countries concerned. In any case a mere truce in the Cold War might well carry over some of the suspicion which poisoned earlier relations. This is not to be construed as a disparagement of an immediate and limited relaxation, indeed this is now an absolute

necessity, but rather as a warning against resting too long in this position, and not pressing forward to a more secure world order.

Such a *co-operative world order* is the third or optimal condition which I have postulated earlier in this chapter. However, just because of its optimal character it is as difficult to define as is heaven, and any attempt to do so would probably cause violent dissensions among rival theologians. It would be even more difficult—indeed in the present state of the world almost impossible—to indicate by what political steps any kind of co-operative world order could be established or maintained. It is, however, not so difficult to see the general lines along which the transformation of the world could be achieved under the best conditions and at the fastest practicable rate. We might, for instance, consider how this transformation would be planned by a kind of world welfare general staff, concerned with a global planning for peace, just as we had in the war a global planning for mutual destruction. This could be done under world government, but it does not necessarily imply world government. What it implies is something more indefinable but probably more attainable. It would mean an explicit engagement of governments, expressing the wills of their peoples, to co-operate fully for the benefit of all, having regard to their present respective positions, wealth and traditions. It would, in effect, be a new all-inclusive World Alliance, for if nations can co-operate in war without losing their identity, they could do so far better in peace. No overall authority more than exists at present in the United Nations would be necessary in the first place. All the organization required could be met by functional agencies such as the present Food and Agriculture Organization (F.A.O.) or World Health Organization (W.H.O.). Even the economic framework is already there in councils like the Economic Commission for Europe (E.C.E.), which, though sadly neglected in favour of the Organization for European Economic Co-operation (O.E.E.C.) of the Atlantic Powers, has managed to function all through the Cold War.

The prospects of such an alliance would from the outset be favourable. One benefit, a rather ironical one in the present situation, is that we have wasted and are wasting so much of our efforts preparing to kill each other that merely to stop this would give us so much wealth and resources in hand that an immediate programme of general welfare could be entered into without loss to any country. Indeed, we might take this as a basic aim for the alliance—to safeguard and improve the standard of living of all the peoples of the world.

There are, no doubt, people in many countries—possibly as many in the industrialized as in the underdeveloped countries—who would consider that justice should come first, and that we should begin with a more even sharing out between the people in wealthy and in poor countries. It would, indeed, be intolerable in a world devoted to peace

and welfare if some people's incomes were to remain indefinitely a thousand times more than those of others. But in view of the fact that such changes will be carried out by human beings and not by angels, by human beings of all ages with memories and conceptions of established rights and standards, it will be easier to start from the economic levels already reached in different countries, and to anticipate that the process will be a general one of levelling up. The responsibility for the economic state of each country, apart from initial aid from outside, would be primarily the concern of the people of that country themselves.

There would be no need to enforce the co-operation of all nations in such a scheme of world welfare. The advantages it offered would after a time suffice to attract all nations into it. The only limitation that would have to be enforced would be an absolute prohibition of military forces, and especially of nuclear weapons, by which the rest of the disarmed world might be threatened.

The political preconditions for the third stage of co-operative world planning need not be decided in advance, but the very nature of the problem presented on a world basis—that is, of using the material and human resources of the world to their best effect for the general benefit—must put some limitation on what economic and political forms would be in fact compatible with such an aim. It is obviously incompatible with any form of uncontrolled capitalism, with an economy in which both investment and operation of enterprises are determined entirely by an expectation of profit. It is, however, at least in its early stages, not incompatible with some form of controlled profit making and investment similar to that which operated for some time in the Chinese People's Republic.

Again, such an economy can only work effectively when all class and race distinctions have been removed. Human capacity can only be used to the full if all the abilities of every person are also fully used, if every person has the same access to education and fits in to the position where his trained abilities can be used to the full. All class and race-divided countries can make use only of the full abilities of sections, usually very small sections, of their population, and, as everyone knows, the present world contains a majority of people who have neither the education nor the possibility of using their abilities for anything more than the hardest and most unremunerative tasks. On the other hand, the whole idea of a co-operative world implies the ultimate ideal of communism itself, expressed in the phrase, "From each according to his ability, to each according to his needs".

However, as this third condition, of co-operative world order, even if it were only to be a generation off, can only be reached as a result of prolonged and varied political evolutions, it would be premature to discuss here how far it need at the outset have the characteristics either of a world state or of communism. Nor do we assume that the change is likely to be made all at once all over the world. It might be

achieved through existing world organizations such as a really representative United Nations, including China and all the present colonia, territories, which could gradually take on the positive function of world development, with the necessary financial resources, and with the necessary powers to channel these resources where they could be most useful at any given time.

The different stages to be described here need not come strictly one after another. All over the world some countries would reach them earlier than others. We would not start from a blank slate, so that a period of survey and assessment, essential to long-range planning for the world, need not be a matter of years in which nothing will happen. It would rather be that the development plans at present existing, or which would be in existence at the time considered, should continue in action while the new world planning organization was getting to work, and while the organs to carry out the heavy and more industrial changes at the later stages were being prepared. With this qualification, the kind of stages needed are fairly clear. They are essentially the same as those discussed in Chapter VI in dealing with the industrialization of individual countries, but here with emphasis on their international character. They are based on the experience of the kind of transformations we have already witnessed, but to some extent rationalized.

There would have to be some general agreement on the scale of operation. But it can by no means be a hard and fast one in view of the rapid changes of technique. This would necessarily lie somewhere between the rigid concept of a single world economic organization, where one or a very few central producing units would provide the goods and services for all the world, and the other extreme of complete decentralization, in which every region of any size, from a city to a province, would for the most part supply its own needs and only require a minimum of goods and services from other regions.

Experience has shown that the first of these is only economic in exceptional circumstances, and that in the extreme form of having one centre for any particular commodity it might even be positively damaging in the sense that it would preserve obsolete methods for longer than necessary in the absence of any competition. But the essential reason for its uneconomic character, as already brought in the experience of the Soviet Union and China, is that centralization implies the greatest degree of back-and-forth communication, not only of information but also of goods, and clutters up the whole system with orders which, however rationally conceived at the centre, very often do not fit the local conditions. The decentralization, which has occurred recently in the Soviet Union, has been universally welcomed because there the early centralization had outlived its usefulness (p. 131).

We must, however, consider the need of some limited centralization in some of the early stages of world development. Some kinds of heavy equipment can be made already in one or two large works sufficient for

the initial demands of the world. For instance, in the very first stage of improving agriculture, the best plan would be to call on the full capacity of the vehicle-building industry of the United States, which going all out, and with some assistance from the smaller motor industries of Europe, could simultaneously produce not only all the cars, but also the tractors and lorries the whole world will need in the early stages of its industrialization. Later on it would appear absurd to transport such equipment over tens of thousands of miles and a rational distribution of a relatively small number of vehicle-building factories would be quite sufficient.

At the other extreme the local self-sufficing region suffers from the inability to make use of economies in productive methods depending on scale. Although for many purposes the general availability of energy makes it possible to produce manufactured goods locally, what goods should be produced will depend in the first place on technical factors. It would be absurd, for instance, to try to produce heavy electrical equipment in every village, whereas shoes might be quite a reasonable kind of local manufacture. By and large such decisions need not be made beforehand in detail but only roughly. One of the advantages of new methods of economic analysis is that by using electronic computers it might be possible to work out at any given stage the most economical and rational distribution of size of enterprise in view of the manpower locally available and the costs of transport links between them. This would be in itself one of the major tasks of the planning organization, not only in the first stage but throughout the sequence of phases to be planned.

The kind of phased development planned for a fully co-operative world must clearly depend on the stage of world economy that has been reached at the time of its adoption. If a long period has elapsed in the second condition of "Truce", we have postulated, it would start from a world in which there were further technical advances in the industrial countries and in which several more countries had made a substantial start in their industrialization programmes. However, as it is very unlikely that under the still considerably restricted conditions of competitive development this will have occurred to a large extent, we will probably not be far wrong in estimating the kind of plans that would be made with the world more or less in the position in which it is now. As the suggestions here are very general the precise point of departure will not make very much difference.

With the qualifications already mentioned, of the possible overlap of different phases, the rough scheme might be something as follows. We would envisage three main phases: first, one of preparation and planning; second, a phase of construction of the common industrial basis; and finally, an indefinite third phase of actually operating the world economic organization on a co-operative basis. The first or *preparatory* phase, which might last ten years or less, would begin with a stocktaking

of human and natural resources—here not only local surveys in each country but co-ordinated world surveys having full co-operation between the planning authorities of different countries. At the same time and on a world basis there would be a correlation between assessed resources based on the geological-geographical sciences on one side, and the knowledge of current industrial needs and forecast of future industrial needs provided by economic and technical organizations on the other. We may reasonably assume, for instance, that the era of fossil fuels—coal and oil—will be seen as a limited one, in other words, the current accessible reserve of coal and oil must be used in the first phase to carry over the transition to atomic or thermo-nuclear power and, in the later phases, become sources of chemical raw materials and of food. The importance of the location of industry in relation to minerals will be less than it is now and other factors, particularly those of climate, water supply, possibilities of the soil, previous concentrations of population, would be the major defining factors for the location of industrial centres.

The object of the first phase would be that of deciding where the major international capital investments should take place. I stress the word international, because even in a far more closely-knit world state than anything I anticipate, most of the effort of transformation and investment would not be international but essentially national and regional. International capital help would be required only where the project was either of such scope or difficulty that it required help not available nationally or locally, or was a subject which was of more interest in its results to other countries than that in which it was located. The first, for instance, would apply to major valley control or irrigation schemes; the second, to the mining of a rare but key mineral such, for instance, as uranium or beryllium ore.

The first phase would aim at producing a rough outline plan of the kinds of constructive enterprises that would have to be set up in various parts of the world, trying as far as possible to even out resources by making the greatest proportional advance in the most backward areas. It would include not only the plans for the construction of public works, factories, and so forth but, as this would be perhaps more important, of schools, universities, and research establishments.

With regard to basic common services such as power, existing organizations of a purely informative nature, such as the World Power Congress, could be transformed into executive organs, aiming at finding in a scientific manner the best distribution of centres of power of different kinds—hydro-electric, thermal, fission, or thermo-nuclear—together with their connecting grids to provide power in appropriate quantities in different areas of the world as and when it would be needed, that is, to determine the sequence of phases of their coming into operation. The power-planning would probably have to be the most long-term of all, unless technical progress were such that not only the capital cost

of such plant could be cut to a fraction of what they are at present but the time of erection of power plants could be shortened to a matter of a year or two. The ultimate objective would be to have power on tap in quantities as required all over the world—a kind of world power grid. This would not necessarily be continuous all over the world (which would probably be uneconomic) but rather arranged in latitude bands to even out the daily fluctuation of needs. In this way the real power utilized might be quite as large as is anticipated for a growing economy, without any need for a corresponding growth in installed power plant.

The second phase would be that of *construction*. It would include the actual building of the heavy industry centres, already mentioned, as shown in Map I (p. 247), which should suffice for the needs of the world for a generation or so. If this construction is to be put through all over the world at the same time, the second period might be of the order of ten or fifteen years, although by reasonable phasing the same major constructional teams might carry on a virtually continuous work of construction, moving from place to place as the plans in the different regions demanded. In each country the development of the industrial base, or subsidiary bases—for the smaller countries will certainly not be expected to have major industrial bases—would be drawn up in the countries. On the international level, the national plans would be so dovetailed that the stage of most rapid construction in different countries would follow one after the other. Thus, over the world as a whole, there would be a fairly even constructive effort, so that the equipment for very heavy construction could be moved from country to country as required, as is done for hydroelectric plant in the Soviet Union.

At the same time in the older industrial countries, and making use as far as possible of the newly-developed constructional engineering plants in the new countries, there would be a rapid production of construction machinery—of present or improved types—so that the great work of the constructions, which would be the heaviest drain on resources, could be done with the minimum of interference with current consumption or labour. Indeed, technique is already sufficiently advanced, as I have tried to point out in earlier chapters, for this to be done already in many fields—the Soviet and United States capacity between them could, with a slight enlargement, probably provide contractors' plant for all projects likely to be needed in the world for the next ten years, and could easily be expanded to provide that required for the twenty years after.

As already discussed, it would not be reasonable to expect that the sequence of industrialization in the new countries should be the same as that in the old. Not only will it have to occur in a much shorter period of time, but many of the intervening stages will be left out. The amount of railway construction introduced may, indeed, be rather slight. Air and road transport, now largely automatized in the way I have indicated earlier, might largely take its place. Nevertheless, as the

experience, particularly of the Eastern Soviet Union and China has shown, the opening up and industrialization of a country requires, with present techniques, quite considerable railway construction programmes.

It would also be necessary to fit into this period the first effective stages of improving the standard of life. The first priority would be food. An arrangement such as that already existing in the F.A.O. of the United Nations, if it became, as its former Director, Lord Boyd Orr, wanted, an operative service, should be able to ensure directly that the whole population of the world received its basic calorie minimum and vitamins from the very start of a world co-operative plan. This would mean, in the first place, the using up of existing surplus stocks of food, the opening-out of agriculture in advanced countries to its maximum capacity, at the same time using those devices that are likely to yield the quickest return to improve the agriculture in the backward countries. When I say "quickest returns" I have, of course, also in mind that they should be such as would not lead to soil erosion or diminution of future fertility. It would be at this stage, also, that the first large-scale regional efforts could be made to extend the area of agriculture by control of whole river systems, and to begin to use radically new methods of agriculture. How much need there would be for them would depend on population policy and also on the degree to which it was desired to go in for biochemical or chemical food production (pp. 273 ff.). See also Map II (p. 249) and Table VIII (p. 69).

In this period also one of the major capital investments would be in fertilizer plant, which could, after five years or so, come into full operation, and thus enable the first burst of increased food production to be sustained and turned into a steady, year-by-year improvement, matching or preferably exceeding the demands caused by a greater rate of population increase. The difficulties of such a food programme have, in the past, been largely financial, in origin. It is not that food could not be produced in larger quantities, but that farmers very reasonably fear that if they were to produce such additional food it would be all right at first, but the markets would soon become glutted, prices would fall, and they would be ruined. The world food organization could prevent this by arranging for guaranteed prices for a reasonable period, such as twenty or thirty years. Meeting the excess cost of this operation on a world scale would only be a book-keeping transaction to be set off against long-period construction loans.

During the first two periods, the transformation of industry in the already advanced industrial countries towards the greatest degree of automation, and at the same time, though here not limited to the industrial countries, automatic office machinery and administrative machinery could be produced and generally distributed. This would enable all the changes in the different regions of the world to go through with the full advantage—which we are only just beginning to appreciate—of an

accurate knowledge of what is being done and, what would be far more important, with reasonable estimates of the consequences of different proposed courses. For instance, in the early stages of agricultural development it would be important to know where a limited supply of fertilizer could be best distributed to get the most advantageous crop all over, and yet to leave no particular region with such poor crops as to risk local famine.

The administrative problems that would arise at all stages are such as will create the greatest demands on human intelligence and goodwill. It cannot be expected that there will not be differences of opinion and rival interests, but as not only war but all the minor types of hostile behaviour, such as mutual non-recognition, economic embargoes, and interference with communications, will be out of the question, they will have to be settled as normal internal disputes are within countries today.

One major problem needing all the experience that has been gathered in the last forty years in different countries of the world from the Soviet Union to India is how to get the best balance between local and central administration. It is easy to draw up quite a number of tidy systems of administration or of constitutions, but what would seem to be more appropriate to a scientific age would be a great deal of experimentation in administration and adoption of this or that system as a measure of its success—not necessarily the same system in different parts of the world. For it must be remembered that for a long time, and particularly for the two first stages that we are now considering, the development of different regions of the world will be on different levels, and will correspondingly require different types of administrative machinery.

It will be in the second phase also, on the basis of preparations made in the first, that the common health services of the world could get fully into action. Their objective should be to wipe out all infective diseases—virus as well as bacterial—on a world scale. The already largely successful piecemeal efforts in different countries could be brought together and foci of endemic disease stamped out. This has already almost been done in the Soviet Union with respect to the malaria. Malaria is probably the greatest killer in the world today, and its elimination, which is a perfectly feasible operation if undertaken with sufficient support on a wide enough geographical scale, would make the largest single difference to the lives of the majority of peoples living in tropical climates.[1] The same kind of co-ordination should also result

[1] President Eisenhower in his State of the Union message for 1958 proposed a co-operative international programme for the use of science for peaceful purposes.

"Another kind of work of peace is co-operation in projects of human welfare. For example, we now have it within our power to eradicate from the face of the earth that age-old scourge of mankind: malaria. We are embarking with other nations in an all-out five-year campaign to blot out this curse for ever. We invite the Soviets to join with us in this great work of humanity. We would be willing to pool our efforts with the Soviets in the campaign against the diseases that are the common enemy of all mortals—such as cancer and heart disease."

In this respect he is likely to find co-operation easy, for already a campaign to eradicate malaria entirely from the Soviet territories is in sight of its goal.

in the elimination of animal diseases and plant pests, such as locusts, and generally to a world made healthy for human beings and their food-plants and animals.

Naturally, as this campaign succeeded and the death rate fell, the population would increase. However, as we have discussed earlier in this chapter, this need not cause any alarm, although it may be desirable, especially in the second phase, to spread knowledge of birth control so as to keep this increase within comfortable bounds. A 3 per cent per annum increase, which has been reached in some isolated islands, would be hard to keep up with for the first few years in agricultural productivity, though later on it would be quite easy to beat it. In my view birth control has a definite permanent place in human society, that is to prevent births unwanted by the parents—unwanted not for merely material reasons, because they cannot afford children, but because they think they have enough of them. The rearing of two to three children would suffice for the slow and steady growth of the population of the world (pp. 64 ff.). What we do not want to see is the rapid growth in some places and actual decrease in others.

By the end of the second phase the general equipping of the world as a running co-operative organization should be completed, that is in about a generation or thirty years from the start. Then the *third phase* of indefinite length might begin. I do not think it is useful to try and divide this into further phases, but it would be anything but a static situation. It may be, however, that it would be distinguished from the second phase by a slowing down in the rate of capital investment and by an increase of its investments in the consumption goods industry.

Ultimately we might reach some kind of equilibrium in which the industries already established by then, and largely automatized, were co-ordinated in a rational rhythm of production. We are, perhaps, today somewhat blinded by the introduction of new devices at a rate which makes us think that normal production methods will always change over once every two to five years, and that this change must occur in an irregular and largely unpredictable way in different parts in different industries. Co-ordination on a world level would enable these changes to be introduced not by any kind of dictation, but in a more or less rational way. It would mean setting apart a large enough experimental industrial sector and corresponding sectors in agriculture, so to be able to try out new methods on a large scale. Thus the new knowledge could be applied not when it was still in an extremely rapid state of development, but when it seemed to have reached some kind of temporary stable plateau.

Certainly the increase in the proportion of scientific and technical personnel in the population as a whole cannot possibly continue at its present rate for more than a generation or two, for the simple reason that the total population is limited. But we would expect this increase to

tail off and lead to a new stable distribution of occupations, as shown in Fig. 6 (p. 183). Phase three might be considered as that in which this redistribution had actually occurred, but it is probably more accurate to expect it to occur in the older industrial countries first of all, and only later in the countries at present non-industrialized, but which will be industrialized by then.

I have left the end of the third phase completely indefinite. It may be possible, even before we reach a stage of international co-operation, to see further than this. But although I hope in the subsequent chapter to give further prospects of a technical and scientific kind, any economic and political forecasting beyond the point I have now reached would be purely Utopian. Decisions will in fact be made by the men of the time with the knowledge they have gained in reaching their first two stages. I am, however, reasonably sure of the outline of these phases, because all that I have done is to extrapolate on a world scale the concrete experience of many countries in the last hundred years or so. What has been done then can be done in the future, and can be done on a larger scale better and quicker. The major problems are not really so much how to organize the subsequent development of a rational world economy, as to ensure that we get to such an economy at all, and that we do not remain static in the present situation or in the half-way house that I have envisaged in my second alternative.

A completely realistic forecast would demand not only an account of how the world might progress under conditions of Cold War, of international truce, and of international co-operation, but also what are the prospects that the latter two conditions may succeed the first in which we are now. After solving the over-riding problem of how to stop war, the securing of a change towards more peaceful and co-operative method of living is the most important political problem before all of us today, upon whose solution all other political and economic questions will depend. Nor are these two questions really separate. As long as we remain in the present state of Cold War the prospect of active nuclear war remains with us, and indeed this is the real, though not always the acknowledged, reason for maintaining the Cold War situation.

The breakaway from the Cold War will only take place as the result of very great political pressure all over the world, and not least in the countries themselves that are most involved in it. In every country people have a duty to see what they can do to change this situation, a subject to which I will turn again in the last chapter. But just as the Cold War may break down suddenly into active hostilities, as already mentioned (pp. 18 f.), so a sustained situation of mere truce might easily engender the Cold War once more. The logical step would, therefore, be to pass directly from the first to the third stage, that is from hostility not merely to tolerance but to co-operation. This may seem too big a jump to be humanly possible, but in the psychological sense it is probably

the other way round. If we are not to be enemies any more, it is easier to be friends than just to ignore each other's existence.[1]

How long it will be before the really decisive change away from the Cold War occurs is hard to tell. On any rational grounds it is difficult to see how the world has managed to endure the present intolerable and unstable situation for the thirteen years that it has existed. It is only because people in the "Free World" have believed, or been led to believe, that the alternative of coexistence would be worse, that it has lasted so long. Now however, with the advent of the hydrogen bomb carried in intercontinental ballistic rockets, the naked horror of the threat of mutual and almost automatic destruction has already generated a very considerably greater feeling against the present state of affairs than we have had in those thirteen years. And it does not seem as if it can last very much longer. Certainly the longer it lasts the longer we shall have to do without all the good things that we could get if we worked together and used our knowledge, and the knowledge we could get through further research, to better our position.

If this were to happen soon, in a matter of two or three years, we could get mankind out of most of its worst troubles within another ten years after that. By then the present underdeveloped countries would be well on the way to industrialization and the building up of an educated and technically competent population. Another thirty years, perhaps twenty at the best, sixty at the worst, would see them all through into

[1] Jean-Paul Sartre expressed the need for this complete transformation towards a positive peace in the same Helsinki speech, already quoted (p. 210):

". . . what do we all mean when we demand peace? Is it simply a question of perpetuating the absence of conflict, of postponing indefinitely recourse to arms by achieving a few compromises, by securing mutual concessions from states? If our peace were nothing else than that, it could be regarded as the continuation of the Cold War. And certainly the Cold War is better than War. But we would be in pretty desperate straits if our efforts were aimed at putting off the catastrophe from day to day. Of course, we want coexistence. But we must be clear as to what kind of coexistence it is. Not that of the two blocs, for this coexistence is already a fact, and it actually carries the danger of provoking a war. We want the peaceful coexistence of all nations despite the differences of systems. This coexistence cannot be achieved unless the peoples' efforts succeed in breaking up these blocs. Thus, we are beginning to understand that our peace cannot mean the maintenance of or even the strengthening of the status quo, but must mean a real transformation of relations between men and nations."

"What all of us here want, what we call peace, is the positive construction, the inauguration of new bonds between the nations. They have lost their sovereignty because the world was cut in two. They will recover it if the world recovers its unity, that is to say if the sovereignty of each nation, irrespective of its system, is guaranteed by all the others."

"Peace demands the return of every nation to independence, mutual respect and coexistence on an equal basis. In the West as in the East, *our* peace can have only one meaning: it is possibility for all nations and all men to master their own destiny; in a word, it is freedom. This, it seems to me, is the common meaning of our work; we want to construct peace through freedom and give back freedom to the people through peace."

the phase of modern scientific industry which would be all the time developing in the older countries. The levelling-up process could certainly be achieved within a century.

This is as near as I can get to the prospects of mankind in a reasonably foreseeable time, apart from the further possibilities that even now we can see but cannot reach, and that I will guess at in the next chapter.

XIII

THE LIMITS OF THE FORESEEABLE FUTURE

THE discussions of the last few chapters on the way forward and its difficulties may have to some extent obscured the view of what is ultimately aimed at. Why, it may still be asked, should mankind undergo all the effort involved in reorganizing his whole way of life? Is it really necessary? If not, what would actually make it worth while?

Now, as has been argued already in the early part of the book, there is one compelling reason for organizing a rational world economy, and it is that unless we do so a very large proportion of the human race will die untimely deaths, that is, a very much larger proportion than are at present dying untimely deaths from disease and starvation. Either this disaster will come swiftly in a nuclear war, or more insidiously as the effects of the Cold War make themselves felt. If we try to carry on as we are now disaster will come about through the using up of the available natural resources of the planet in the form of land erosion, shortage of fuels, general impoverishment, and most immediately by starvation and disease. This is the present prospect for most of mankind, beginning with the poorest, and it is doubtful whether that small fraction that could still, under present circumstances, maintain and even increase its wealth, would in the long run be happier on account of the misery that would surround them in the rest of the world. We must, in other words, be sensible or perish.

That negative aspect is rather a sad reason for wanting to change things. We must escape from disaster if we can, but what we would much prefer to do as well is to gain a better life. And people want not only a better life in a material sense, but one where they can live without fear and without the uncomfortable knowledge that what they enjoy other people are being deprived of, a life of "the war of all against all", which has been for such a long period in human history the normal pattern of human life. To provide that hopeful perspective, it is not enough to explain what is perfectly feasible with present knowledge and resources. We should try also to learn and picture to ourselves now what the full realization of the possibilities of science would mean to those who come after us—possibly to our children or grandchildren.

This chapter, though it deals with the future, is not an attempt to write a Utopia or even science fiction. I make no attempt to draw any kind of imaginative picture of life in the year 2000 or the year 2050. All I can hope to show are the kinds of conditions into which people may choose to fit their pattern of living and the kind of opportunity this will provide not only for a more secure but for a fuller life. Some of these will have an appeal even to those of my readers who may be already living a tolerable if not luxurious life in the older industrial countries. But they will appeal far more to those whose whole life is a continuous struggle against poverty and disease. This is because the first requirement of the changes of which I have been advocating is the abolition of poverty and disease in the whole world—a perfectly feasible and, indeed, a not very costly or long-term objective. Food, clothes, shelter would become as generally available commodities as air and water are today.

But, many have asked, supposing all this were available, how would people live—what would they do? The next goal to be aimed at, though to reach it would require a great and sustained effort, is the ending of all hard and monotonous work, the ending of any task which employs men's and women's muscles either in pushing or pulling, or fitting or loosening, or anything that has to be done over and over again—totting rows of figures, typing out letters, hoeing, or weeding. This ideal of a life of plenty of food and no work to do has, of course, been mankind's for many a long year, and has been realized by all who could gain or inherit enough advantage over their fellows to do so. However, the lives of princes and millionaires show that luxury and idleness are not as great gifts as they appear to be to those who do not have them. When we are told we could all be as happy as kings, we begin to wonder how happy kings really are. But the comparison is a false one. The rich, always a minority, often feel lonely, frightened, and sometimes a little guilty as well. The more they appreciate the good things of life, the more they fear that these will be taken away from them. And because of their very exclusive standard of life, they cannot share in general enjoyments and they are obliged to justify their position in society by doing a great number of intensely boring things, including enduring each other's society. When everyone is rich the prestige value of being rich will disappear, at the same time the real value of wealth—the liberty it gives to see the world and enjoy it at leisure, the possibilities of really finding out what one would like to do and doing it—will be for the first time realizable.

The fear that the wealthy often express, that this release may produce catastrophic results just because the poor, unlike themselves, are not trained for leisure is illusory. For even though these changes may come about quickly from an historic point of view, they will take time measured in decades to achieve. The full achievement of wealth and leisure will come as a gradual improvement to which people will adjust themselves

as it arises, and in fact they are, in the more fortunate countries, already adapting themselves to it. There is, however, a fundamental difference between the kind of enjoyment that is available to the better-off European or American of today, and the kind that would be available in the kind of new world which the scientific transformation of the economy would bring about. First of all, the avenues of enjoyment would be freely open, in the sense that they would not be directed by organizations trying to make a profit out of them. The commercialization of enjoyment would no longer exist. People would have to work out their own forms of enjoyment for themselves individually or in groups.

Secondly much of the desire for idle enjoyment today comes from the very monotony of people's lives—the monotony of the factory or the office—far greater than even primitive men with their hard but variously occupying lives ever had to put up with. Coming from this boredom of work, and to a large extent because people become adapted to it, they are unable to think out new and adventurous ways of spending their spare time. The change in the structure of industry already described, while it ends monotonous work, would create, for the smaller number that would be employed in it, many new kinds of interesting and adventurous work.

In fact, when we reach the third phase with industry already transformed on a world scale, nearly all work would be an adventure or a research—there is not very much difference between them. Even for those who like hard muscular work under severe conditions with a spice of danger there will be plenty to do exploring the recesses of the unknown earth and the wide range of the unknown universe. The transition period, that is the next one or two generations, would in any case be one involving a very great deal of work indeed. It will be work that could be eased by modern methods, but which would nevertheless call on all the energy and enthusiasm mankind has ever produced in the great periods of stress in the past. For those intellectually inclined, that is for everybody in one way or another, there would be endless horizons of inquiry and of composition. Indeed, science itself is already visibly turning from its immediate purpose of analysing the fundamental mechanisms of nature to constructing new things never known in Nature, new machinery and new electronic devices (p. 93). These will soon provide a new artificial Nature much more complicated, and at the same time much more fluid and amenable to human creative genius than ever Mother Nature provides.

Most intellectual workers in the past and even of today have spent the greater part of their time, in fact, doing dull things for a living. Perhaps now many of us would find it difficult, if we had the licence, to think and compose all the time. To those that come after us, and are experienced and trained in it, it will certainly come more naturally, because investigation and learning are pleasurable activities in them-

selves, doubly pleasurable when undertaken as part of some common and world enterprise. This is a fundamental difference. What we have lost, particularly in the old capitalist countries, and what really gives salt to life, is *purpose*. What purpose we conserve is for trivial or negative ends —to secure our income or the position of our families, or to defend ourselves against real or threatened dangers to our way of life or our very existence. We have almost forgotten the possibility of a real constructive purpose into which we can throw the whole of our energies and intelligences. When I think of myself, after nearly a full life-time of scientific work, I still resent the fact that I have never had at any time of my life the possibility of really planning and doing things that would be practical and useful for humanity. The only time I could get my ideas translated in any way into action in the real world was in the service of war. And though it was a war which I felt then and still feel had to be won, its destructive character clouded and spoilt for me the real pleasure of being an effective human being.

The society in which everybody can be effective all their lives would be a really good society. Many of my non-scientific readers, that is if I have any non-scientific readers, will no doubt feel that the picture I draw is a purely material one, that it leaves no place for the higher aspects of culture which in even the most barbarous times could always be cultivated. They are afraid, and rightly so, of an ordered world in which fantasy and irregularity have no place. There is, however, in the kind of change I have suggested absolutely no need for this to happen. If it did it would be largely the fault of the intellectuals themselves, who must maintain the arts by their own efforts. The arts cannot be provided for otherwise, there is no formula for art—at least if there is a formula it will be a long time before science discovers it, and by then I suspect art will have got several steps ahead.

On the other hand, it is highly probable that the arts will be changed in many of their characters. They have in the past adapted themselves to the kind of general patterns of society in the different phases of human evolution. The art of the cavemen hunters and that of the neolithic farmers were absolutely different. It is now nearly two hundred years since Vico noticed that the kind of poetry that the Greeks produced in their early Homeric period reflected quite a different society than did the sophisticated pastoral poetry of Hellenistic times. With such radical changes, both in the social pattern and in the material well-being of man, as have been discussed in this book, much larger changes in art might be expected, but they cannot be predicted.

All we can hope for is that the division which has existed in most countries for the last two hundred years or so, but no more, between the arts and the sciences will disappear. It was in its time a consequence of an unfortunate division in education, itself a reflection of class differences in society—the gentlemen followed the classics, the cads went in for science. One could almost say it will be necessary to change all the

arts, not only the visual arts but also those of literature and music, as well as the domestic arts. For unless the arts keep changing, then, with the increased possibilities of making and doing things, the result might be to perpetuate uglier and feebler forms of art on a scale that man in the past could not reach. In other words, the responsibility of the arts will become greater the larger proportion of people participate in them, and the greater the means they will have for expression.

As the division between the arts and the sciences fades away more people with the bent of artists will see what exciting possibilities lie in the further advance of science. At the same time the scientists, freed from forced attachment to material considerations, will be able to appreciate more than before the aesthetic side of their work. It is difficult to imagine what would be the effect of the enormous release of human intelligence for scientific research which will follow from the liberating of mankind from the threat of atomic war and from the outgrown capitalist system that has given rise to it.

In this book, I have dealt mostly with the use of science for satisfying man's urgent material needs, and in consequence I have stressed the need for a science that is immediately useful. But every scientist knows, though perhaps he should say it more often, that immediately useful science is only possible if there is a sufficient amount of apparently useless fundamental science to back it. Today, fundamental science costs, in money or manpower, less than a tenth of the research effort in applied science. It is, however, proportionally far more important because it has at all times commanded the best brains. Indeed, as the growing point of all knowledge and control of man's environment, it is of absolutely essential importance. Now, with the world entering an era of full utilization of science building up to an expenditure of twenty times more relatively to what is spent on it now, the amount spent on fundamental science must increase at least proportionally. In fact it is likely that it will increase more than proportionally, even in the early stages. Because the more intricate the applications and the more profound our knowledge of natural phenomenon, the longer becomes the bridge between them, and the more important it is that people should occupy them and pass the information along, both ways, from practice to theory, from theory to practice. This means a larger and larger proportion of science not immediately connected with use. But here will also be a great opportunity for human adventure, greater than all the physical adventures of the past—adventures of the mind, adventures of experiment (p. 93).

Some of it may be still in the physical realm, in the exploration of outer space. What we have now, in the artificial satellites, are just the first ravens let out of the Ark. When the doves come back, let us hope with olive branches, we shall know directly something immediate of the great completely mysterious world outside. And this will be the most exciting knowledge, even if it remains useless, though I am con-

vinced that it will not, and that we shall be using space, just as we have used everything that man has discovered since the beginning of time.

But the other inner adventures are going to be at least as exciting, probably more exciting. There is far more complexity, more information as we say now, inside the smallest speck of living matter than in all the galaxies put together, that is all the galaxies apart from whatever life may be in them; and this exploration is also enough to occupy the drive and will and interest and sense of beauty of millions of people in the future. Such research is certain to lead to the alleviation of human distress and prolongation of life, but it will be followed directly because of its intrinsic interest.

Beyond that will lie the interest in constructing a new mathematical scientific world, a new world of computers and other devices for multiplying the speed and range of the human mind, for making constructions of complexities unimaginable and impossible in the past—for stretching mathematics to provide us with a new language for understanding the very complexities it creates. All this means that just when a larger and larger proportion of mankind will be occupied with science, science itself will become a most intrinsically exciting and satisfying occupation for the men and women of the future.

I will return now to some of the other and more practical and material aspects which follow from considerations in earlier chapters but which have been deferred to this because they deal with a somewhat more distant, though still foreseeable future, than those we were there concerned with.

The objective to be reached at the end of the process of the scientific Industrial Revolution is not any kind of steady state, not one of a Utopia where mankind has achieved its objectives and can sit down to enjoy the fruits of the labours of past generations. The state of the future as of the past will be one of transition, but we may hope that difficulties which will have to be faced will be to a far less extent than they are now, those created by man's stupidities, by a social system which makes the worst rather than the best of their natural desires. Once the cleaning up process and the building of a new scientific industrial system is roughly completed, a stage will be reached in which, at any given time, there will be, for that time, the greatest use of men according to their interests and their abilities—a very different distribution from what we find today.

A large number of people, if not everybody, today occupy professions which hardly existed as much as three hundred years ago (p. 184). The part of science and technology would be much greater, but that of technology as against science might actually diminish, once the greatest part of the constructive period was over. For most of the work of the technician of today would be taken over by the automatic machinery already installed, and which would by then have been so perfected as

not only to run itself but repair and improve itself with little human help. Similarly, administration, after a first period of increase to deal with the problems of organizing the whole world rather than only a small part of it, would in turn decrease with the automatic development of the administrative machinery. And administration itself would become simpler and less important. Much of what passes for administration today is designed to prevent people cheating each other. Without the need for any moral reformation the pointlessness of this occupation in a state of plenty would be evident.

In contrast the importance of personal human occupations, particularly those of bringing up the young, would be much increased. Assuming a regular span of life of eighty to a hundred, or perhaps a little more, some thirty years of this would tend to be taken up with education of one kind or another—not necessarily whole-time education, but education tapering off but never quite ending. This will be necessary to cope with the increasing speed of advance of knowledge so that everybody indeed can keep abreast of the times. Perhaps education in one sense would be one of the normal occupations of mankind, and if all people are being educated, then a very large number must be occupied in educating them, though this also may become largely a part-time occupation (pp.199 ff.).

All these occupations together would not take up by any means the whole of mankind. Dirty work there would still be, but less of it as time went by—not so much by passing it on to machines, but arranging the ordinary domestic ways of life so as not to produce dirt. The revolution in the apparatus of domestic life, in the house in Corbusier's phrase "as a machine for living", would diminish domestic drudgery to a vanishing point. The task of dealing with the inevitable, if far less frequent, accidents would be a matter for voluntary and devoted bands of people, equivalent perhaps, though again on a smaller scale, to the military service of today. What would be left would be for the enjoyment of life and the creation of culture.

On the main lines of industrial development there is little that needs to be said here about the distant future. The main lines of the transformation, the use of atomic energy and the introduction of automation, will carry us a long way forward. Thermo-nuclear energy is already on the horizon; if it can be practically realized it will liberate man completely from want. Beyond that we may look forward, as thousands of young people are today doing, first to the conquest and then to the exploitation of outer space, though it will be some time before we can construct in space or on another planet anything as comfortable as the earth to live on. Now that we are likely to have plenty of energy, the unsolved problems of the storage of energy and its transmission by means other than cables will become more and not less important. For even in an energy, and material-rich age we want to get rid of the clutter that our present clumsy methods involve. If, for instance, vehicles could pick

up electrical energy direct, it would end all our dependence on combustion engines or trolley-bus lines.

Now that we can see the way to automatizing the processes of manufacture, we ought to look further into the question of what we are making, which has often been conditional on the skill and power of the original handicraftsman, which has only been magnified and multiplied by the machine. For instance, it has been a practice, ever since skins were given up in the neolithic period, to make clothes from natural fibres. With all our ingenuity we have only gone on doing the same thing on a bigger scale. Indeed we try to imitate Nature even to the extent of producing fibres. The major utilization of natural fibres is first to ply them together in spinning into thicker threads, and then to make a fabric out of them by some form of weaving or knitting—which has now become a very complicated mechanical process to carry out essentially the operations of the fingers of the first neolithic spinners and weavers.

The ultimate problem, however, is not whether a machine can be made to spin or weave a hundred or a thousand times faster than a spinner or weaver, but rather what is the object that the "textile" material is really required to serve. And here again we follow a sequence of purely traditional evolution: we produce cloth very largely for clothes, for covering and to a certain extent for ornamenting the human body. Skins did this moderately well, woven cloths did it better. We ought, by our ingenuity, to produce something as much better than woven cloth as it was better than skin. We have the two, not necessarily incompatible, aims in developing such materials: one is to produce something which has better wearing capacities, which is easier to wash or clean, and necessarily as cheap or cheaper than present woven cloth. The other is to produce something even cheaper still—indeed so cheap that it can be effectively discarded after one wearing—and does not need, what is now a tedious and expensive process, washing and cleaning.

To solve this problem, once we applied ourselves scientifically to it, would not be difficult, Nor would it be any harder to simplify, without loss of flavour or consistency, the tedious and messy tasks of cooking, as well as those of eating at table and washing up. Indeed, when the pursuit of major engineering problems begins to seem too easy, scientists may well devote themselves—as they never have up till now—to the problems of the housewife in what will probably be called domestic engineering and chemistry.

There remains one major problem, that of food and population which, though in principle at least soluble for the next two generations, still perplexes people as applied to the more distant future. The many scientific pessimists of today prefer not to consider that mankind has any assured future. If it escapes self-annihilation through atomic warfare, it will only meet it through over-breeding and starvation.

One of the most distinguished exponents of this school in Britain, Sir Charles Darwin, has even stated in his book *The Next Million Years*

—an extent of prediction to which I lay no claim—that the last days of the nineteenth century may well prove to be the golden age of mankind. Now from the arguments already given, it is clear that such a judgment can only be based on the assumption that the goods and resources of this earth will be as stupidly, if not more stupidly, used by those who control the destinies of the men of the future than they were at that time, which was one of unexampled luxury for a very small plutocracy in Europe and America, and unawakened misery in their colonies, which between them by then covered nearly the whole inhabited world.

No serious nutritional or agricultural expert now doubts that with methods that are already available and resources already in the hands of the industrial nations we could feed not only the present population of the world on an adequate diet, but also face the problem of feeding population of some three times as great, up to eight billion souls according to the authors of *The Next Hundred Years*.[1] But what, the pessimists ask, is to happen after that? And *that* is not very far away, because with present rates of increase, with birth-rates still round about 30 and death rates sinking to 10, this situation will have been reached by the early years of the next century (pp. 64 ff.).

What are the limits to the number of people that could find their living on the earth? The answer to this is very simple. The people themselves determine and always have determined them whenever they are in a position to do so, and they will presumably do so in the future as well but more intelligently and with a greater freedom of choice. There have been various times in history, for instance in early tribal times, when a dozen or so and no more, men, women and children, could just be maintained off the ground that a man could hunt over within a day's walking distance. Various forms of restriction of birth, and even infanticide, were used to keep the numbers constant. And very similar practices followed even as late as our own Middle Ages, for the population of Europe as a whole did not exceed that of Roman times until somewhere in the middle of the sixteenth century.

Whenever the opportunities came, however, whenever there was land to be had or new jobs such as fishing or maritime trade to be done, the population increased—people do not like losing children, and for the most part religions prevented them from finding out how not to have them. Those limitations, both of death and birth, have been overcome, but the question now is at what level will it be necessary to hold down the increase of population.

What are in fact the limiting factors—food, space or simple human convenience? Food would be the first limitation, at least as long as men limit themselves to extracting it from the soil, rain and sunlight in traditional ways. The limit of eight billion people fixed in this way could be at least doubled if enough energy was available, as it will be from atomic

[1] *Op cit.*, p. 68.

power, to irrigate the present desert belt using distilled or electrically freshened sea-water, or ultimately, if it proves cheaper, by using plastically covered closed water circulation greenhouses. If the men and women of the twenty-second century wish to feed a still larger population, then we can already see well enough, and undoubtedly they will be able to see even better, what steps need to be taken to increase the human food supply. The stages we see are the microbiological and the chemical, with a number of mixed systems between them.

The higher plants and the animals that are parasitic, either directly or indirectly on them, have highly specialized and set chemical reactions. They require specific kinds of nutriment. However, the more primitive forms of life, the algae and the bacteria and most of the fungi, manage on a much more varied diet, and have much greater possibilities for chemical synthesis. Not only that, but being small they can be handled in bulk by industrial chemical methods, instead of having to be spread out over the fields as do the higher plants, and they are readily dealt with genetically to evolve breeds which can synthesize a great variety of chemical products.

It is reasonably certain that within the next century or so microbiological food production by algae, yeasts or other fungi, will be one of the major sources, first of animal and possibly afterwards of human food. Much work has already been done for the production of food from the very simple green algae, chlorella, using sunlight as a source of energy.[1] Later on we may find it more convenient not to use sunlight, because of its relatively low intensity, but light produced from electrical energy and ultimately from atomic energy. But whichever source is used we shall be applying the process of photosynthesis under controlled and factory conditions.

Field agriculture is in direct contradiction to the whole tendency of modern industry, which is to limit the volume of the working space and to maximalize the output by carrying out reactions quickly instead of having to wait for the cycle of the year. Algae would produce carbohydrates, protein and fat. Fungi which are unable to utilize carbon dioxide photosynthetically can however convert almost any animal or vegetable waste products, that is turn carbohydrates into protein or fat. Further, on account of the research work which has already been carried out first of all in the old traditional microbiological industries of brewing, and later in the production of antibiotics, we now know how to handle these fungi and bacteria on a large scale. Human food habits being what they are it would seem reasonable psychologically, if highly uneconomic from the point of view of energy and capital, to use the products of these industries in the first place for feeding animals, especially pigs and poultry who need more concentrated and protein-containing food than the grass-eating ruminants. The small conversion factor that these animals

[1] H. Brown, *op. cit.*, and R. L. Meier, *Science and Economic Development*, New York, 1956.

have might be offset by the far greater efficiency of production of the chemical raw materials on which they are fed.

The most economic use of microbiological synthesis however, would not be production of what might be called crude basic foods, carbohydrates and fats, because these ingenious micro-bio-chemists are best utilized in producing the various odd molecules, like vitamins and antibiotics, which, though possible to synthetize by chemical methods, would cost far more if produced in that way than by bacteria or fungi. If we are concerned with producing in quantity, it will be better in the long run to produce directly chemically. We should never in fact have to face the problem of protein synthesis, or at least of food protein, on an industrial basis. We are already in fact producing fibres of proteins, or protein-like substances like nylon, for industrial purposes, but these only need contain simple sequences of one or two amino acids. The production of an organic or food protein, containing a great variety of amino acids linked in a most complicated way, is not only extremely difficult—in fact it has never been done yet—but would be an absolutely pointless operation, considering that the human body immediately it gets such a protein breaks it down to its constituent amino acids. These are rather than the proteins, effectively, the raw materials of our bodily protein synthesis. In other words, what we have to synthesize is not protein but amino acids. Industrial amino acid production is not intrinsically a very difficult project, and if it were perfected the fear of protein starvation would entirely disappear, and with it the ultimate fear of shortage of human food.

At an intermediate stage it might, however, be worth while to synthesize the two or three amino acids, such as methionine, which are lacking in most vegetable products. Here a few factories might produce enough to convert the poor diet of most Asian peasants into one as protein-rich as a full meat diet, and possibly without some of its other deleterious components, which are already suspected to be the cause of such diseases as coronary thrombosis, most common among meat-eating peoples.

The simpler energy-producing foods, the carbohydrates and fats, are in fact far easier to synthesize. It is even now rather difficult to synthesize a simple sugar molecule like glucose, but here again this may not be effectively necessary. Even in animals, glucose molecules are in fact synthesized from simpler ones. The main carbohydrate source of energy in cattle for instance is acetic acid or vinegar—a very simple substance to produce by straight chemical synthesis. From acetic acid in turn we can build up the fats. The overall aim of the chemical food synthesis is to find the best ways of producing the very simplest chemicals that can be transformed in the body into what is needed for energy production and tissue building. Many of these syntheses are already known and only need adapting to an industrial scale. The rest could always be found if it were considered worth while to put enough money into the final stages of the research.

In the light of these prospects of food production and synthesis we are in a position to deal with the question that has somewhat unnecessarily worried a number of people, namely where would this multiplication of the human race have to stop? They may admit, for the sake of argument, that we can find a rational way, with the proper flow-sheet of food production, to satisfy the needs of ten thousand million people. But surely, they say, we will only meet the same difficulty another fifty years ahead, when the population has doubled again. Now in principle this is not a question that we really ought to worry much about when we are occupied with the greater and immediate one of preserving peace. For if the people of the next century have succumbed to an atomic war or have failed to solve the problems of co-operating for mutual benefit they will never reach the figure of ten thousand million. On the other hand if they do multiply to this extent it will be a proof that these problems have been solved and that they are capable of solving the bigger problems of dealing with a larger population, or alternatively of deciding that a population of ten thousand million is enough. However, if they do decide to go on they have still a very long way to go.

In fact, once the problems of basic chemical synthesis of food materials have been solved in a world where energy is freely available, there are ample reserves of all the elements from which these foods can be built up. It must be remembered that when we talk of synthesizing food chemicals we are synthesizing them straight from the elements or from very simple compounds such as carbon dioxide. The whole of the limestone which covers vast areas, tens of thousands of feet thick, all over the world are calcium carbonate, and that is basically food material, all of which has incidentally already been through animal metabolism in the shell fish that laid it down. Not only, therefore, are the coal and oil reserves no longer needed as energy sources, but with atomic energy the limestone and other sources of carbon will be available for food.

We must remember also that we really need only consider the amount actually incorporated in any given time in the human bodies because the circulation of carbon dioxide, nitrogen and so forth which goes on in the world today ensures that every atom of carbon is used up over and over again, often in the same body at different periods of its life. The whole inorganic, carbon, and nitrogen resources of the planet can be turned into food, providing we have enough energy to do so and we want to use it for that. Reckoning on the amount of nitrogen available in the atmosphere alone, and assuming that by then most of it would actually be incorporated in the bodies of human beings, the world would support a population of several billion billion, or the square of its present value. That is, every person in the world today could have as many descendants as the present world population.

Long before that comes, however, room would present a problem. I am not suggesting that we should attempt to plan for populations of this density. It is not in any case for us to decide, the populations of

succeeding centuries might have quite different ideas. Rather if we limit ideas of a good life to the kind of thing experienced by ourselves, we would not go to these lengths. But what lengths would we go to? The world today, for all its crowding here and there, is a remarkably uninhabited planet. In fact only 8 per cent of the world's land surface, outside the Arctic, is at all densely inhabited. Much of the continents consist of barren mountains and forests, and an almost continuous desert runs across the old world from Morocco to the shores of the Yellow Sea. Anyone travelling over Canada and Siberia for instance, and looking at the endless succession of forested hills, lakes and rivers, thinks what a waste of good holiday country.

In the earliest stages of the scientific industrial transformation we may need to use this country for agriculture, to increase food production for the eight billion population that as far as we can see is bound to come in the next century if there is no war. One corollary of a more efficient method of food production is that it will throw land open for more agreeable uses, and not only land, but sea. When there is less work to do then we will have more time to enjoy ourselves and will therefore need more places to relax in. Later on more country will become available by an actual reduction in the areas of agriculture. This reduction is already occurring for sheer necessity in many parts of the world even as close to us as the Highlands of Scotland or the South of France. Even in the United States deserted farms and villages are to be found in the once densely inhabited counties of New England, now rapidly being taken over by holiday camps.

With automation, the energy-producing and engineering plants, so enormous today, will occupy far less space, and in fact might be conveniently put underground, either actually or by building gardens over the top of them. There will also be very little necessity for living all the year round in the same place. One of the advantages enjoyed by the animals, on whom early man lived, was wandering up north in the summer and coming down to the Mediterranean or Egypt in the winter. But human migrations, even with the vast numbers that I have mentioned, would be by no means impossible in the future.

But it may be more desirable to reverse the process and bring the weather to the people, rather than the people to the weather. If we are to have an enclosed agriculture (p. 71), we might just as well have enclosed cities, that is large areas covered in by transparent and practically invisible plastic sheet under which the conditions should be made just what people most like—some mild type of climate which might or might not require any houses to live in. In fact they would be in a position to revert to the legend of our first parents: to return to Paradise, an earthly Paradise, and one from which we would not be driven by increasing knowledge.

Now would people be limited to our present earth. How long it would take before seriously organized space travel occurs is difficult to predict.

It may be several decades, it is unlikely to be more. How far people would want to live in the perpetual sunshine of outer space is really a question for them to settle. Certainly many of the adventurous would want to do so already, though it may turn out that only a few thousand or millions of scientists will want to leave their habitual surroundings on our particular planet.

It may be asked why anyone should want there to be so many people in the universe. Now the simple answer in any reasonable world is that people are born because their parents wanted children and that children as they grow up like each other. If we do not like children enough to bring them into the world when there is any choice in the matter, then the human race would die out and perhaps would deserve to. But this is not a serious danger, the problem will always be how to stop the family instinct at the first two or three children.

Quite apart from such natural feelings, there is now, and will be increasingly as the age grows more scientific, a need for people just to provide intelligence. And the more we begin to grope into the mechanism of thought processes the more we appreciate the illimitable excellences of the human brain. Compared to the brain of even the most stupid of men, our most complex electronic machines, despite their enormous speed and extensive memory, are terribly rigid and silly things. And only man, so far, can create new things. As long as large numbers do not mean, as they certainly do today over most of the world, poverty, crowding, disease and ignorance, they cease to be a curse and become a blessing. Once we achieve the situation in which everyone has the fullest possibility of developing under the best conditions, then the more we have of people the better. A greater population means more variety, and more possibility of picking out from amongst the thousands and the millions, those exceptional geniuses who will give us new perspectives. Men are not needed any longer as beasts of burden or hands for factories, not even as cannon fodder for war. But we do want more and more people to enjoy life and make it more worth enjoying.

The future I have so far envisaged is simply of a kind based on the present, but without the conscious limitations of that present, that is, without its burden of misery and toil. However, if we look further ahead, it is evident that the present can no longer give us a guide. Once free from the old limitations, men will rush forward until they come up against new ones, and we should say something about these possible achievements even though some of them may be decades or even centuries ahead.

Indeed our present limitations have weighed on us so heavily that the ones I have been talking about have not been felt by most people to be limitations at all, but part of the normal pattern of existence. However, looked at rationally, it is the very advances that mankind has made since the period when he was hardly more than a wild animal roaming

in the forests, which have made the physical and biological limitations of life far more galling than they could have appeared to earlier man.

Take first what is the greatest and apparently eternal common fate of man—death. The nature of death may appear as a mystery, but as a fate there is no question. Now among the animals there is hardly such a thing as we call natural death. The chances are hundreds or millions to one that each new creature would be eaten up at once in the egg or as a small embryo and almost a certainty that he would be eaten the moment there was any sign of failing powers—most probably long before. Not even the largest and most powerful animals, the lions or the elephants, could be expected in our terms to live out their life, for any enfeeblement insured that they would starve to death. Nature, therefore, did not and could not evolve for long life as such. It is only under very special circumstances affecting man's early ancestors, probably through some glandular mutation delaying the period of maturity, that early man acquired a possible life span of some 70 years—far greater than most animals of the same size, or even larger animals such as horses or cattle. But very few indeed can have reached such an age. Even now, over most of the world, only about 5 per cent of the population die of anything that could be described as old age. A third or so die in infancy, and the remainder at varying stages of life from accidents and diseases, mostly epidemic diseases, as the Indian life table shows (p. 98).

Now, the advances of modern medicine, particularly in control of infectious disease, have completely altered this life table and have enabled the pattern of natural life of the human species to be revealed, beginning with the very small — per cent infant mortality, and thereafter very little mortality from anything but accidents, until from 55 onwards there is a sharp drop confirming the Biblical limited span of life averaging about 70 (pp. 99 f.). Here we can see the difference between the two stages of limitations—the limitations of disease, once thought an act of fate or retribution for private or ancestral sin, but shown to be almost entirely preventable or curable, and the limitations of infirmity and senility which we now see as a new kind of challenge to medicine, and through medicine to the fundamental biological sciences. We do not know whether this challenge can be successfully met, but we do know that it is worth taking up. Prolongation of life and vigour has been the dream of mankind since very early times indeed. Only now are we really beginning to get to grips with it, and the prospects are by no means hopeless.

We know that even, and perhaps particularly, in remote districts of the world and without any benefit from science, there are people who live active lives well into their second century.[1] That means that the human frame itself can be modified by inheritance into a longer living form. Once we understand how this is so, and this is not just a research on a few old men and women but one of age generally, we would be able

[1] *Soviet Weekly*, 26th June, 1958, p. 10 f.

at least to determine the conditions for indefinitely postponing old age and, as far as future generations are concerned, possibly the physical and chemical factors by which we can control it. If we were just ordinary animals the answer would be by breeding. However, there now seems a possibility of another way that would not take nearly so long or interfere so much with our social habits or personal preferences. As the science of genetics advances we begin to see that what is done by breeding really operates through the action of specific chemical substances. Already in certain cases by using these we can make up for what inheritance neglected to provide us with.[1] Beyond that there are other possibilities which I do not want to pursue here, though thirty years ago when I had more imagination and fewer responsibilities I anticipated them in a little book;[2] we have still a long way to go in this quest for immortality.

But possibly long before we have found out how to preserve the bodily frame and its functions indefinitely, and are no longer at the mercy of cutting off, by a lack of oxygen in the brain, the whole score of memory and wisdom accumulated over nearly a century, we may find a way of increasing our social rather than our personal immortality. So far human beings have communicated with each other essentially by a means of speech evolved in the Old Stone Age, possibly as long as 200,000 years ago. That was a wonderful advance for the time, for it made all the other advances of humanity possible. Just because it came so early speech remains the most primitive part of our means of social communication. It is only now that we are beginning to appreciate how primitive it is. A point made by Gordon Childe in his last book[3]—one which we would have much longed to see him develop further—was that much of our trouble is due to the fact that we are trying to express twentieth century ideas in palaeolithic language.

It is by no means impossible that man may succeed, by a combination of electronic devices reacting with brain cells, to communicate thoughts directly from one mind to another, without the use of language. This would probably mean that not only thoughts but also emotions and memories could be transmitted with the vividness of actual experience. Such a method of communication would enlarge immensely, in content and immediacy, the picture and the book. It would permit mankind to pass on from generation to generation the essentials of personal contributions and not only a few relics which is all we can do now. It is not only for this perhaps pious purpose of preserving the best in every human spirit that we wish to be able to improve the immediate quality of our communication. Perhaps this is the least of reasons, because if we could improve that quality of communication it would alter the whole pattern

[1] J. B. S. Haldane, "The Genetics of Some Biochemical Abnormalities," *Lectures on the Scientific Basis of Medicine*, Vol. III, London, 1953–54.

[2] J. D. Bernal, *The World, the Flesh and the Devil*, London, 1929.

[3] V. G. Childe, *Society and Knowledge*, London, 1956.

of social co-operation. Even now we realize that for reasons deep laid in history and custom we manage to co-operate with each other over all extremely badly, hence indeed come many of the troubles of our time.[1]

Science itself has before it great and complex problems such as those of the origin of life, or the control of weather which cannot be dealt with inside the scope of a single mind, however well-trained. There just is not room enough for these abilities, or time enough to acquire them if there were. Solutions can only come from co-operative scientific research, merging different disciplines for some common purpose. How clumsy that merging is today; how slow is the co-operative effort compared with the rapid darting of individual minds, capable of bringing together a whole store of experience and memory elements needed for the solution. If we could only think together as well as we think by ourselves, what a transformation it would make to the knowledge and competence of mankind.

Perhaps what I have said here will seem fantastic to some, and even repulsive to others. That is largely because it represents such a change

[1] Technically the problem of communication is a very difficult one and despite recent advances is far from being solved. Our languages developed for the most part in the early Stone Age and have been only slightly modified since then. We are using a system of writing which was developed some three thousand years ago, and, as far as the letters go, has hardly changed at all. We have already had some five hundred years of printing in Europe and some thousand years of printing in China. The electronic devices for translation (p. 56) are only of a stop-gap variety. What we need to evolve is a radically better way of communicating, particularly now the world is becoming an effective scientific and economic unit, where the babel of tongues is a terrible obstacle. It is fantastic to see at a scientific meeting a number of men, dressed all alike, looking alike, of whom we know that their thoughts and knowledge cover almost identical regions of science, and yet absolutely unable to communicate with each other, and in need of the services of a translator, unless they have endured the labour of learning three or four foreign languages.

The very growth of scientific devices, such as the tape recorder and other forms of recording and reproducing the human voice, only makes this problem of translation more difficult. Already merely in scientific literature the labour of translation is so much greater than the number of trained people to do it, that much valuable scientific material is untranslated, and the knowledge is only available to one part of the world. We badly need to revise the old idea of Bishop Wilkins in the seventeenth century of a universal character, which at least would enable people's thoughts to be put on commonly understandable basis. But we probably also need other devices for a common language, not as previously imagined through the choice of one existing language—probably national prejudices would always be too great to achieve this. Nor would it be really desirable to do so, or, as I have said, languages at present are not made to convey thoughts, at least not in any economical way. And while they can convey feelings it is largely by association and largely disappears in translation. A basic language for use rather than literary expression could be constructed *de novo* to convey thought most clearly and economically, and at the same time to contain in itself enough flexibility to take in developments for at least another hundred years or so by which time scientists will probably have thought of some better means of communication.

from our whole concept of existence that it is really beyond our imagination. Nevertheless, it does not follow that it is beyond our power to reach and in fact the movement of present-day communication theory and electronic practice is all going in this direction. By trying to trace the relation of electric currents detectable in the brain with the thoughts going on inside it on the one hand, by trying to build up circuits to imitate the action of the brain on the other, there will come the possibility of linking brain to brain and thought to thought directly.

Because I have lived so long among such prospects and ideas they seem brighter to me than to those who see them here for the first time, and many of us are so wedded to our ordinary ways of life that we would not change them even for a better way. But then we will not be asked to do so. It is the people who come after us who will. What we have to do is to prepare the place for them.

The culture of the future may well be entirely different from that which we have known. Much of what the people who come after us may do would appear to us frivolous or downright wicked, just as what we do would appear so to our ancestors. But they will be answerable only to each other. All that we can do is to build as good a foundation for them as we know how. As I have said elsewhere (pp. 267 f.) the recovery of the spirit and practice of beauty will be one of the major features of the new age. For science in contrast it will be a matter of preserving and increasing rather than recovery for here new knowledge is built around old and new powers added to old powers.

But can men with all their science ever do the kind of things I have been writing about here? Here most people turn away and say, all this is very fine and large, but it is Utopian, and is impossible, it is beyond human capacity. And yet the answer is quite simple—we do not know but we can find out. I would ask those who doubt the power of science to consider very carefully the arguments and the facts contained in the first part of this book. They will see that the possibility is there shown to be inherent in the laws of nature, as discovered by science. Most of the things (apart from those in this last chapter) that I said will be done all over the world have been done to some extent and on a certain scale somewhere in the world already. And we can see in the light of what has been done quite a number of other achievements that certainly would be possible. The reason people may not believe this will be done is not so much any lack of faith in the competence of science, but that they do not believe in the good will and the good sense of people. They think it is simply too good to be true.

We have seen in this century so much misery, so much senseless destruction, slaughter and cruelty, waste and stupidity that we almost are tempted to believe that men are always like that and always will be, that this is what men want even though it is absolutely evident that they do not like it when they get it. But to set against that, this very same

unhappy century has seen such other examples of intelligence and foresight, of construction and heroism, that we can be sure that not only are the great achievements physically possible, but also that men can be found to think them out and to do them. I have seen in China a great dam being built across a river by tens of thousands of men with no more equipment—hoes and baskets—than could have been mustered for the same job three thousand years ago. But three thousand years ago the ancestors of these men were not building dams to check unruly rivers, but had to build walls to hold out enemies in the battles between wandering nomads and cultivators who took over their herding grounds. Man has never yet been able to get on with the job that he really needs to do because so much of the time has been taken up with fighting other men for the meagre pittance that was all that either could win from the soil. With potential plenty in sight the cause for these struggles is gone; only the habit remains.

As long as people did not understand how human affairs were governed, what caused poverty and wars, they had some excuse for treating these as the worst things they could think of, as acts of God, like earthquakes and hurricanes, droughts and diseases, about which nothing could be done. It was this fatalism which prevented an effective reaction against them, and this fatalism is still the strongest support for the people who are laying up preparation for war today. "Human nature will always be so, there always have been wars, there always will be". Now we have reached the limit. If there are going to be any more wars, certainly if there are going to be any more big wars, this time it will really be the last because there will not be anyone left to fight another one; and the sooner people see this the sooner they can settle down to do the perfectly sensible, if unbelievably good things, that I have tried to sketch in this book.

XIV

CONCLUSIONS

THE years we are passing through are years of decision; the choice between the alternatives of peace and war cannot be delayed much longer. And people are feeling this. As we move towards a position in which the fate of humanity can be determined by a couple of men standing at the buttons which will release the fatal rockets, everyone in the world is beginning to realize the danger that we have allowed to grow to these monstrous dimensions. War, always wicked, has now lost any sense. It has ceased to be a way of imposing the will of the stronger on the weaker. It has become a suicide of madness. A future world war will have no victors but only vanquished. Even if we did not have a better alternative—we would still have in the interest of self-preservation to end the present nightmare. But we do have such an alternative. With the knowledge and experience already at our command we could build a world that would provide for every single person in it more than the richest can hope for today, a world in which men's energies would be turned away from struggle against each other to the conquest of the forces of nature.

It has been my purpose here to examine this alternative critically and constructively and to describe it in as concrete way as possible. And these are the only alternatives—the destructive use of science in war or the constructive use of science for peace. In either way we cannot do without science. As I have tried to show, the lives of hundreds of millions of people today depend on the continued use and the further development of science. We cannot go back to a period which made no use of science. Even if those days were happy, they were the happiness of ignorance which our knowledge has now dispelled for ever. As in the fable of the fall, knowledge of evil or good cannot be taken back, we have passed the point of no return. We must now go forward, but not to destruction. Unfortunately, ever since the Cold War started, that is the direction in which we are aimed. Unless the peoples of the world act in time all—contestants and neutrals alike—are doomed to the slow painful death that will follow the horror of nuclear bombardments.

Now in these wide and general terms, this situation is being recognized by more and more people. In fact, I should think it is fairly well recognized by the great majority of people all over the world—in Africa and Asia, just as much as in Europe and America. But it is clearly not sufficient to realize it in these general terms. To be effective we must look

closer and find more precisely what to do to arrest this madness and to set us on the other course. This is what I have tried to do in a small way in this book—to chart and make provision for a reasonable future, where men's knowledge can be turned to make use of the resources of this planet for the benefit of the people on it. I have tried to show that the resources themselves are adequate. If we are wise we have no reason to fear, for an indefinite future, any shortage of human necessities, of food and shelter, or of the means of constructing all the instruments and machinery that we need to make the things we want. Indeed what I hope to have brought out is that we are on the eve, in fact have already embarked on a second Industrial Revolution much more conscious, more scientific and carrying far greater hope for humanity than the first Industrial Revolution of the eighteenth century. To complete this revolution, to release men from the tyranny of monotonous labour as well as the hard physical toil, is now within our grasp.

The second objective, at least equal in importance, though it can only be effected by the use of the new Industrial Revolution, is to remedy the gross inequalities of human opportunity in the world today, inequality which the advance of science and industry have made far sharper than it ever was before. The majority of the people in the world, perhaps, are not much poorer than they were in the past. But that is only because they could not be much poorer and be alive at all. The wealthy everywhere—and in the privileged countries large sections of the population as well—are much better off than any substantial number of people have ever been in history, and their wealth is increasing at a more rapid rate than has ever been known in the past. The most urgent task for humanity is to see this inequality corrected, to see the division between wealth and poverty abolished. The real solution is so to organize society that there should be enough and to spare for all. This objective, never before possible, has now come within reach thanks to the advance of science. The most rapid raising of the standard of living of all the poorer parts of the world and all the poorer classes in all parts of the world can be most rapidly effected through the use and spread of a scientifically directed and controlled productive system.

My object was to show in the most concrete terms how this could be done, how in the span of a generation or less the industry and the agriculture of the world, and even science itself, could be transformed by material means already in existence and by use of knowledge already available. I have tried to show not only how it could be done in detail in this country or another, but also how it could be done in all spheres of human activity all over the world. I hope I have shown that what might be called "Operation Plenty" is far more likely of success than any military operation in any war, but that like military operations it needs to be thought out, planned, and executed not only with intelligence but with general good will, energy and enthusiasm.

I have also been concerned to show that, though this is a quite pos-

sible task, it will not be a simple and easy matter to carry it out. In setting out and finishing it we have to face obstacles far more serious than those presented by the indifference or cruelty of Nature. We will have to face entrenched interests and ancient suspicions and hatreds which have been turned to serve those interests. Science is no fairy godmother that will just shower gifts on people who have not worked to get them. If people turn away from the difficulties of the present situation, say that it is no concern of theirs, or that nothing that they can do would make any difference, they are evading their plain responsibilities as human beings and really deserving the worst fate that can befall them. But I do not think many would do this once they saw not only the dangers but also the possibilities and the way to achieve them in action. This way is inevitably one of political discussion and action. However, in a book such as this, dealing primarily with world problems, the political aspects can only be indicated in the broadest lines. Finding what must be done is a different problem in every country and with every turn of the political situation.

Only the first step is abundantly clear—that is, to end the Cold War, to disarm, and to make peace. These are not, though they are often represented to be, extremely complicated, technical, military and diplomatic problems. To solve them only requires one thing—the will to peace. And if that will is not to be found in the statesmen—or not in all the statesmen—who rule the world today, it is the business of the peoples to see that it becomes their will, or else to change their rulers. To do this we need to gather together in all the countries the positive forces of the people, which in their diverse way will all help in one great movement for peace.

With the hydrogen bomb, war has reached the limit of its destructiveness. No further piling up of weapons could make it worse. Already there are enough atom and hydrogen bombs in store with planes and rockets to carry them to blot out every big city in the world and these bombs would release enough radioactivity into the air to poison fatally, or perceptibly every living thing on the earth and damage untold generations of those that survive. Whatever the reasons, real or pretended, that are given to retain nuclear war in any form, the first and most persistent demands of the people should be for its absolute abolition. Every country has its own reasons for wanting this abolition, but whatever the reasons are, whatever the particular forms of nuclear warfare that have to be resisted, all the resistances add up to one great repudiation which must be made effective without delay. Every year we lose makes the danger greater, and there may not be very much more time.

In Britain we are, for example, committed to a complicity in nuclear warfare as the site of ballistic rockets. These weapons can no longer be claimed to defend our people, they will serve only to attract a hydrogen bomb counter offensive which will wipe out everything in the country.

However, as it is only by the co-operation of the people of Britain, and not only of that of the government of the day, that these bases can be built and the whole system of which they are a part can be maintained, there lies on the people of Britain a special responsibility. If we hold out, if we repudiate this policy, then the policy will be dropped, and another step will have been taken to ensure the success of a negotiated peace. Such a peace would necessarily include the total abolition of nuclear weapons and such a degree of conventional disarmament that military aggression would be impracticable.

Other countries which may not feel themselves so directly threatened by atom and hydrogen bombs are in reality hardly less interested in securing their abolition because the spread of radioactive fall-out will not respect national boundaries. What we need as soon as possible is the expression of a universal popular opinion which will leave no government, however wedded to the policy of nuclear warfare, any possibility of preparing to wage it. And if they cannot do that, they cannot, in fact, afford to have war of any kind. For in an age in which even the knowledge of nuclear weapons exists any war may sooner or later turn into a nuclear war.

To put an end to war for good it is not sufficient just to call a truce. It must be stabilized by positive constructive action, if only to take up the energies now used for armament production. The alternative to war needs some degree of international co-operation to set the world to rights even if in its first stage it may appear as peaceful economic competition. What people find hard to realize now, because they have never experienced it, is the enormous material benefit that would accompany the abandonment of the military solution and would bring with it an immense feeling of relief from a fear which, although we may not really be conscious of it, weighs on our every hour. I have tried to show in this book what stores of resources are immediately available and would be released by the cessation of arms manufacture, what potentiality of the most advanced science that could be switched within a few months from destruction to construction.

The nature of that constructive task was my major theme. I have tried to show how the new powers brought by science—among them atomic energy and electronic automation—could transform industry, increasing without limit our supplies of materials and manufactured products and at the same time removing the necessity for all monotonous as well as arduous work. I showed something of how the advances of biological science could transform agriculture to provide abundant food and medicine for better health and longer life.

Most important of all, because it is the key to success in all these fields, is the advance of science itself. The flourishing of science in research and teaching is indeed the characteristic feature of the social and economic transformation of the present and near future. It is here, even more than in the idea of planning, that the Soviet Union has realized

in practice the ideal of socialism, and in doing so has brought a gift that the whole world can use. It has shown that a whole population, boys and girls together can be given a basic scientific education and can provide the great proportion of scientists and engineers which can speed up the new Industrial Revolution without which it will be impossible to make it succeed.

Throughout I have stressed the need to consider the economic, political and military problems of our time from the outset as world problems. They cannot be solved in isolation in each country but only in a general framework. It is in this way that the gross economic disparity between countries, which at present is actually growing, can be halted by a process of levelling up to be achieved in the first place by the industrialization of the underdeveloped countries.

I hope to have shown that the two immediate objectives, the ending of war and of poverty are essentially one. The energies released by lifting the immense burden of the costs of preparation for war, which now for years has terrified and paralysed the world, would find their best use in helping the peoples of the underdeveloped countries. It would at long last enable them to use their own resources and their own labour to raise themselves to a high technical level, and for the first time in history provide them within a generation with the opportunity of a full life free from hunger, disease and ignorance.

However, it is not just to alleviate the economic dislocations of disarmament that such a programme needs to be undertaken. It would be what William James called it many years ago, "The moral equivalent of war", and needs to be undertaken all over the world with the same intensity, with the same vigour and sacrifice, as war has been throughout history. But the enormous difference will be the consciousness among the people taking part in this common effort that they are working for good and not for harm. In this new war against poverty and for the fullness of human life there will be no vanquished but only victors.

The idea that all will gain and none need lose is one still unfamiliar to many people in the countries which at present enjoy the highest standard of living. They feel and indeed are made to feel by the propaganda that others can only gain at the expense of their losses, and they are prepared to inflict the most horrible destruction on any, however poor or deserving, who seems to threaten their standard of living. However, as I hope I have shown, the prospect of a scientifically reconstructed world in which the standard of life in all countries is levelled up holds no threat to any country, even the richest. The more they give to others the more they are enriched themselves, and not only in a spiritual sense.[1] The enormous new market provided by the industrialization of

[1] But this kind of enrichment must not be overlooked. On 25th February, 1958 at a meeting at the Statler Hotel, Washington, in support of the Foreign Aid Bill, the principal speaker after President Eisenhower and Ex-President Truman was Monsignor Sheen, a Catholic Bishop *in partibus* and notable television personality

(*Continued on next page*)

the backward countries is the stabilizing factor needed for the further transformation of industry into its fully automatized scientific form in the advanced countries, pending its introduction and further improvement in the underdeveloped countries themselves. The people of the old industrial countries have indeed the greatest interest in effecting this change.

But it would be too much to expect people in the wealthier countries to be the first to see the benefits that they will get from helping others. It would indeed be better if their natural instincts of justice and for the restoration of what they have taken from others—or what their fathers have—were to be the first motive power for the change, and this is happening to some extent in many countries, particularly in Britain. However, the real drive behind the change must come and is already coming from the peoples of the underdeveloped countries themselves. Starting with the example of the Soviet Union, and now with the renewed efforts which are going on in China, in India, in Egypt, and elsewhere, the whole of the fifteen hundred million peoples in Asia, Africa, and Latin America are insistently demanding their full right to live. They are insisting on the right to participate and work in a modern productive system that can alone give them the elementary needs which they have gone without for so long and that is already absolutely necessary if they are to avoid mass starvation.

This great movement has taken as its first demand national political independence, and many countries have won that independence in the last few years. Soon after—a state already reached in many countries—there comes a demand for economic independence—the right to use their own resources and not have them exploited and taken out of the country by foreign governments or business concerns under any pretext whatever. If this natural desire is badly handled, it can lead and indeed it has lead in the last decade to wars some of which are still going on in countries like Malaya and Algeria. These wars are both futile and

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in the United States. His message was that of aid to underprivileged countries as a moral duty:

"In aiding underprivileged countries we are not to think of ourselves as superior because we are economically wealthier; or that those who were aided are inferior because economically poorer. There are several kinds of need. The underprivileged countries of the world need one thing; we need another. Both the giver and the receiver have their respective needs.

The underprivileged countries need our machinery for their fields, our clothes for their backs, our shoes for their feet, and our food for their stomachs.

But we have need too; we are poor in another way. We need to justify our wealth by sharing it; we need to thank God for making us the most prosperous nation of the earth; we need the blessing of heaven on our hearts and grace of God on our whole being.

Therefore with humility and not with pride and superiority we extend our hands to the needy. Theirs is the burden of being underprivileged; ours is the burden of being overprivileged.

It is their stomachs that are empty; it could be our hearts that are empty. In any case, they could conceivably do without our aid, but we cannot continue to be without justice and charity . . ."

dangerous: futile because it is impossible now, with the way the world is, to resist for long the movement to full independence in any country; dangerous because they cause lasting bitterness and division not only in the countries in which they occur, but throughout the world and provide the most likely occasion for the outbreak of a nuclear war—as nearly happened in Viet Nam and more recently in the Middle East (pp. 295 f.).

In contrast, the opposite policy of helping to restore prosperity and dignity to the peoples of these formerly oppressed countries gives aid to the forces of peace. By doing so people will be working not only for material reconstruction but also for the advancement of knowledge and culture. Many of these countries, whose peoples today are among the poorest in the world, were great contributors to culture in the past. Indeed the whole culture of the so-called Western World derives from them. Not only have they the right to contribute to the culture of the new world, but that new world will gain greatly from their contribution. This will not merely be in numbers but also because, drawing on a different source in tradition they would be more likely to introduce new and exciting elements to science and art.

The point I have tried to make is that both parts of the world, the old-industrialized and the new underdeveloped countries, need each other, that their economies are complementary. The concrete task of changing the world is an operation whose stages I have outlined in which the surplus capital of the industrial world can set going, through a new industrialization, the rest of the world, without the foreign exploitation which has accompanied capital export in the past. It will help to bring into action a viable and harmonious adaptive world economic system yielding returns to all on a scale far greater than any can achieve today.

We already know how this can be done. We have seen it being done in our life-time in the Soviet Union and in China. There we have seen the possibilities of raising the productive level of a country far more rapidly than anyone thought, and at the same time the extreme difficulties of doing it without any financial assistance from abroad, and in the face of sustained hostility of the capitalist powers and active wars of invasions supported by them. It was these conditions that from the very beginning, and once again after the Second World War, forced the Socialist countries to sacrifice the present to the future and to accept hardships which in a juster world order would never be necessary.

Under these new conditions the pace could be the same or faster, but the rewards would not have to be so long deferred. Indeed, with any reasonable generosity they could come almost at once. As I have pointed out, enough food exists in stocks or could be raised by rapidly expanding agriculture, to ensure a basic level of nutrition within three years all over the world. These immediate rewards should be clear enough, and behind them come further possibilities that I have discussed, the full extent of which can only be revealed by scientific analysis and experiment. As we know well enough from the achievements of the past

this is something that can be relied on, we are not likely to be held up by intrinsic natural impossibilities but only by the human difficulties.

In the problem of levelling up the conomies of the former colonial territories these difficulties may well loom large. On both sides there are obstacles to be overcome. On the side of the old imperial powers there has been for centuries an assumption of superiority which barely covers a sense of guilt. The justification of the imperialist has always been that it is only because the natives of other countries are inferior that it has been a moral duty to exploit their resources and work them for their own good. On the other side there is a deep sense of grievance and suspicion—after all the Westerners came into their country in the first place bearing gifts. These attitudes and suspicions can only be dispelled in a common working task.

Such obstacles, however, are not the most important of those that stand in the way of a peaceful and prosperous world community. The chief among these, and the most obvious, is the present political division of the world between the two great economic systems—the old and the new—which bear to their various protagonists different names. Here, the Free World stands opposite to Communist Dictatorship; there, the world of Socialism to Capitalist Imperialism. But behind this quarrel about names, there is in fact little doubt about what the struggle is really about. The old system is one based on private profit, the new on production organized for the benefit of the whole people.

Now I may be criticized for not having made this basic antagonism and its resolution, in the triumph of one side or the other, the central theme of the book. In part this is because the book itself was concerned primarily with the scientific, technical and quantitive economic aspects of the process of transforming the world, rather than the political driving forces that will ensure that the transformation is actually carried through. I wanted to show, and hope that I have shown, that the transformation is neither physically nor economically impossible, that only some men's interests and prejudices stood in its way.

In part also, my comparative neglect of the major political issues was quite deliberate. Because, as is evident throughout the treatment of the book and particularly in the chapter where I consider the political difficulties and the stages of transformation, I have shown that it would be absurd to expect any very rapid disappearance of this antagonism—that we will have to get along in a world where both kinds of economic system can exist for a longer or a shorter time. To emphasize the irreconcilable character of the differences between them would only make the task of securing their coexistence and ultimate co-operation more difficult. One can believe, as I do, that the socialist system will in the end spread over the whole world, not necessarily by revolution and certainly not by war. But I do not want to put this belief in any dogmatic form, because the whole trend of my argument is that the events themselves will show.

Now that it is becoming clear that no attempt to conquer the world by military means can be successful without a destruction which would make the conquest entirely meaningless, the two systems must stand up to be judged by their merits: by what they can give to the peoples of the world. I believe that the socialist system can give so much more that sensible people will come round to see this as soon as the immediate danger of war has been removed, and with it much of the deliberately created misunderstanding between the two parts of the world.

By the very act of entering into such peaceful competition, some may think it possible—though I do not—that within the framework of the capitalist system a way may be found to stop the exploitation of the backward countries, and actually to help them on their way to full independence, industrialization and prosperity. I believe that far more effort will be needed by the peoples of the capitalist countries to secure this end, and that in doing so capitalism itself will be changed out of all recognition.

Even before this happens, however, under combined internal pressure and the needs of competition with socialist countries, real aid on a substantial scale may come to the underdeveloped countries from the capitalist countries. At the same time the socialist countries, relieved of the burden of military preparations, will be able to multiply the aid they have given already and to show how it can be given in a way that will help the peoples of the underdeveloped countries to stand on their own feet in real economic independence.

And there, with the easing of the pressure of military threats which has hung over the socialist countries from the very moment of their liberation, we may also expect to see a corresponding internal political easing. It should reduce and ultimately remove the features in them which have prevented many people of good will, workers and intellectuals, in the older industrial countries from supporting communist régimes and have even ranged them in support of the Cold War front against them. With the easing of Cold War tensions, together with a much greater possibility of mutual exchange and travel, people throughout the world will be able to judge political systems on their merits, to make rational choices between them, and to make those choices felt in changes of their own governments. As a scientist I want to see the thing work out as a social experiment, which will unequivocably decide between the rival social theories of the socialist and capitalist worlds.

Certainly we cannot hope to go forward to achieve the kind of transformation of the world that I have discussed, in an atmosphere of mutual hatred and suspicion. These are the seeds of war and not of peace. With the arrival of nuclear weapons, war can no longer lead to the triumph of right or even of might. That is the new fact, which has been recognized in theory at least in all parts of the world, but it is far from being recognized in practice, as the continual preparation for war and

as the refusals of some powers to accept any serious disarmament bear witness.

Our first task, therefore, is to work to reduce the antagonisms which have led to the dangerous stalemate in which the world finds itself. We need to persuade people that they have to live together in peace for the simple reason that if they do not, none of them will be able to live at all.

To overcome such human difficulties is one of the tasks I set myself in writing this book. I wanted to show enough of the possibilities and the visions of the future to attract people and at the same time to give them an idea of the practical steps necessary to realize them. But this is not just my task, it is also the task of the scientists, the economists, the writers and politicians, and of all others who see all or part of these possibilities. It is their responsibility in the first place to make these clear in their own ways, to let people see that by turning from the absurd distortions of the present economic system to one of real, general utility, they will infallibly get what they want and more than they expect.

It is not only the responsibility of the scientists, it is also a release for them. The frustration which all socially conscious scientists and engineers have suffered all their lives—the enormous gap between what they felt they could do and what they were allowed to do, the years they have had to waste on trivial or negative activities, in the service of war for example—all this will disappear once the constructive job can be got under way. And with that release and with that sense of a really worthwhile job to do, would come a new burst of constructive activity and constructive knowledge which will astonish even the most sanguine prophets of the new Industrial Revolution. What I have tried to put down is only what I have been able myself to see and estimate, and I am quite sure that the achieveable reality is much greater and much better than my best imaginings.

The scientists and technologists, although they have their special responsibility at this critical time, are not a class of people apart from the others, nor in any reasonable view of the future should they ever become so. Rather, the future holds out a promise for a much wider distribution of knowledge and experience all through the populations of the world—everyone being to some degree a scientist, and all scientists being full citizens and sharing the experiences and the enjoyments of the others. I have never been able to separate, as some of my colleagues have, my responsibilities as a scientist from those as a citizen. I feel that together we need, now as never before, to assume our common responsibility. We must in every country throughout the world organize and struggle against the madness of war and the crime of scarcity.

POSTSCRIPT

In a book that aims at dealing with the short term as well as the long term prospects of peace of war, there is always the danger that events which occur between the writing and the printing will raise new points of substance that affect the argument. It was for this reason that I had thought of adding this postscript to discuss such points and to get as close as possible to the contemporary situation.

Events, however, moved too fast at this juncture to make this procedure as useful as I had hoped, although some new information relevant to my topics has come to hand and there have been important developments in the political situation on which I can briefly comment. However, great events seem to be imminent and may well have taken place by the time this book appears.

The major issues of the course of the Cold War and the world economic situation still hang in the balance. Though in principle there is still a general agreement for a meeting of Heads of States, it appears in practice as remote as ever, and the tension of the Cold War has again increased. Without such a Summit Meeting there seems little hope for a general disarmament agreement. In the meanwhile, nuclear armaments pile up and we are threatened by their possession in many countries, multiplying the danger of an outbreak of war.

Only in a few small but important directions are there some signs of returning sanity. The NATO and Warsaw Pact scientists have at least met to consider the possibility of detecting nuclear tests, and this may prove a first step to the United States and Britain following the Soviet lead and suspending them. There is also the possibility of international technical discussions about means of preventing surprise attack and the possibility of a world war starting by accident. Whether these moves will lead to some actual agreement which would mark the first step towards disarmament remains to be seen.

In the economic field the prospect, if less tragic, is also uncertain. In the United States, though the recession has not notably deepened, there are few signs of recovery to date. How serious is the situation has been revealed in the United Nations *World Economic Survey for 1957*. This shows that U.S. production of metals and materials, which had been 90 per cent of capacity at the beginning of 1956, had fallen to 65 per cent of capacity in the first quarter of 1958. In Europe, the capitalist States are suffering from stagnation, if not from any very active recession in their industries. Production in Britain has shown no significant increase since 1956. Stocks of coal there and in Europe

generally now stand at record heights and there seems little prospect of their being used in the near future.

This stagnation, combined with the fall in wholesale prices of food and raw materials, is having ever more serious effects on the economies of the underdeveloped countries and is particularly damaging to their prospects of industrialization. Conditions like this are familiar enough in the working of the capitalist trade cycle, but the present recession, the most severe since 1930, takes on a new importance on this occasion, for the decline of production in capitalist countries is now contrasted with the steady, and in places accelerated, advance of the countries of the socialist part of the world. This contrast of stagnation in the capitalist sector and advance in the socialist sector of world economy is likely to become more evident in ensuing months. As it is realized, the demand for free exchanges between the sectors is bound to mount. Indeed, it seems probable that at long last the embargo on certain exports to the Soviet Union and China may be largely lifted.

Here I must specially comment on the developments in China in this year, because they illustrate that the pace of construction of an underdeveloped country can be far greater than I had indicated in my fairly optimistic account of Chinese economy (p. 116). What has happened this year (1958), called "the year of the great forward leap", is that over and above the centrally planned advance, the impetus has been given to local initiative both in the industrial and agricultural fields. Machine construction, using local material and labour, is everywhere pushing forward. One county having to transport ore from a local mine has laid a railway with home smelted cast-iron rails, such as Stephenson used a hundred and thirty years ago—and it works. The greatest achievement is the building and setting to work of sufficient blast furnaces and side blown Bessemer converters distributed over every province to produce in one year 20 million tons of cast iron and 10 million tons of steel, all made from local supplies of ore and coal. At this rate, British iron and steel production will be surpassed in far less time than the fifteen years that had previously been estimated. All the native ingenuity of thousands of years of Chinese civilization is now being liberated and turned to the solving of immediate problems by improvised machinery, in advance of the arrival of factory-produced machines and professionally trained engineers.

Much of this home-made machinery is being used to speed the tasks of agriculture—in ploughing and harvesting, and above all in irrigation. In three years it should be possible to bring water to 80 per cent of China's cultivable land. Already the new drive is paying dividends. This year's winter wheat crop, at 32 million tons, is half as much again as last year's, despite unfavourable weather. China has thus overtaken the United States and is now the second largest wheat producer of the world.

Such achievements, good in themselves, are a better augury of the

possibility that exists for all underdeveloped countries to raise their standards of living at a rate far greater than anyone had thought possible. It would appear, however, that the essential pre-condition is the activity of a popular government so trusted in giving a lead so that, for the first time in history, the people themselves are able and willing to use all their strength, intelligence and initiative.

It is on such a positive example that we must rely to deal with the accelerated growth of world population revealed by the careful studies of demographers in their report to the United Nations, *The Future Growth of World Population 1958*. They have shown that owing to the continuous increase of the rate of growth of population, the estimates made as recently as 1954 (Fig. 2, pp. 64 f.) are already shown to be too low and that by the year 2,000 a world population of between 5,000 and 7,000 million may be expected. The spread of birth control is unlikely to affect these numbers in the time, and the stable population is more likely to be 10,000 million than the 7,000 or 8,000 million previously anticipated.

Though, according to arguments already given, there should be no insuperable difficulty in feeding such a population, the fact that these numbers will be so soon with us should be a warning. There is little time left for stopping the waste of the world's resources and manpower in preparing for war. We must get down seriously to the task of making sure that such an abundance of people should not starve, but should be able to live abundantly.

10th July, 1958

P. P. S.

In the few weeks since these paragraphs were written great events have indeed happened and are still occurring. The revolution in Iraq set going just that train of action and counter-action which for some critical days threatened to spread into a limited and then into a general nuclear war. But, for the moment, the reaction has been stopped, largely by the resolute and at the same time conciliatory attitude of the Soviet Union. The Summit Meeting so long put off, now seems imminent. The reader will know whether it met and how it succeeded.

Yet over and above the excitement of these immediate events, they seem, at least to me, to be the signs of far more important changes. Perhaps a turning point in human affairs has been reached and safely passed. At last it may have been realized, even by the governments of major powers, that full-scale nuclear war is outside the range of possible policy. Events in the Middle East have shown further, however, that even the stages of limited conventional warfare and still more of limited nuclear warfare are too dangerous to embark on. We may hope that the first step actually taken along this road, the traditional show of force in the pointless occupation of Lebanon and Jordan, may prove abortive and the last effort of its kind. Despite all the tensions and embitterment this sharp lesson may prove that the Cold War cannot be maintained in its old form as a continual threat of hostilities. Peace and international law may have been shown to be not only desirable ends but absolute necessities for the maintainence of human life on this earth.

With that lesson comes another of more positive portent. The revolutionaries of Iraq have shown to the world that indirect as well as direct colonial rule no longer has any place in the modern world. Henceforth, within the limits of their power, the wealth of their country—one of the richest oil fields of the world—is to be used for the benefit of the people, and not of foreign investors or royal families. This does not mean that the industrial countries will be deprived of the oil, or even that they will have to pay more for it; indeed, the price may well go down. But it does mean that they will get only the oil and not the profits on it, which can now be used for financing industrialization and intensive agriculture in the country of its origin.

The example of the Iraqi revolution, and even more of the failure to suppress it, will spread. We may expect the process of liberation of colonial territories to move faster than ever and to reach completion well within a generation. This will only be just in time to cope with the problems of feeding a population of 10,000 millions.

1st August, 1958

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INDEX

Ability, *see* human ability.
Academy of Science, 89.
Academia Sinica, 192.
Administration, 54 ff., 203, 259, 270
  See also planning.
Advisory Council on Scientific Policy, 199.
Afghanistan, 240.
Africa, 127, 239, 246, 251, 283, 288.
  education, 190.
  energy consumption, 50.
  food, 64, 70.
  housing, 32.
  industrialization, 147, 244.
  land use, 69, 77, 79.
agricultural co-operation, 82, 132.
  productivity, 61 f, 77, 169.
  Revolution, 61, 82, 182 ff.
  surpluses, 70, 77, 120, 146, 234, 236 *n.*
agriculture, Chapter V.
  and chemistry, 45.
  greenhouse, 71.
  and industry, 132.
  mechanization of, 50, 70, 77, 130, 169.
  plantation, 78, 82, 109, 239, 273.
  and science, 77.
  subsistence, 61, 72, 78.
  See also under names of individual countries.
aircraft, 131 f.
  military, 22, 139, 151 f, 165.
  research, 20.
Algae, 79, 273.
Algeria, 205, 233, 239, 288.
aluminium, 43, 126, 131.
amino-acids, 75 f., 94, 274.
Anglo-Iranian Oil Company, 238.
Anshan, 124.
antibiotics, 83, 95, 97 f., 153, 226.
anti-communism, 210, 212, 215, 218, 220.
architecture, 168
armaments,
  production, 139, 142, 146, 286.
  profits, 3, 148, 151, 215 f.
  race, 20, 216, 230, 243, 250.
Armenia, 123 *n.*
arms race.
  See armaments.
Arms Race, The, 220 *n.*
Arnott, D. G., 166 *n.*
Asia, 105, 113, 239, 246, 283, 288.
  Central, 112, 123.
  energy consumption, 50.
  food, 64, 274.
  housing, 32.
  industrialization, 120, 147, 237.
  land use, 69, 77.
  See also names of individual countries.
Aswan Dam, 124 f., 237.
atomic bomb, 7 f. 10, 15 ff., 164, 214.
  See also nuclear weapons.
atomic energy.
  See nuclear energy.
Australia.
  natives, 18.
automation, 4, 36, 42, 51–59 *passim*, 93, 138, 143, 152, 154, 258, 260, 270, 276.
  and administration, 55 ff.
  and agriculture, 36.
  and redundancy, 58, 182 ff.
Azerbaijan, 123 *n.*
Bacon, Sir F., 86.
bacteria, 97, 259, 273 f.
Baghdad Pact, 16, 212, 237.
Baker, J. F., 43.
Baku, 123 *n.*
ballistic missiles, ix, 1, 7 f., 24, 84, 138 f., 150 ff., 205, 230, 283.
  bases, 1, 151, 164, 285.
  intercontinental, 8 f., 12, 23, 151, 262.
  ranges, 18.
  United Kingdom, 20.
Bandung Conference, 208.
Barlow Committee, 199.
Belgium, 128 f., 130, 229.
Bernal, J. D., 90 *n.*, 91 *n.*, 204 *n.*, 279 *n.*
Bernard, C., 97.
biochemistry, 92, 94 f., 97, 273 f.
biological needs, 30 ff.
biology, 93, 274.
birth-control, 66, 78, 101, 226, 260, 272.
Blackett, P. M. S., 16 *n.*, 91, 114.
blocs, *see* military blocs.
Bolivia, 133, 240.
Boyd-Orr, Lord, 258.
brain.
  See human brain.
Brazil, 71, 125, 229, 240.
Britain
  See United Kingdom.
British
  Commonwealth, 112 f.
  Empire, 113, 156 f., 170.
  Association for the Advancement of Science, 114.
British Economic Policy Since the War, 160 *n.*
British Peace Committee, 176 *n.*
Brown, H., 76 *n.*, 273 *n.*
building
  industry, 44 f.
  materials, 43 f.
  mechanization, 45.
  prefabrication, 45, 168.
bureaucracy, 56.
Burma, 131, 136, 240.

Calder Hall, 22, 167.
  See also nuclear energy.
calorie intake, 28, 64, 258.
Campaign for Nuclear Disarmament, 176 *n.*
cancer, 95, 226.
  bone, 18.
  lung, 100.
capital
  export of, 108 f., 114, 243.
  formation, 111 f., 144, 160, 231, 246.
  goods, 108 f., 111, 121, 124, 126, 145, 147, 153.,
  investment, 4 f., 109 f., 115, 119 f., 123, 124 f., 141 f., 144, 147 f., 223, 230, 243, 256, 258.
capitalism, 25, 110 f., 125, 133 f., 207, 223 f., 253. 291.
  crises of, 5, 139, 141 f., 149, 184, 233, 293 f.
capitalist countries,
  economic aid from, 112, 239, 243, 291.
  industrial production, 143.
  military expenditure, 150.
  surplus production, 111.
carbohydrates, 94, 274.
Cardwell, D. S. L., 179 *n.*
"Carte Blanche" exercise, 15.

cell, living, 95
cellulose, 80.
cement, 44.
centrifugal governor, 51.
Ceylon, 70, 131.
chemical industry, 34, 45, 126, 149.
chemistry,
  synthetic, 94, 274.
  See also under food, fibres.
Chesterton, G. K., 92.
Childe, V. G., 279.
Chile, 133, 229.
China,
  agriculture, 61 ff., 66 f., 73 ff., 77, 82, 132.
  birth control, 66, 78.
  Communist Party, 237.
  economic aid, 240.
  economic development, 109, 140, 288, 294.
  education, 5, 177, 181, 191.
  energy use, 107.
  geological surveys, 117.
  health, 97.
  industrialization, 27, 38, 105, 108, 121, 145, 182 *n.*, 216, 232, 236.
  irrigation, 73, 116.
  land use, 77.
  literacy campaign, 181, 189 f.
  military expenditure, 21.
  natural resources, 113 f., 117 f., 236.
  population, 61, 66, 78, 236.
  scientific manpower, 185.
  Soviet aid, 78, 112, 123 f., 237, 239 f.
  standard of living, 216.
  steel industry, 107, 116, 124, 294.
  trade embargo, 22 f., 153, 171.
cholera, 97.
chromatography, 94.
Churchill, Sir W. S., 212.
civilization, 183.
  destruction of, x, 1, 6, 8, 11,
  and energy supply, 46.
  scientific, 33 f.
class,
  social classes, 6, 27, 175, 188, 193 ff., 207, 235, 253.
clerical workers, 55, 182.
climate, control of, 74, 276, 280.
clothing, 32, 271.
coal, 42, 117, 126, 158 f., 160.
  energy, 35.
  fields, 47.
  reserves, 118, 130, 256.
Cockroft, Sir J., 167.
co-existence, x, 146, 209, 222 f., 262, 290.
Cold War, 206–24, *passim.*
  advocates of, 220 ff.
  casualties of, 217.
  consequences of, ix, f., 3, 19, 22 f., 101, 125 f., 146, 208 ff., 213, 221, 231.
  continuation, 211, 217 f., 225, 230 f., 232, 261.
  cost of, 20.
  objectives of, 121, 153, 171 f.
  origins, 207 f.
  truce in, 225, 230 f., 242, 244, 250 ff., 261, 291.
Colombo Plan, 114 f.
Colonial Development Fund, 112 f.
colonialism, 135 f., 141, 178, 231, 238 f.
Comenius, 178 f., 197 .
common markets, 134.
communication, 54, 56, 95 f.
communism, 212, 214, 216, 223, 290.
competition
  See economic competition.
computors
  See electronic computors.
Congo, 127.
Conservative Government, 156, 160, 165.
construction, x, 1, 38, 217, 256 ff., 287.
consumer goods, 112 f., 124, 136, 146, 235
conventional weapons, 15, 18, 150, 164.
co-operation
  See international co-operation.
copper, 42, 133.
Corbusier, 270.
creative thinking, 52, 93, 184, 202 f.
Crisis of Britain and the British Empire, The 113 *n.*
culture, 281.
Current Digest on Atomic Danger, 19 *n.*
Czechoslovakia, 131, 236 n, 240.

Darwin, Sir C., 271.
death, 278 f.
decentralisation, 131, 254.
Denmark, 68, 99, 130.
deserts, 66, 70, 113, 276.
deterrence, 143, 207, 219, 220.
  policy of, ix, 16, 18, 23, 164, 176.
development, unevenness of, 27, 66, 106, 139 f.
Dien Bien Phu, 16.
diet, 74 f., 76 f., 274.
  minimal, 31.
disarmament,
  agreement, 152, 211, 230, 242 ff., 250, 286.
  Anglo-French Plan (1954), 23, 219.
  consequences, 151 f., 171, 222 f., 287.
  conventional, 23, 150, 219, 286.
  negotiations, 23, 150.
  nuclear, 176, 219 f.
  and redundancy, 215
disease, 75, 99 ff., 259 f., 265.
  infectious, 32, 97, 278.
disengagement, 24, 222 f.
doctors
  See physicians.
drugs, 95, 98 f., 100.
Dulles, J. F., 14, 16, 19, 24, 218, 221.
Dutt, R. P., 113 *n.*

earth satellites, 84, 102, 179, 188, 233, 268.
E.C.E., 252.
economic aid, 4 f., 109–37 *passim*, 238 ff.
  capitalist, 121 f.
  socialist, 123 f., 240.
  See also under names of individual countries.
economic,
  competition, 223, 242.
  co-operation, 227, 251 ff., 255.
  See also international co-operation.
  depression, 38, 58, 141 f., 147 f., 293 f.
  exploitation, 106, 113 f., 133, 141, 288.
  regions, 255.
  systems, 3.
economics, 104 f.
education,
  adult, 270.
  flowsheet, 179 f.
  higher, 187.
  in industrial countries, x.
  medieval, 178.
  and scientific research
  Chapter X, 201.
  technical, 179.
  See also under names of individual countries.
Egypt, 46, 51, 136, 209, 223, 243, 246, 288.
  See also United Arab Republic.
Eisenhower, President, 153, 211, 242 *n.*, 259 *n.*, 287 *n.*
  doctrine, 113, 239.
  open skies plan, 24.
electric power, 127.
electroencephalograph, 96.
electronic
  computors, 51, 55 ff., 93, 96, 255, 277, 280n.
  control, 51 f., 56, 84, 152.
electronics, 92, 266.
  industry, 126, 135, 157.
electron microscope, 94.
eleven-plus examination, 193 ff.
embargoes, *see* trade embargoes.
energy, 35, 42, 46–51 *passim.*
  conservation of, 86.
  consumption per head, 28, 50, 107.
  saving, 44, 50.
  waste, 44, 50.
  See also nuclear energy, solar energy.

engineering, *see* industry engineering.
enzymes, 95.
Europe, 130 f.
  Eastern, 115, 131, 207, 212, 236.
  Western, 233.
  See also NATO.
exploitation,
  colonial, 105 f., 112 f.
  See also Economic exploitation, resources.

Fall Out, 19 *n.*
fall out,
  See radiation.
famine, 37, 83, 86, 100, 259.
  See also starvation.
F.A.O., 252, 258.
Federal Germany,
  economy, 246.
  energy use, 107.
  industrial employment, 158.
  military expenditure, 215.
  natural resources, 118.
  nuclear weapons, 15 f., 19.
  scientific manpower, 185.
  steel use, 107.
fermentation, 95.
ferro-electrics, 93.
fertilizers, 71 ff., 76, 81 f., 119, 121, 126, 131, 258 f.
  used, 28.
feudal economy, 33 f.
fibres,
  artificial, 32, 45, 126, 242 n.
  natural, 32, 271.
fisheries, 79.
food, Chapter V,
  cattle, 80f., 110.
  chemical synthesis of, 94, 170, 273 ff.
  and population, 31, 61–82 *passim*, 75, 101 271–6 *passim*.
  production, 61–82, *passim*, 170, 258, 274 ff.
  values, 75 f.
  forest products, 80.
France,
  economy, 141, 246.
  energy use, 107.
  foreign aid, 240.
  land use, 68.
  lycées, 178.
  military expenditure, 21, 215.
  natural resources, 118.
  nuclear energy, 48.
  nuclear weapons, 19.
  scientific manpower, 185.
  steel, 107, 127 ff.
"Free World," 135, 144, 208, 212, 222, 239 ff, 262, 290.
Freedom of Necessity, The, 91 *n.*, 162 *n.*
Friend's Peace Committee, 176 *n.*
Fuel
  See resources, coal, oil.
Fulton speech, 212.
fungi, 75, 273 f.

genetic dangers, 8, 18.
genius, 201 f.
geology, 117, 256.
Georgia, 123 *n.*
German Democratic Republic, 236 *n.*, 240.
Germany, 127 ff., 250.
  education, 178, 181.
  unification, 218 *n.*, 242.
  See also Federal Germany, German Democratic Republic.
Ghana, 113, 136, 239.
gold, 42 f.
Grass, 74.
Great deterrent, 3,
  See also deterrence.
Greece, 9.
Greek,
  poetry, 267.
  science, 51.
groundnuts, 70.
Guernsey, 71 *n.*

handicraft, 119, 127, 123 f., 161.
Hannibal, 8.
Harwell, 22, 166.
  See also nuclear energy.
health, 5, 31 f., 97 ff.
  See also under names of individual countries.
Hereditary Genius, 202.
Hill, A. V., 32 *n.*
Hiroshima, x, 7, 11, 15, 19 *n.*
Hitler, 7 f., 115, 120, 145, 233.
Hoover, President, 142.
housing, 32, 44 f., 121.
Huai river barrage, 116.
human,
  ability, 4, 33, 177, 253.
  brain, 93, 96, 277, 279.
  needs, 25, 29 ff., 64.
  resources, 2, 37 f., 86, 102 f., 108, 177, 236, 256.
  welfare, 36, 188, 250.
humanities, 197, 267 f.
Hungary, 120, 131, 213, 236, 240.
Hutton, G., 34 *n.*
hydrogen bomb, ix, 1, 7–24 *passim*, 151, 164, 214, 262, 285 f.
  See also nuclear weapons.

imperialism, 109, 207, 215, 233, 290.
India, 28, 161.
  agriculture, 61 ff., 68, 70 f., 78, 82, 134.
  economic aid, 240.
  economic development, 71, 109, 122, 139 f., 288.
  five year plans, 71, 78, 117 ff., 139, 227, 243.
  health, 98 f.
  independence, 133, 136, 239.
  industrialization, 105, 116, 119, 124, 216, 223, 229, 232, 237.
  literacy, 177, 190 f.
  military expenditure, 20 f., 115.
  natural resources, 118, 125.
  science in, 192.
  scientific manpower, 185.
  steel, 122 *n.*, 124.
  Soviet aid, 98, 112, 124.
  U.S. loans, 20, 70.
Indonesia, 105, 127, 136, 209, 237, 240, 243, 251.
industrial centres,
  existing, 51, 109, 117, 126 f., 165 ff., 247.
  new, 51, 126 f., 130 f., 149, 229, 244, 247, 256 f.
industrial production, 139 f.
  See also under names of individual countries.
Industrial Revolution,
  First, 25, 35 f., 41, 45, 82, 154, 156, 160, 167 f., 182 ff., 227, 284.
  Second, 41, 45, 138, 145, 154, 182 ff., 231, 269, 284, 287, 292.
industrialization, 101, 116 f., 123 ff., 134, 146, 150, 153, 191 f., 229 ff., 237, 257.
  See also under under-developed countries *and under names of individual countries.*
industry, Chapter IV,
  chemical, 40. 126,
  construction, 40.
  engineering, 40, 53 f., 126, 157, 235 f.
  nationalization, 122.
  transformative, 40.
  See also under names of individual countries.
Industry and Society, 174 *n.*
Inquiry into the Nature and Causes of the Wealth of Nations, 174.
international co-operation, 3, 176, 223, 226, 230, 242 *n.*, 243, 251 ff., 255, 261, 286, 290.
Inter-services Mud Committee, 85.
investment,
  See capital investment
  and also under names of individual countries.
Iran, 179 f., 238.
Iraq, 296.
iron, 42, 118.
  See also steel.

irrigation, 49, 71, 73, 82, 119, 273.
See also under names of individual countries.
Ismay, Lord, 219 *n.*
Israel, 240, 242.
Italy, 130.

James, W., 287.
Japan,
agriculture, 61 ff., 73.
economy, 27 f., 126.
energy use, 107.
industrialization, 116, 121, 148.
natural resources, 118.
population, 78.
scientific manpower, 185.
steel, 107, 127 ff.
Japanese fishermen, 18.
Java, 78.
Jordan, 240, 296.

Kadar government, 213.
Kazakhstan, 72.
Kennan, G. F., 211, 213.
Kenya, 190, 239.
Keynes, M., 139.
Khrushchev, N. I., 17, 72, 145 *n.*, 153, 209, 219, 235, 242 *n.*
Kissinger, H. A., 13, 17.
Korea, 16, 110, 209, 232, 237, 239 f. 242.

labour, 114, 266.
Labour Government, 156, 250.
Labour Party, 156, 160, 171 *n.*, 174, 176.
Lancashire, 161.
land use, 66 ff., 70 f., 127, 169 f., 244, 249.
See also under names of individual countries.
language, 279 f., 280 *n.*
Laos, 240, 251.
Latin America, 126, 127, 222, 238, 246, 251, 288.
energy consumption, 50.
food, 64.
industrialization, 121, 147, 244.
land use, 79.
Latter, A. L., 19 *n.*
leaf protein, 74, 76, 170.
Lebanon, 296.
leisure, 266 f.
Lenin, V. I., 192, 213 f.
leukaemia, 11, 18.
liberation movements,
See national independence.
Libya, 240.
life,
origin of, 95, 280.
expectation of, 26, 217, 278 f.
lignin, 80.
limited nuclear war,
See nuclear warfare.
literacy, 178, 181, 189 ff.
literature, 268.
loans, 110–37 *passim*, 147, 223, 242.
See also under names of individual countries.
London Transport, 56.
longevity, 86, 101, 278 f.
Lyons, J., Ltd., 55.
lysine, 76.

McCarthyism, 210.
machine tools, 161.
machinery, 35 f., 52 f., 147.
See also agriculture, mechanization of.
Magnalia Naturae, 86 *n.*
magnet, 92 f.
Mahalanobis, P. C., 71, 119.
maize, 62, 74.
malaria, 100, 259.
Malaya, 112, 115, 133, 205, 239, 288.
Malthus, T. R., 67.
theory of, 64, 67, 81.
manufacture, 40.
Marshall Aid, 163.
Marx, K., 105, 214.
mass production, 51, 53, 135, 149 f.
Meaney, G., 150 *n.*
measles, 97.
meat,
consumption, 63, 76.
production, 62, 74 f.
See also food.
medical research, 99 f.
medicine, 97, 99 ff.
Meier, R. L., 273.
Mendelssohn, K., 179 *n.*
metallurgical industry, 94.
methionine, 76, 274.
Mexico, 191, 229.
Middle East, 127, 246, 251, 296.
and limited war, 16.
oil, 16, 109 f., 126, 133, 162, 172, 237
standard of living, 133.
military,
aid, 110, 115.
blocs, 19, 24, 208 ff. ,251.
See also Baghdad Pact, N.A.T.O., S.E.A.T.O., Warsaw Pact.
changeover, 150 ff.
expenditure, 20 f., 111 f., 148, 150, 188 f., 230 246.
production, 110.
See also under names of individual countries.
research, secrecy 22, 101 f.
militarization, 138 f., 141.
Mills, C. W., 194 *n.*
mining, 40.
money, 56.
Mongolian People's Republic, 239 f.
monopolies, 135, 143, 147, 215.
Morocco, 191, 240
Moscow Piston Factory, 57.
motor-cars, 28, 45, 52 ff., 110, 135, 143, 255.
music, 268.

nagana, 75.
Nagasaki, 7, 15, 19 *n.*
Napoleon, 14.
Nasser, President, 117.
National Health Service,
See under United Kingdom.
national income, 246.
See also under names of individual countries.
national independence, 122, 133, 136, 339, 141, 156, 208, 237, 241, 288.
See also under names of individual countries.
nationalization, 117, 122, 136, 158 f., 165, 168, 174 f.
See also under United Kingdom
N.A.T.O., 15 f., 18, 21, 156, 212, 218 ff., 239, 293.
NATO, The First Five Years, 219 *n.*
natural resources, ix, 2, 4, 30, 34, 37, 42 f., 102 f., 113, 118, 125 f., 133, 177, 206, 256.
See also coal, oil.
Neal, B. G., 43.
Nef, J. U., 17 *n.*
"negotiation from strength," 18, 207, 212.
Nehru, J., 210.
nervous system, 96.
Netherlands, 130, 179.
New Zealand, 76.
Next Hundred Years, The, 76 *n.*, 272.
Next Million Years, The, 271 f.
nineteenth century,
civilization, 105.
technology, 29.
nitrogen fertilizers, 72, 76.
Noel-Baker, P., 220 *n.*
Nova Scotia, 70.
nuclear energy, 4, 35, 42 f., 46–51 *passim*, 92, 94, 127, 135, 138, 229, 256, 270, 272 f.
and agriculture, 47, 70 f., 272 f.
Calder Hall, 22, 167.
Geneva Conference on Peaceful Uses (1955), 22.
research, 167.
Zeta, 22, 167.
See also under names of individual countries.
nuclear science, 22, 92.
nuclear warfare, 2 f., Chapter II, 144, 176, 206 ff., 215, 230, 242, 262.
limited, 3, 13 ff., 232.

nuclear weapons, Chapter II, 139, 214, 218 f., 291.
abolition, 242.
"clean," 14, 17, 19.
tests, 8, 18 f., 23, 211, 214, 220.
See also hydrogen bomb, nuclear warfare.
Nuclear Weapons and Foreign Policy, 13 f.
nucleic acids, 95.
nutrition, 31.
nylon, 43, 45, 94, 274.

occupations,
present, 34 f., 182 f., 269 f.
flowsheet, 182 f., 200.
future, 182. 200, 203, 261.
O.E.E.C., 252.
oil,
concessions, 109 f., 126, 133 f., 237.
energy from, 35, 46 f., 50 f.
investment in, 112, 125, 296.
supplies, 46, 50, 109, 118, 166, 256.
waste, of, 113.
See also Middle East oil.
Old Stone Age, 83, 86, 228, 279, 280 *n.*
On Limiting Atomic War, 14.
Oparin, A. I., 95 *n.*
Organization Man, The, 194 *n.*
Organization of Science in England, 179 *n.*
Origin of Life on the Earth, The, 95 *n.*
Our Nuclear Adventure, 166 *n.*
Our Nuclear Future, 19*n.*

Pacific islanders, 18.
Pakistan, 237, 240.
military expenditure, 20, 115.
Panchashila, 208.
Pasteur, L., 97, 99.
peaceful coexistence,
See Coexistence.
Peaceful Coexistence, 214 *n.*.
peaceful co-operation.
See international co-operation.
Peace Pledge Union, 176 *n.*
penicillin, 97.
Peru, 133.
pestilence, 32, 37.
See also disease.
pests, 75, 260.
Peterson, M. L., 74 *n.*
phosphate fertilizer, 72.
physicians, 26, 28, 97 ff.
physics, 91ff.
solid state, 92 f.
piezo-electricity, 93.
Pirie, A., 19 *n.*
Pirie, N. W., 76.
Plan for Engineering, 175 n.
plankton, 79.
planning, 117 ff., 135, 145, 152, 226 ff., 231, 255, 284.
flexibility in, 29, 132.
for human welfare, 25, 29 ff., 267.
international, 30, 134, 227 f, 251, 253 f.
socialist, 117, 145.
State, 227.
plant breeding, 74.
plastics, 45, 92, 94, 126, 242n.
"Point Four" Programme, 114.
Poland, 120, 131, 212, 236, 240.
poliomyelitis, 97.
polymers, 45.
See also fibres.
polythene, 43, 94.
popular forces, 38, 285.
population, Chapter V, 246.
density, 101, 256, 275.
future, 64 ff., 80.
growth, 31, 36, 61, 75, 82, 97, 101, 115, 260 f., 272, 277, 295.
supportable, 1 f., 71, 81, 272 f.
world, 64 f, 295
See also food and population.
potash fertilizer, 72.
potatoes, 62, 110.
poverty, 82, 265.
Power Elite, The, 194 *n.*
production,
per kilowatt hour, 34.
per man hour, 34, 140.
productive capacity, ix, 5, 148, 234, 243.
See also under names of individual countries.
productivity, 34, 140.
world, 37.
profits, 25, 34, 38, 86, 104, 109 f., 112 f., 115, 122, 133, 141, 143 f., 147 f., 174, 203, 223, 245, 290.
proteins, 46, 273 ff.
animal, 75.
vegetable, 74, 76, 80, 170.
providence, 27 ff.
psychology, 38, 96, 202 f.
industrial, 97.

radiation,
atmospheric contamination, 8, 13, 285.
hazards, 9–19 *passim*, 286.
sickness, 13, 15.
radioactivity,
See radiation.
railways, 29, 44., 54 f., 59, 132.
Rapacki plan, 24.
raw materials, 105 ff., 109, 113, 132, 135, 142, 147, 169, 172.
Renaissance, the, 178.
research, Chapter X.
See also, medical, military, nuclear, scientific research.
resources, 3, 5 f., 37, 104 ff., 117, 177, 205, 227.
See also fuel, human, natural.
Reston, J., 209, 216 *n.*
restriction, 156, 159, 165.
Rhodesia, 127.
rice, 62, 74.
See also food.
roads, 44, 55, 131 f.
rockets,
See ballistic missiles.
Rome, 46.
Roosevelt, President, 125, 149, 176, 235, 250.
Rothamsted, 76.
Rothstein, A., 214 *n.*
Royal Institute of International Affairs, 14.
rubber, 43, 78, 133.
Rumania, 236, 240.
Russell, Earl, 210.
Russell, Sir E. J., 169 *n.*
Russia, the Atom and the West, 211 *n.*

Sahara, 70, 113.
Sartre, J.-P., 210, 262 *n.*
Saunders-Roe, fighter, 165.
schools,
curriculum, 195, 197 f.
grammar, 194 f.
public, 194.
secondary modern, 193 f.
teachers, 189, 196, 200 f.
science,
advancement of, Chapter VI, 286.
and agriculture, 77, 276.
applied, 2, 84, 88 ,97.
and the arts, 267 f.
and civilization, 33 f., 178, 204.
financing of, 89, 163.
freedom of, 90.
fundamental, 85, 87, 268.
history of 86, 89.
for human welfare, ix, 2, 4, 25, 36, 97, 101, 206 Chapter XIII,
and industry, 161.
international co-operation in, 22, 152, 192.
military expenditure, 20, 163.
militarization, 4, 139, 163, 234.
organization of, 88 ff., 203 f.
secrecy in, 22, 90 f., 101, 152, 230.
and society, 86, 102, 178, 182, 204.
strategy of, 85, 90 f.
and technology, 87, 100.
in underdeveloped countries, 192.

science, (*contd.*)
utilization of, x, 2, 204, 266, 283.
and war, 17, 283.
See also scientific research.
Science and Economic Development, 273 *n.*
Science in History, 86 *n*, 91 *n.*, 97 *n.*, 202 *n.*, 206 *n.*
scientific,
discovery, 4, 87, 91, 178, 226.
education, 178, 236.
exchanges, 101.
industrial revolution, 105, 138, 269.
information, 90, 203.
personnel, 260.
scientific research, 36, 83, 102, 203.
agricultural, 169.
and development, 84, 163, 186.
efficiency of, 90, 203 f.
expenditure on, 168, 268.
fundamental, 85, 87 ff., 268.
governmental, 163, 203 f.
industrial, 89, 203 f.
military, 89, 163, 186, 226.
operational, 186.
and technology, 83 f.
university, 89.
on waste materials, 81.
Scientific Revolution, 37, 121, 235.
See also Industrial Revolution, Second.
scientists, 192, 204.
against nuclear tests, 19.
numbers of, 36, 88, 102, 184 ff., 199 ff.
responsibilities of, 204, 292.
supply of, 119, 260, 287.
Scotland, 170, 179, 276.
S.E.A.T.O., 16, 237.
semi-conductors, 92 f.
Shaw, G. B., 199.
Sheen, Monsignor, 287 n.
shelters, 12 f., 151.
ship, 29, 84.
Shonfield, A., 160 *n.*, 162 *n.*, 165 *n.*, 173 *n.*
skill, 45.
slump. *See* economic depression.
Smith, Adam, 174.
Social Function of Science, The, 204 *n.*
socialism, 116 f., 207, 251, 290.
Socialist Countries,
capital formation, 144.
economic aid from, 108, 112, 237, 240, 291.
housing, 32.
industrialization, x, 144 ff.
military expenditure, 150.
science, 89, 102, 145, 286 f.
trade with, 171 f.
See also under names of individual countries.
social science, 96 f.
Society and Knowledge, 279 *n.*
soil,
conservation, 72 ff., 77 f.
erosion, 72 f.
solar energy, 46 *n.*, 79 f., 273.
South Africa, 122.
See also Africa.
South America.
See Latin America.
South East Asia, 114.
See also Asia.
Soviet Union,
agriculture, 61 ff., 67, 70, 73, 82.
armed forces, 213 f., 219.
automation, 52, 57 f., 235.
Central Asian Republics, 112, 123, 131, 229 *n.*
Communist Party, 213 *n.*, 226 f.
decentralization, 131, 254, 259.
earth satellites, 179, 188, 234.
economic aid, 78, 223, 238 ff., 243, 246.
economy, 27 f., 105 f., 115, 123 f., 214, 246.
education, 38, 177, 179 ff., 187 f.
energy use, 107.
five year plans, 145, 226 f., 237.
geological surveys, 117.
industry, 108, 121, 126, 145, 226, 235.
military expenditure, 21, 188, 216, 235, 246.
military technology, 18, 236.
new land, 70, 72.
nuclear energy, 22, 48, 235.
planning, 117, 149 f., 226.
plastics industry, 153, 242 *n.*
scientific organization, 89 f., 286 f.
scientists, 185 f.
standard of living, 26, 216.
steel, 28, 107, 127 ff.
trade embargo, 22 f., 171.
wars of intervention, 108, 214 *n.*
space travel, 277.
speech, 279.
sputniks,
See earth satellites.
standard of living, ix, 2, 5, 25 ff., 37, 106, 112 124, 136 f., 146, 205 f., 231, 241, 245, 258, 284, 287.
See also under names of individual countries
starvation, 30 f., 32 f., 82, 278, 288.
Stassen, H., 211.
steel,
and building, 43 f.
industry, 41, 117, 126 ff., 131, 147, 150.
production, 28, 107, 119.
See also under names of individual countries.
Stein, M. J., 202 *n.*
Sterling bloc, 112.
strontium-90, 18 f.
Suez, 124, 164, 176.
sugar, 76, 78, 95, 274.
production, 62, 80.
suicide,
mass, 2, 9, 19, 176, 215.
Summit Meeting, 218, 220 f., 293, 296.
SUNFED, 115 .
surplus production, 110, 144.
surveys, 111, 117.
survival curves, 98, 278.
Sweden, 130, 156, 179.
and nuclear weapons, 19.
Switzerland, 130 f.

Taiwan, 240.
Tata, J., 122 *n.*, 124.
technology, 146.
See also science and technology.
telegraph, 93.
Teller, E., 13, 19.
Tennessee Valley Authority, 149.
Tiflis, 123 *n.*
tin, 42, 133.
tracers, 92.
trade, 135, 170, 230.
East-West, 22 f.
embargo, 22 f., 134 f., 153, 171 f., 216, 230, 236, 241 f.,
State, 135.
Transcaucasia, 112, 123, 229 *n*
transistor, 92.
transport, 131 f., 257.
of goods, 54 f.
motor, 29, 54 f.
See also motor-cars.
Truman, President, 287 *n.*
tryptophane, 76.
tsetse fly, 75.
tuberculosis, 99 f.
Tunisia, 136, 240.
typhus, 97.

underdeveloped countries,
agriculture, 67.
aid to, 111 f., 114 f., 223, 230, 239 f., 242, 244 ff., 287 *n.*
and arms race, 20.
industrialization of, 59 f., 106, 113–37 *pa ssim*, 143, 147, 153 f., 191, 229, 244 f., 250, 262, 287 f.
investment in, 109 f., 115, 124.
needs, 108, 181, 189.
population growth, 34.
problems of, 126, 132, 135.

undeveloped countries (*contd.*)
purchasing power, 148.
standards of living, 25 f., 124, 134, 217, 233.
technical resources, 119.
upsurge of, 138, 290, 296.
unemployment, 58, 122, 141 f., 184, 234.
See also under names of individual countries.
UNESCO, 181 *n.*, 191.
United Arab Republic, 237, 240.
United Kingdom, Chapter IX,
agriculture, 67 f, 156, 169 f.
aircraft industry, 165, 167.
automation, 150, 168, 235.
capital formation, 160, 171 *n* 246.
building industry, 43 ff., 168.
capital investment, 160, 165.
coal, 44, 55, 158, 166.
economy, 140 f, 155–76 *passim*, 246.
economic restriction, 159 f., 165.
education, 162, 173, 178 ff., 187 ff., 193 ff.
Education Act (1944), 193 f., 198.
electric power, 158, 166.
electronics industry, 157, 159.
energy use, 107.
establishment, 160.
industry, 6, 121, 126, 155–76 *passim*.
land use, 68.
military expenditure, 21, 155, 164 f., 171 *n.*, 173, 188, 215, 217.
military research, 20, 163.
monopoly, 159, 174.
National Health Service, 173.
national income, 160.
nationalization, 158, 160, 165, 168, 174 f.
natural resources, 118, 162.
in nineteenth century, 156.
nuclear energy, 48, 150, 157, 159, 166 f., 235.
and nuclear war, 13, 164, 175 f.
nuclear weapons, 164, 285.
productivity, 140, 157, 162.
scientific manpower, 88, 162, 185.
scientific research, 160, 163.
standard of living, 165, 169, 172 f.
steel, 28, 107, 127 ff., 159 f., 166.
textile industry, 167 f.
trade, 156, 159, 165, 170 f.
trade unions, 174 ff.
transport system, 168.
and underdeveloped countries, 6.
universities, 196.
U.S. investment, 161 f.
working class, 157, 175.
United Nations,
Association, 176 *n.*
Committee on Radiation Hazards, 19.
Disarmament Sub-Committee, 23, 219, 242.
General Assembly, 14.
Technical aid, 114.
World Population Conference (1954), 64 *n.*
See also ECE, FAO, SUNFED, UNESCO, WHO.
United States,
agriculture, 68 ff., 234.
aircraft industry, 20.
automation, 57, 234.
automobile industry, 67, 255.
Central Intelligence Agency, 216 *n.*
economy, 27 f., 106, 110 f., 139 ff., 156, 234 f., 246.
education, 179, 187 ff., 193, 196.
energy use, 107.
foreign aid, 13, 70, 110, 113, 122, 125 f., 161, 238 ff., 243, 246, 287 *n.*
military expenditure, 12 f., 21, 110, 188.
Mutual Security Administration, 216 *n*,, 238 f.
national income, 66, 106.
National Security Council, 216 *n.*
natural resources, 118.
nuclear energy, 48.
nutrition, 76.
oil interests, 238.
overseas investment, 109 f., 161 f., 243.
productive capacity, 234, 293.
Psychological Strategy Board, 216 *n.*
Red Indians, 141.
scientific manpower, 185.
scientific research, 89 f., 163.
slump, 141 f., 233 f., 293
standard of living, 25 f., 106, 111, 141, 216.
steel, 107, 111, 127 ff.
Stategic Bomber Command, 12.
surpluses, 110 f., 135.
waste, 37.
university, 181, 189, 196.
U.N.R.R.A., 70.
U.S.S.R., *See* Soviet Union.

Venezuela, 109.
Vico, G., 267.
Vietnam, 16, 232, 239 f., 289.
virus disease, 97, 226, 259.
vitamins, 75, 258.

war, 138, 144, 205.
and civilization, 1, 11.
cost of preparation, 19 f., 287.
effects of, 37.
and human nature, 282.
limited preparation, 2.
push-button, 8, 17, 283.
Second World, 7 f., 17, 120.
Third World, 205, 208, 232 f.
See also nuclear warfare.
War and Human Progress, 17 *n.*
Warsaw Pact, 213, 219.
waste,
of energy, 44, 50.
materials, 81.
of materials, 3, 34, 37, 43 f., 80, 111, 113.
of scientific experts, 22.
utilization of, 170.
of war preparation, 22, 111.
water, 42.
power, 35, 47, 118.
We too can prosper, 34 *n.*
Wheat, 62, 74, 110.
See also food.
W.H.O., 252.
Whyte, W. H., 194 *n.*
Wilkie, W., 251.
wood pulp, 46, 80, 111.
working class, *see* class.
working hours, 58.
World Assembly for Peace (1955), 210.
World Bank, 124.
World Council of Peace, 222.
World Federation of Scientific Workers, 203 *n.*
World, the Flesh and the Devil, the 279 *n.*
World Population and World Food Supplies, 169 *n.*
World Power Congress, 256.
World Survey of Education, 181 *n.*
Woytinsky, W. S., 130.
Wuhan bridge, 116.

Yalta Agreement, 212 f.
yaws, 100.
Yugoslavia, 236 *n.*

Zeta, 22, 48, 167.
See also nuclear energy.