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# PROSPECTS FOR THE FUTURE

by

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**N**o one of us is an expert on the future. We can only guess about it, and we can try, by extrapolating from the theories of development that we have observed in the past, to see where certain processes are moving in the future. The physicist Bridgeman once said, "The future is a program." That is to say, we can to some extent estimate the probability of future events from the deployment of forces in the present and in the recent past. But these patterns of deployment are changeable.

On the door of a well-known Swiss economist and friend of mine at the Institute of Technology in Zurich, you can read the inscription, "The future is not what it used to be." The future is changing when we begin to estimate how much energy, or oil, or coal we still have left. It is changing when we begin to figure out how much copper or how much gasoline would be required if everybody in the world would use as much as Americans do—in short, if that shift of the developing economies to economies of high mass consumption which we predicted so confidently in the middle 1950's really came to pass. We should certainly face severe shortages and increasing pollution. Will water still be fit to drink? Will the air still be fit to breathe? Will the oceans still produce food? Or will they be ruined by the results of our own ever-bigger industrial activities?

We would like to find out about these things, and in order to notice what the prospects in the world are, what the new revised estimates of the future might tell us, we might begin by saying how many people do we have? What will these people need?

## HOW MANY PEOPLE?

There are four billion people in the world today. According to the estimate of the United Nations, we will number seven billion by the end of the century. The growth rate of

population is roughly 2 percent per year. At this growth rate, population doubles every 35 years, and that means that roughly around 2010, there ought to be eight billion people in the world.

If we try to look at the future a little farther ahead, we might think in terms of three time horizons. Let us call the first 2010; that is roughly the year in which our college-age children will retire. Let us then take 2050, the time when our grandchildren will complete their professional careers and will retire. And, our grandchildren's children should still be of some interest to us, and that gives us the year 2100.

If we are now four billion people, then we can expect to number about eight billion in 2010, as already noted. The birth rate will not much change in the interim. It is very, very difficult to persuade hundreds of millions of villagers in Asia and Africa to change their habits of marital life. If we tell them that they should take a certain pill on a certain day of the month, it will turn out that many of them may not know what day of the month it is. Moreover, it will turn out that they don't have the pill and can't get it, and can't pay for it, and don't trust it anyway. What is more, they will know that when they're old they will need children to take care of them. They will also know that, at present mortality figures, quite possibly only half of their children will grow up. It would be emotionally intolerable for many parents to have only two children if they know at least one of them will die before growing up. There still is emotional safety and financial safety in numbers.

Eventually people will be able to think more carefully about the future, once they become convinced that they have a future—once they get far enough so they can say, as we say in the United States, that of a thousand children born, 975 will survive the first year, and that later attrition is also relatively small. Our life expectancy is now about 73 years for women, and in India it is now around 58 years. It used to be 40. Still, it takes quite a long time for the habits of people to change. For this reason, I assume that the growth rate will be 2 percent per year for the next 35 years.

Eventually however, medicine does do its work. Epidemics become rare; fewer children die; and as the parents notice that more and more children are staying around, the idea will spread that it might be better to have fewer children, get better acquainted with them, and do more for them. As this happens, quite possibly, the rate may change. It may be that we'll then have only a growth rate of 1 percent per year for the next 40 years, giving us about 12 billion people in 2050. Then, with a half-percent growth rate in the last half of the next century, we might arrive at 16 billion in the world in 2100. Then we might finally have that famous zero population growth which some people are so eager for. I don't think we can reach it sooner than that.

The habits of hundreds of millions of people are one of the greatest and most terrible forces in the world, and there is no way in which governments can easily change these habits in depth. We will eventually stabilize world population, but by the time we do that, we'll be 125 years in the future, and we will number some 16 billion. The world will then be about as crowded in population density as Switzerland is now, but Switzerland is a place in which one still can live. That is to say, we will probably be able to find a place to live; we will still be very far away from an earth, which some fanciful writers have pictured, where there will be only standing room. It will be still a world with room for human beings. We will, however, have other problems.

#### FOOD, ENERGY, AND CAPITAL

In 2010, we will have twice as many people. Now *producing* babies is a process that requires relatively little capital. But feeding babies is more expensive, and raising them to maturity, as parents know very well, costs quite a bit. But there's more. If we have to produce food for eight billion people, we will have to double food production, and there simply is not enough farmland in the world to double production. Most of the good land in the world is being used already. To be sure, our scientists can find high-yielding strains of wheat, of maize, of rice, as they have done, and with luck they may even, in

the next 35 years, get around to producing high-yielding strains of beans and legumes which enrich the soil rather than impoverishing it, but they haven't done that yet.

However, all of these high-yielding strains that we now have, the miracle strains of wheat and rice and corn, require more water, and they require much more fertilizer. That is to say that many countries will need what India seems to need already, invasions by armies of plumbers and more irrigation ditches, drain pipes, pumps, big barrages and dams, the whole tremendous technological and social infrastructure required for shifting from dry agriculture to irrigated agriculture. It can be done, but it will cost a lot of energy. The bulldozers take energy, and pipe-laying machines take energy, and the factories making the pipes take energy, and the pumps and their factories take energy, and so do the big dams and barrages.

We shall need more energy, but where will we get it? We can still increase energy production, but we have been riding the crest of a wave of cheap energy, namely, a wave of cheap oil. There isn't all that much cheap oil in the world. There's more than we think, probably. It is a strange coincidence of geophysics that most oil has been found until now in small countries with a monarchical form of government and of the Islamic religion. Eventually, if we really urgently need oil, we will somehow get around to discovering oil in the large, obstreperous countries that have governments likely to interfere in business, such as Brazil, India, Argentina, and so on. This will come. But even with some additional oil discoveries, it is a safe bet that it won't be easy.

Most of the new oil that we get will have to be obtained by drilling more deeply, or by going under the surface of the sea. Deep drilling costs more capital than shallow drilling, and going under the sea costs a *lot* of capital. Thus, we will need more energy per ton of food, and we will need more capital per megawatt of energy. If you put all this together—remembering once again that we are starting out with twice as many people—and even if you feed the people as badly as they

are fed today in many countries, you still would need twice the food we now have, and you would come up with a bill for capital of at least four times as much as we're now using.

## THE POLITICIZATION OF MANKIND

But there is another point: We will be dealing then with a somewhat different world. I've asked how many people we'll have; now let me ask what kind of people they will be. In some ways they will be different.

For instance, they will be literate. Today, two-thirds of mankind are literate. This is something that has never happened before. The majority of mankind became literate in 1955, the first time since writing was invented. By 2010, between 85 and 90 percent of the world will be literate, and Lord knows what they will read—probably very many different and partly quite stirring types of literature.

Something similar is happening in regard to people moving out of agriculture. Agriculture is becoming too serious an occupation to be left to peasants, and people are moving out of it. In the United States, which feeds a good part of the world, less than 5 percent of the workforce is in agriculture.

I always remember the report of the American television commentator on the Winter Olympics in Innsbruck when the Russians had just collected another cup of gold medals: "There, you see, American wheat makes fine athletes." Well, we are producing the fine wheat that helps produce fine Russian athletes with 5 percent of our workforce. In England, it's 3 percent of the workforce. In Germany, it's 9 percent. In France, it's 10 or so. This is quite different from what it was only 20 or 30 years ago. In 1950 Germany still had a quarter of its population in agriculture. The changes are tremendous. At present, every 10 years, 7 percent of the world's workforce is shifting out of agriculture; that is to say, by 2010 we will have very roughly 75 percent, three-quarters of mankind, occupied with things other than agriculture. Peasants will become a protected minority in the world,

and they have been a majority ever since agriculture was invented about 10,000 years ago. This is, again, a quite radical change.

Something similar is also happening with cities. At this moment, in the second half of the 1970's, the majority of mankind is changing to city dwelling; city slickers are the majority now. This has never happened before. The shift into cities is 4 percent per decade, and we can expect therefore by 2010 approximately two-thirds of mankind will be living in cities.

A similar change is occurring more slowly with wage earners. At the present time, roughly a third of mankind is working for wages in industry, business, transport, and so on. Approximately 4 percent per decade are shifting. We will have, therefore, nearly half of mankind being wage earners by 2010. You see an entirely different composition of humanity in education, in residence, in literacy and culture.

I have left out other sources of change that move faster, such as the demonstrated effects of modern technology. I will never forget how in Washington, D.C. during World War II, my 3-year-old daughter came running to me when an airplane roared overhead saying, "Daddy, lift me up, I want to be up there in the sky." Everywhere in the world where small children see airplanes and realize that human beings can fly, the world is changing. It will never be the same again. Every truck on an Indian road, every stationwagon in a Peruvian village market, is changing the image of people in the world. People discover that many things—not all, but many things—are the work of people and the responsibility of government. They are not written in the Book of Fate, and they're not the will of Allah.

In the old days when a child was sick or died, the mother said it was the will of God. Today, she'll say, "Why can't I get him to the hospital; why can't I get medicine for him; why can't I get the doctor to see him?" The demonstrated effects of hospitals and automobiles and airplanes are supplemented, of course, by the effects of the mass media. Every decade, approximately 20 percent of

mankind is brought additionally into contact with mass media. By 2010, probably not more than 5 percent of the people in the world will have no contact at all with mass media. The transistor radio has already done for Nasser in Egypt what the printing press did for Martin Luther, providing a new, inexpensive, effective means of mass communication that can be used to disseminate a particular new doctrine.

We have the radio, we have television, we have movies, we have the printing press; all of these are reaching more and more and more people. The most subversive piece of literature I know is not the Communist Manifesto by Marx and Engels; it is the Sears Roebuck catalog. The most provocative picture I know is not a poster by some radical artist; it is a show window. People are learning all over the world what they're missing. In the riots of the late 1960's, the ghetto areas, where the fires were burning, were bristling with television antennas. Again, the slum dwellers had seen what they had missed.

This does not mean a straight line toward immediate change, but it does mean a level of awareness, of restlessness, of demands, and of needs, unprecedented in world history. I said needs. A *need* is an input of something which, if missing, is followed by observable damage. In this sense, children

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need a minimum of milk and calcium, or they grow up deformed, and you can see their little bow legs which are the result of rickets or of a bad diet. Children do need some vitamins, even if they've never heard of them. Even if they don't know what vitamins are, their teeth still will fall out if they don't get them.

Needs are increasing. In a village, the problem of drinking water is solved by one little well, or more often by some brook or spring nearby. It's not a political problem. In the city of Bombay in the 1930's, there were 700 people to one water faucet. That was a political problem. I've seen people in Calcutta on a hot day turn on the fire hydrants to wash because there was no other place where water was available. That was a political problem. The problem of sanitation in a village could be solved behind the nearest bush. The problem of sanitation in a city is a political problem. I've seen, again in Calcutta, the big, 6-foot pipes going in along the road where there hadn't been any sanitation for the 200 years since Calcutta was the capital of India under the British viceroy. Britain had produced this place with more than oriental splendor; Victoria had been crowned Empress of India; but the sewer pipes had not come in. Now India has to do it. That is to say, water, sanitation, health, regular food supplies for the cities, all these become political questions. The same is true of old age pensions. In the village, you have your relatives nearby; in a city, your children or relatives may be working and living hundreds or thousands of miles away. Whether you get social security is, therefore, no longer a question of the family system; it is a political question.

When you're sick in a village, your relatives look after you. When you're sick in a city and no relatives are nearby, there either is or there is not an adequate municipal hospital. That's politics. In all these respects, modernization of daily life is politicization. Consequently, we will get a mankind more politically interested, more moved by political needs, and to some extent also more stirred by political desires and demands than we've ever had before.

A political dimension like this means another thing. Even in the highly developed

countries, all the forgotten groups will come out, and are coming out. All the skeletons are coming out of the closets. Black people in the United States who worked in the cotton fields have moved to town, and they have demanded more rights. White farmers in the rural South have also moved to towns, and the South began celebrating their arrival into towns by voting for Governor Wallace. But as time goes on, of course, people begin to get together, and what it comes down to is that they will demand more social services and more public amenities. They will also demand more equality, more human dignity. That's not only true of racial groups; it's equally true of language groups. Our Spanish speakers—from our Chicanos in the Southwest to our Puerto Ricans in New York City—demand more of a chance. They demand schools in which their children don't have to think they're stupid simply because they learned to speak Spanish at home rather than starting out with English.

We'll see other political demands as well. We'll see demands from regions—such long overlooked and neglected regions as the South of Italy, the South of the United States, the North of Brazil, and Wales and Scotland in Britain. All these half-forgotten regions will demand more attention, more service, and more help. Also, religious groups, such as Roman Catholics in Northern Ireland, will not want to be discriminated against; and even age groups—the youngsters aged 18 to 21, the older citizens over 65—will not want to be forgotten.

#### GNP AND PUBLIC SECTORS

What this adds up to is that even in the most highly developed countries in the world, we must continue with some degree of economic growth if social peace is to be preserved. This growth is necessary because most of the things that people want—even where some of the demands could be symbolic for respect or prestige—will cost something. Thus, if we want to give those who have little or not enough a little more, and if we want to avoid taking it away from those who have more and who are very likely

to fight tooth and nail to keep what they have—if we are, in other words, to avoid bitter and prolonged conflicts among social classes and strata—we can only succeed by somewhat increasing the total economic wealth, even if we live in the rich countries.

And what is true of the highly advanced countries, such as the United States and the countries of Western Europe, is doubly true for the developing countries. There, where there is high child mortality, where the poverty is appalling, where the housing is miserable, much more will have to be done; and, again, people are seeing what they are missing. Mass media send a message to people all over the world, and in an American television play—like “I Love Lucy,” which I have seen broadcast in Japanese in Osaka—it’s a highly political message. It’s a political message in Peru, for example, where people in the poorer neighborhoods of Lima see such programs broadcast in Spanish, and then say: “How these people live! Isn’t it remarkable! What’s in that kitchen?” One can easily sense the feeling of being deprived among the people in the poorer countries who view what we consider perfectly normal entertainment programs.

**C**learly, we will have to maintain some economic growth in the world. Let us consider some estimates—and I think they’re not immoderate estimates. Suppose we manage to keep per capita income in the world growing at 2 percent on the average, and we divide this into the very unequal world that we have; what figures do we get?

One-fifth of mankind lives in the highly developed countries and has 80 percent of world income. Four-fifths of mankind live in the poorer countries and have 20 percent of the world’s income. If we let the rich countries grow at 1.5 percent per capita, and the poor countries at 3.5 percent, we can maintain the 2 percent average for the world as a whole. But this means that by 2010 per capita income for the world as a whole will have to be twice what it is now.

Now consider this need to double per capita income while also recognizing that the population will double by 2010, requiring proportionate increases in energy and capital.

The result is that we will need about eight times the capital that we now have. Let us be modest, and say that with luck we may need only four times our present capital; the net result is that by 2010 we must have between four and eight times the capital we have now. This is to say that world politics 30 years from now and in the intervening decades will be to a large extent the politics of capital formation and investment guidance. Some investments are well-guided by the market; others are not. It is often more profitable to build a dog race track than to build a hospital, and on the market it is more rewarding in a poor country, let us say, to provide luxury apartments for a few than a more sanitary food market for the many. So we will have an increase in public sectors, an increase in the interference of governments, and an increase in politicization of life.

In Communist countries, this is obvious. The governments are trying to do everything there already, insofar as they can. In the constitutional democracies in the Western countries, we will have to learn how to combine and balance the public and the private sectors, how to get the best out of each; but we must see that probably the balance will change somewhat. It will not be exactly the same cocktail mixed in the same proportions as we have it now.

At the moment in the Western world, we have very roughly one-third of GNP in the public sector, two-thirds in the private sector. Perhaps 30 years from now this ratio may be 40 percent in the public sector and 60 percent in the private sector, but my guess is it’ll be closer to half and half. In the Communist countries, it may very well be 4 to 1, or 5 to 1, or more in favor of the public sector. It is at the moment in Russia about 4 to 1; in China, it is still 1 to 2. But the ratio between the public and private sectors is probably going to move in those directions.

If you put all this together, you see the tremendous need for capital. You could say, of course: “Why is all this necessary? Why don’t we simply say to the poor people in our country, and why don’t we say even louder to the poor people in other countries, ‘That’s your tough luck that you’re poor; we are not responsible.’” As Cain asked so eloquently in

the Old Testament, "Am I my brother's keeper?" You will remember that the gentleman who said that got quite a reputation and a characteristic sign in his eyebrows. I would not like to have Uncle Sam pictured with that kind of eyebrows, and I don't think it's likely, either. The United States has helped in the past—and will help in the future.

#### THE DECLINE OF POWER

Another epoch in world history has come to a close. From approximately the time of the Birth of Christ until the year 1500, the military capabilities of the non-Western world and those of the Western world were roughly equal. On top of that, the differential sensitivity to local bacilli usually made the invading armies very sick after a while. So, by and large, the Romans could not conquer China; the Chinese disdained even to try; and Alexander came to the borders of India but didn't go further. On the whole, no Westerner tried to get south of the Sahara; and, on the whole, most major regions of the world left each other alone or didn't even know there were people somewhere else. The Aztecs and the Incas didn't navigate to Europe; and, until about the year 1500, very few people from Europe had been to the New World.

But then the West took off. The capabilities of the West in transportation and firepower increased very, very quickly. By the time Cortez marched on Mexico City, 200 Spaniards could defeat 50,000 Indians, at least according to the figures the Spaniards have left us. They may have exaggerated a bit, but on the whole it was very clear: Westerners were tremendously superior to non-Western populations. They had iron armor; they had firearms; they had horses; they had organized military forces; and, step by step, they kept defeating everything that was in their way.

The conquest of Mexico was only the beginning. In 1898, General Kitchener, with a British and Egyptian army, moved into the Sudan and at a place called Omdurman took on a force of dervishes, members of a fanatical Muslim sect, who were in full uprising against Egypt and the English

presence. In the battle, 10,000 dervishes were killed. The British casualties were approximately 150. The main problem of the British soldiers was that the barrels of their machineguns grew too hot. When Sir Francis Younghusband marched his troops into Tibet in 1903, and then conquered some Tibetan troops, a writer described what then followed as a "pheasant shoot." That is to say, the West had towering military superiority over the non-Western world. It may have been fun while it lasted—while the non-Western world was not growing much—but then Japan began to catch up to the Western levels, and then much of the rest of the non-Western world began to catch up.

Perhaps future historians will say that 1950 was one of the great turning points in the history of the world. In 1950, an army recruited from one of the most non-Western countries in the world, China, fought to a standstill an army raised in the most technologically advanced country in the world, the United States. Our soldiers as individuals, from all I can gather, fought with courage and loyalty. When one reads General S. L. A. Marshall's account in *The River and the Gauntlet*, one can see that the squads and the groups of riflemen who fought their way back to our lines did as much or more than duty demands of soldiers. The trouble was that the Chinese could fight as well, day or night, and that there were more of them.

In 1947, a British captain got a medal for having taken the last British gunboat down the Yangtze River and delivering it in one piece. For many years British gunboats had cruised up and down the river, but in 1947 the Chinese Communists had guns of approximately the same quality on the shores of the river, and there were more of them than were on a gunboat. It really took a great deal of courage, competence, and seamanship to get a gunboat out of the Yangtze River. The captain fully earned his medal, but no foreign power since has tried to sail a gunboat up the Yangtze River.

The recent past holds many unpleasant memories: Korea, the Yangtze River, the failures of the French troops at Dien Bien Phu

in Vietnam and in Algeria, and our own tragedy in Vietnam. We find in the field of conventional weapons, the vast superiority of the West is no longer what it used to be. Our soldiers are still courageous and loyal; our officers are still competent; our weapons systems are still modern and of good design. But the submachineguns which non-Westerners now have are not much worse than the submachineguns or other rapid-fire weapons our infantrymen have, and the same goes for many other things—rockets, grenades, bombs, and so on. There are still advantages in some ways, but they are not what they used to be. The superiority of the West is largely gone, so far as quality is concerned. It may still be there, but it is marginal now, and no longer decisive in conventional weapons systems.

And non-Westerners, let us remember once again, are the great majority of mankind.

#### NUCLEAR PROLIFERATION

Well, what about that wonderful gadget, the atom bomb? We were the only ones to have three of them in the summer of 1945. We exploded the one at Alamogordo, one at Hiroshima, and one at Nagasaki. Then—according to Mr. Henry Stimson—we didn't have any until December, but the rest of the world didn't know it, and so our tradition of being a nation of poker players stood us in good stead. We impressed the world very greatly with atom bombs which at the moment did not exist. Then we got more of them, and we got more and more of them. According to the press, we are supposed to have roughly 30,000 warheads today.

The Russians are inferior to us. They've only 7,500 warheads, although some of them are bigger than ours. We can kill them several times over—five or ten times. They can kill us only two or three times, but that might be enough. As Winston Churchill once said, "There is not much point, after you've destroyed the city, to make the rubble bounce."

Also, we and the Russians are not the only ones with these weapons. If you look at the years from 1945 to the present, you can see

that the number of countries that have some nuclear weapons has doubled about every 11 years. Roughly speaking, these countries now number seven or eight, and we have published a list of another eight countries, at least, which are called "candidate countries." These are countries that have the full capability of acquiring nuclear weapons as soon as they would have the motivation to do so. Luckily, West Germany and Japan have a public opinion opposed to this motivation. Eighty percent of the masses in West Germany oppose nuclear weapons; the opposition in Japan is not very different. On the elite level, only one-third of the German elite in the 1960's wanted nuclear weapons, and most of them were not very passionate about it.

So those two may wait. Brazil may be in more of a hurry. Pakistan may be in more of a hurry. For all we know, Mr. Vorster in South Africa may be in more of a hurry. He elected to go slow on negotiating with Henry Kissinger, Rhodesia, and the Black African governments, but I'm not sure whether he's going slow in trying to get a nuclear capability.

By 1986 or 1987, there could very easily be 15 nuclear powers in the world. By 2010, there may be 30; by 2050, there may be about 100 countries with nuclear weapons. Eventually nuclear warheads will spread the way the machinegun has spread, the bombing plane has spread, and the tank has spread. There has been no case in history, since Greek fire and old Byzantium, where anybody succeeded in keeping the secret of a weapon for very long from other countries.

Since civilian nuclear industries also are spreading all over the world, there will be everywhere in the world physicists and engineers who could divert some of this technology to weapons purposes.

There is something else to be added. If we have a world impoverished, if we have a world seething with envy and resentment, hate and fear, and if we have in this world nuclear warheads lying around, the prospects are not good.

Imagine the following scenario: In the late 1980's there is a huge famine in India. The administration in the United States has



accepted the excellent advice of Mr. Jay W. Forrester, my former colleague at MIT, who has said we will have to decide which countries to feed and which ones to let starve. The Indian prime minister comes to Washington, and he tells our President that if the famine is not quickly relieved, he will probably lose power in India. He will be out of office. Unfortunately, he will be replaced by a religious fundamentalist and fanatic, an adherent of the goddess Kali, or a believer in the fiery dance of the Indian god Shiva, who will burn up the world and renew it in this manner. In short, India will get a government of despair, and they do have quite a few nuclear weapons in decentralized locations, including quite a few weapons located on submarines or in other places where they cannot be easily or quickly found. "I have the worst fears for your country and mine," says the Indian prime minister, "if my government should fail." Would you advise the President to let that government fail?

Mr. Forrester has advised us that in case of worldwide famines, we should use the technique of triage. Triage is a French word coming from the battlefield surgery of World War I. If you have large numbers of wounded coming into a hospital, and there are not enough doctors, beds, and medicines, you must make very superficial examinations and quick and desperate judgments of which patients you are most likely to save by medical attention, and for which ones the chances are poor. You then take the people you think you are likely to save and give them the attention you have, and you put the less-promising cases on the side to let them die quietly. That is triage. Professor Jay Forrester has proposed to apply this principle to starving peoples in the world, if in the future food should become very scarce.

There is one catch in this piece of advice. Triage works in battlefield hospitals because the patients are unarmed. If the patients were armed, an effort to apply triage might increase mortality among the doctors. But nations are not unarmed, and by the end of this century, they'll be less unarmed than ever. Here, again, we find a real major danger is moving toward us.

**W**e may, therefore, out of reasons of national security, consider it essential to prevent devastating mass famines anywhere in the world. This may take some doing. We may have to do what the Bible commended to the Pharaoh in Egypt, namely, piling up large supplies of food grains from the good years and the good harvests, and storing them preferably near the areas of expected need. To preserve our security, we may indeed have to store food supplies where they can be used, organize logistical systems that can be activated very quickly in emergency conditions, and see to it that mankind does never again have really devastating mass famines. This will be necessary, and I suspect that we will not have a market mechanism to do it automatically. I suspect we'll have to go through the Defense Department, which has the knowledge of logistics that would be needed to handle such a program on a scale approaching the invasion of Normandy. The armed forces will be called upon for the war against famine in emergency situations.

There are also irrational dangers. In the last 50 years, there have always been at least three governments in the world that were irresponsible, extremist, and potentially suicidal. In the 1930's, there were the regimes of Hitler, Mussolini, and the military generals in Japan. Those men did start wars, but they brought about the defeat of their own countries. They destroyed their own regimes and systems, and the lives of the leaders often did end in suicide.

More recently our irresponsible and potentially suicidal regimes luckily have been small. Idi Amin in Uganda, Ian Smith in Rhodesia, and Muammar el-Qaddafi in Libya come to mind as possible candidates for this dubious title. The point is that among a hundred or 150 states in the world, there have always been three or more irresponsible ones. As the number of nuclear powers grows from 6 to 8, from 8 to 15, from 15 to 30, from 30 to 100, chances are that sooner or later the set of nuclear powers will come to include one or more of these irresponsible governments. And, once a truly suicidally irresponsible regime obtains the destructive

power of nuclear/thermonuclear warheads, then the plutonium may hit the fan.

### TOWARD CONSERVATION

I will not go into detail on such topics as metals and pollution; we can deal with many of these things, and eventually we will. We may have to reorient some of our consumer standards. At the moment we think if we give somebody an outboard motor or a nice noisy motorbike, these heavy metal devices emitting clouds of carbon monoxide and large amounts of noise will represent an increase in their living standard.

Perhaps in the next 30 years, at least in the highly developed countries, some people will rather have a ticket to a symphony concert. Perhaps they'll rather have a municipal theater. Perhaps they'll rather have a first class educational system. Perhaps they'll rather have classes for grade school children with no more than 12 kids to the class, so that teaching is no longer mainly an exercise in making small children sit still and stop wiggling, which is much of what education today still is.

In other words, we may learn to seek the increases in our living standards less in the consumption of ever more metal, ever more noise, and ever more energy, and we may go in part to services, to quality improvements in life. That is perhaps Utopian, but it's worth thinking about.

A second possibility is that we may learn to do more with less, which as Mr. Fuller said, is "the true test of engineering." Consider a Sunday edition of *The New York Times*, and consider the woods, the forests, that must be cut down to print that edition, and consider how the same amount of text can be put on microfilm, or on microfiche, or on a microdot. Consider how big a computer used to be when it required vacuum tubes, and consider how much smaller it became with the use of transistors. Consider how much smaller a radio is now that we have printed circuits. We're learning some of these things as benefits from our space technology.

In principle, this means that more research has to go into the direction of learning how to do more with less and how to increase the *information ratio*—that is to say, the ratio of

technological decisions, yes and no decisions, switching decisions, per pound of material or per dollar of the budget or per proportion of manpower. We may learn to use more information and slow down a gross consumption of metals and other scarce resources.

### NATIONAL SECURITY

We can forecast at least some part of the future because it comes out of the decisions we made yesterday and the ones we're making today. We will get major threats to the national security of the United States, and the conventional idea of the mission of the defense forces to shoot up those who shoot at us, or to intervene, or to try a preemptive strike, or whatever else the various doctrines may say, will not be enough.

If we don't have enough oil, and if we don't know how to harness solar energy, no bomber strike or tank attack will get us the energy we need. If we don't do the research on safer and cleaner nuclear energy now, if we don't now try for wind energy in a cheap and reliable manner, if we don't try for solar energy now, then 30 years from now we'll be in a very bad way. If we don't begin to think now about how to get the food we'll need, where to store it, and how to set up the required logistical systems, we may not have it when the emergency comes.

In some ways we may have to broaden our idea of national security, think more broadly about what could threaten it, and think in time also on what will be the role of our organized forces—including our defense forces which are, after all, superb instruments for getting many things done.

The fact is that we most certainly face many threats and changes. It is not very useful to take a canoe ride in the smooth waters just above Niagara Falls, saying we don't need to change our behavior, because under these smooth waters there is a very wicked undertow, and it is taking us somewhere that won't do us much good.

Many people don't see the emergency yet, but it's coming. We're very close to it, and I would say that seeing it coming, beginning to think about it, and then doing something about it, is perhaps one of the most patriotic things all of us can try to do.