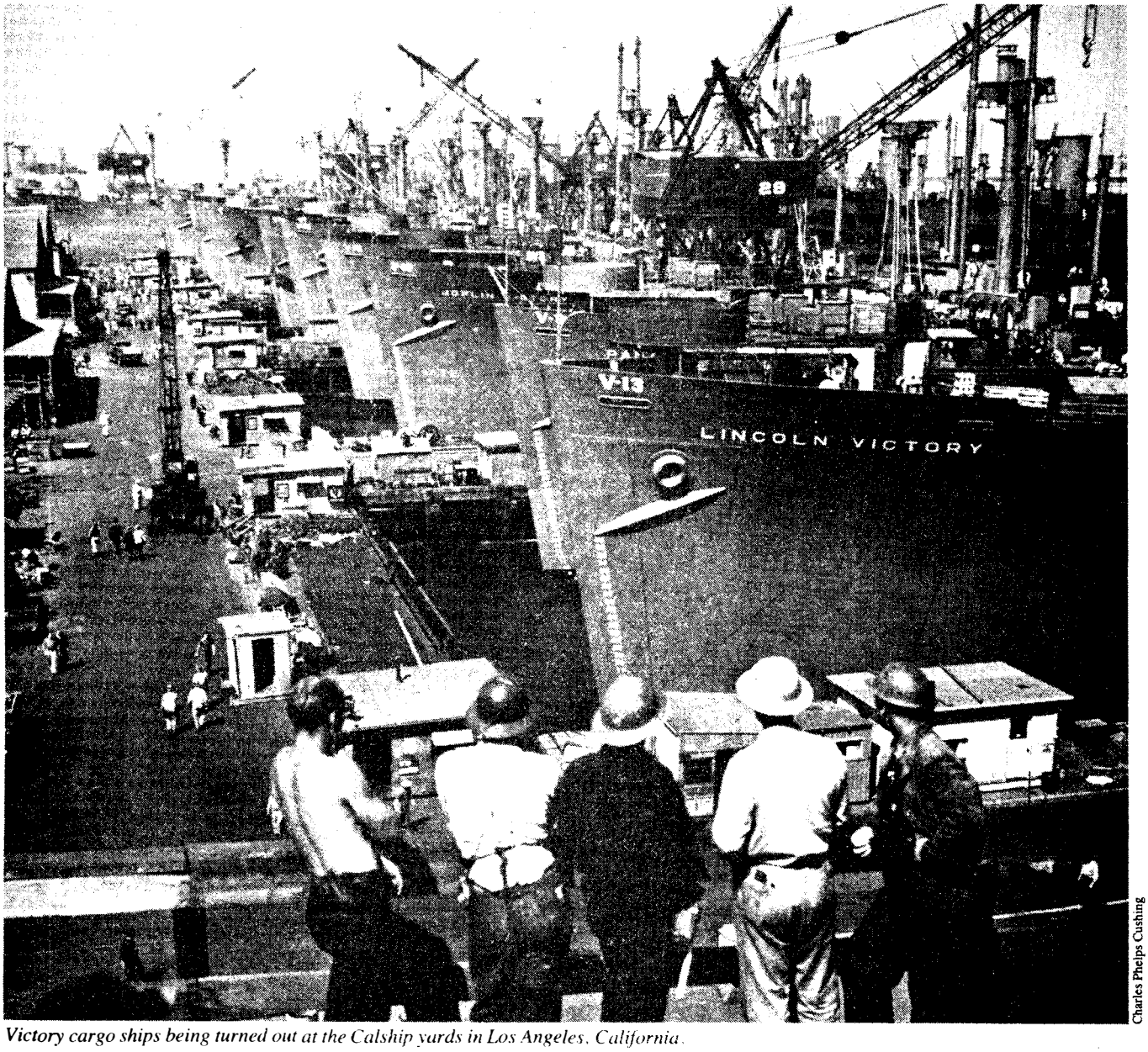
The World War II mobilization that ended the Great Depression

by Richard Freeman



Charles Phelps Cushing

Victory cargo ships being turned out at the Calship yards in Los Angeles, California.

In 1939, the United States was mired in its tenth straight year of depression. Neither Keynesian nor monetarist measures had worked. The common belief was that the depression was insoluble.

Then, between 1939 and 1944, the United States mobilized its full resources to arm itself and crush Hitler. As a result, in those five years, the economy achieved growth rates thought to be impossible: investment in new plant and equipment grew by 65 percent, U.S. manufacturing output doubled, wages doubled, profits increased more than fivefold, and the manufacturing workforce grew by 70 percent.

At the same time, food consumption rose by 15 to 25 percent, and many industries unknown or scarcely existing before the war—ranging from magnesium and synthetic rubber to nuclear power and penicillin—were introduced or pressed into service during the war years. Science became the driver of the economy, spinning off new discoveries week after week. *The United States is still living today by and large off the industrial investment and inventions built during that war and the Korean War!*

From the outside, the World War II buildup seems a miracle. It was—but a repeatable one. The buildup simply demonstrates that for most of its existence the United States, as the world's most advanced industrial economy, is not living up to one-half or even one-tenth of its potential. *An economy is never functioning until it is tested to push itself to extremes.* At that point, industry does not merely double, or triple, but displays the capacity to grow non-linearly, exponentially. The economy suddenly discovers new powers, as if operating at 10 times its normal speed; it gains a new perspective on the world.

It was not the austerity initiated during the war that accomplished this transformation. Just the opposite: it was the targeting—like the aiming of a gun—of the economy's reinvestible surplus, or profit, into those capital goods sectors with the highest potential civilian or military growth rates. These sectors' superior technologies and higher productivities cascaded into the economy as a whole. At the same time, the skill level of the labor force was upgraded and the unemployed put back to work. The creative powers of the population were ignited and directed.

This is the secret of the fantastic rate of growth of the World War II U.S. economy. This secret has a name; it is called the American System, the economic method based on man's creative power to be fruitful and multiply and subdue the earth through technology and science, and the ability of republican government to make such results happen. Under the firm hand of Commander in Chief Franklin Delano Roosevelt, the American System of economics was applied in the following measures:

- Abundant and cheap credit was injected into the economy, through U.S. government agencies and through the Federal Reserve Board lending window, but only for top priority productive sectors—manufacturing, construction, mining, power generation, transportation, and to a lesser extent, agriculture. Other sectors of the economy got limited credit; speculation, rentier-finance, the secondary real estate market, and so forth were suppressed and cut off from credit.
- Teams of the best scientists and engineers were assembled to make breakthroughs. The Manhattan Project is the best known and most breathtaking World War II example. Under this program, within two years, $3 billion was spent and 22,000 scientists and engineers were brought together, including Enrico Fermi, Ernest Lawrence, and Col. Leslie Groves of the Army Corps of Engineers, to unlock the secrets of the atom and produce a controlled fission reaction from uranium 235. In this way—just as with the beam weaponry potential today and the advanced physics behind it—seminal ideas were fleshed out and forced into existence, permanently altering nature and men's lives.
- Electricity was used on a scale not attempted before. Between 1939 and 1945, the electric horsepower funneled to manufacturing was doubled. Electricity is vastly more efficient than thermal-heat energy sources for powering machines, turning generators, and so forth; but this pre-World War I technology was only fully exploited starting in World War II. Projects such as the Tennessee Valley Authority and the Grand Coulee Dam, which had been developed during the 1930s, supplied the massive amounts of electricity necessary to exploit for the first time the highly energy-intensive aluminum industry, without which the United States would not have won the war.
- The training and retraining of workers was undertaken on a scale never before attempted in the United States. Three million were trained between 1941 and 1942 alone.
- Capital goods and raw material resources, where necessary, were allocated by defense authorities.

These elements in their general form are the elements of the system of economics founded by that "American in spirit," Gottfried Wilhelm Leibniz, in the 17th century, and by Alexander Hamilton, George Washington, and Benjamin Franklin, who established America as an industrial republic and permitted America to withstand onslaughts of British rentier-finance and "free trade" for the past 200 years. Its underpinnings are the dirigist directing of credit to capital goods production to secure the greatest rate of growth and technological upgrading of the industrial-agricultural base, and the improvement of the material conditions and creative potential of the labor force. The World War II buildup may have seemed a miracle, but there is no wonder that it worked.

Contrary to popular myth, the World War II buildup did not represent simply "using idle capacity." That occurred, but the essential process was one of building—on top of the civilian economy, which remained basically flat or was converted—a brand new war economy, with the newest technologies and therefore a tremendous rate of growth. War goods production itself represents pure overhead or waste, because these goods leave the economic reproductive cycle. War production is the equivalent of taking goods, putting them on a flat barge, and dumping them into the ocean. Then how can war production generate growth? If it embodies new technologies, the resulting higher productivity in the civilian

economy more than pays for the war expenditure, by means of higher overall output.

There was a personal method by which the wartime command economy worked: President Roosevelt constantly and relentlessly drove the production goals higher and higher, outstripping what was thought possible. An internal memorandum written in 1943 by Stacey Macy, one of the higher-placed officials of the War Production Board, illustrates the point. Macy predicted that the United States would meet its war and civilian goals for 1943, but the next year the economy would fall apart. In fact, the next year, output grew. In 1944, various memoranda concluded that the U.S. economy could not resolve the strains and make it through to the second half of the year. It did. Dire warnings were issued about 1945, nevertheless. Each time, the U.S. economy outperformed itself.

From the beginning of the war, it was FDR who threw out a figure; and then most people proclaimed that it couldn't be done. When FDR first announced production of 26,000 planes in March 1940, the press attacked his "Buck Rogers" plan—exactly the epithet the news media have hurled since March 23 against President Reagan's directed energy weapons program. Roosevelt ignored the idiots of the press. Every six months he would increase the production quotas he demanded, using realistic engineering estimates, but always choosing the extreme end of the scale. And the quotas were invariably met.

When he had to be, Roosevelt was ruthless. This has led various biographers to label him "duplicitous," "double-faced," and "power-hungry." This is buncombe. While not an intellectual in the ordinary sense, Roosevelt had a remarkable attraction to ideas: not formal-logical ideas, but real, live, and important ideas, *such as winning the war*, even if it meant that it appeared he was changing his mind from one day to the next—which he often wasn't—or that he had to step all over someone's bailiwick to get something done. This quality, which emerged especially during the war years, is what made him fill out the office of President during a period of national crisis, and not rattle around in it like a Jimmy Carter.

This becomes clear after a preliminary review of what World War II achieved, what obstacles the Roosevelt administration overcame, how production goals were achieved, and finally an analysis of the capital intensity and productivities of the buildup.

In terms of tangible goods output, the outpouring of the U.S. economy from January 1940 through August 1945, totaled more than half the Allies' combined military and civilian output, and included:

- 300,000 war planes;
- 124,000 ships of all types;
- 41 billion rounds of ammunition;
- 100,000 tanks;
- 434 million tons of steel; and,
- 36 billion yards of cotton textiles.

To indicate a basis of comparison, the Navy is now complaining that there may not be sufficient capacity to produce its order of 30 planes for 1983.

But there were also profound qualitative alterations in the economy and the labor force.

Figure 1 shows the industrial production index during the war years. As can be seen, between 1939 and 1944, *the index and thus the real goods output of the economy more than doubled,* increasing by 118 percent. In 1945, the index fell, reflecting the demobilization from war production in the latter part of the year. The average annual compounded growth rate was an astounding 16.9 percent (the starting point was a depression year).

Figure 2 shows that average gross wages doubled between 1939 and 1944. (The effects of wage-price controls

Figure 1

Industrial output growth, 1939-45

Industrial production

Year	Index (1967 = 100)	Per annum change
1939	21.7	—
1940	25.0	15.2
1941	31.6	26.4
1942	36.3	14.9
1943	44.0	21.2
1944	47.4	7.7
1945	40.7	−16.5

Figure 2

Profits and wages, 1939-47

Year	Average annual wages	Corporate profits
1939	$1.363	$ 5.3 bn.
1940	1,432	8.6
1941	1,653	14.1
1942	2,022	14.3
1943	2,349	23.5
1944	2,517	23.6
1945	2,517	19.0
1946	2,517	16.6
1947	2,793	22.3

Figure 3

Interest rates, 1939-48

Year	Discount rate (NY Fed)	Prime rate
1939	1.00%	1.50%
1940	1.00	1.50
1941	1.00	1.50
1942	1.00	1.50
1943	1.00	1.50
1944	1.00	1.50
1945	1.00	1.50
1946	1.00	1.50
1947	1.00	1.50-1.75
1948	1.34	1.75-2.00

Figure 4

Employment by sector, 1939-47

(in millions)

Year	Armed Forces	Civilian	Manufacturing	Unemployed
1939	0.37	55.75	10.28	9.48
1940	0.54	55.64	10.99	8.12
1941	1.62	55.91	13.19	5.56
1942	3.97	56.41	15.28	2.66
1943	9.02	55.54	17.60	1.07
1944	11.41	54.63	17.33	0.67
1945	11.44	53.86	15.52	1.04
1946	3.45	57.52	14.70	2.27
1947	1.59	60.17	15.55	2.36

finally ended wage increases in 1945.) Some of this increase is of course due to longer hours worked. Real wages, nonetheless, rose by more than 50 percent during this period.

At the same time, corporate profits increased 4.5-fold, demonstrating that profits can grow spectacularly and enough surplus will be available to greatly raise wages as well—because leaps in productivity vastly increase the total size of the surplus.

Figure 3 shows the transformation of the labor force. In 1939, the official number of unemployed at 9.5 million was almost as large as the total number of the manufacturing workforce, at 10.3 million. By 1944, the unemployment level had fallen to 0.67 million; there was an acute labor shortage throughout all sectors of industry. This represented a reduction in the unemployment level of 8.81 million. Were the United States today able merely to replicate the achievements of 1939-44—and we can surpass them—then the official unemployment level would drop from its current level of 11.3 million to 1.7 million by 1988-89.

From 1939 through 1944, the U.S. armed forces grew from 370,000 to 11.41 million. The common interpretation is that the armed forces simply absorbed the unemployed. But look at what happened to the manufacturing labor force. It grew by 7.3 million, or 70 percent, during the war years. Even after the war ended, by 1947, the manufacturing labor force was 15.6 million, a 50 percent increase over the 1939 levels. The unemployment level was only 2.4 million in 1947.

Blacks and women entered the labor force in large numbers during the war. While many women left, blacks stayed, upgrading their status and living conditions. Thus the labor force had been permanently altered, and along with it the economy. The expansion in manufacturing is what equipped the United States to have economic growth in the 1950s.

Credit policy is indicated in **Figure 4**. It can be seen that the Federal Reserve's interest rate on funds lent to commercial banks through the discount window was only 1.0 percent in 1939. By 1942, it had zoomed to. . . 1.0 percent. Then in 1945, it skyrocketed to. . . 1.0 percent. The prime rate held steady at 1.50 percent throughout the war.

This refutes the argument by Paul Volcker and others that when demand for credit is high, interest rates must leap upward. During World War II, there was tremendous credit demand, much more than had been seen for the previous decade. But interest rates remained low, as a result of a dirigistic credit policy. Inflation, even before wage-price controls were applied in 1943, was lower than its level during Volcker's reign, and a good part of this inflation was created by scarcity of goods.

The obstacles F.D.R. had to overcome

Let us take a step back to the outset of World War II, and consider the obstacles that the President of the United States faced in building a war economy. The three major obstacles were as much political as they were economic: 1) a collapsed economy, 2) hard as it may be to believe, opposition to U.S. entry into the war against Hitler, and 3) a non-existent U.S. military. These problems, in general terms, are the same faced by President Reagan today.

The scope of the Great Depression has been alluded to above. The U.S. economy and the American population had been subjected to unrelieved grinding misery for ten years. *While monetarist policies had produced the 1929-32 crash, the Keynesian policies of the New Deal had shown themselves equally incapable of producing a recovery.* The U.S. economy was incapable of adequately feeding and housing the population, let alone providing war goods. Today, if one looks at the state of industry and of former industrial workers, the United States is in a Second Great Depression, inflicted, after years of decay, by Paul Volcker's interest-rate policies.

The second obstacle was the opposition to the United States war buildup from a coalition of variously intentioned individuals. There was widespread fear of war, and there was also a pro-Nazi policy faction, grouped around the Schroeder Bank, and its lawyers, such as John Foster Dulles. Fear was manipulated by this faction through a widespread "isolationist" movement.

For example, in March 1940, F.D.R. asked Congress for funds to construct 26,000 planes. Congress would only approve funds for 57. Moreover, in November 1941—one month before Pearl Harbor—a majority of businessmen polled by *Fortune* magazine opposed the essential efforts to convert U.S. industry to war production, denouncing the effort as a propaganda trick by F.D.R. to impose more radical phases of the New Deal. Today, it is "radicals" who are manning the disarmament movement, but they are supported by Fortune 500 opponents of the President's defense budget, and funded by some of the same Nazi networks that attempted to block U.S. entry into World War II, exemplified by Swiss banker François Genoud, a controller of the anti-nuclear activists, and also an avowed leader of the Nazi International which

protected the Skorzeny/Klaus Barbie networks.

Third, in 1939, the United States was unprepared to fight the war. Within the armed forces, there was a widespread belief—until the moment the Japanese bombed Pearl Harbor—that the United States would send planes and munitions to Europe and the Far East, but would never send its own fighting forces there. Instead it would sit back and defend the coastal regions of the United States if and when Hitler attacked. (George Marshall and Dwight Eisenhower attacked this belief.)

The Nazis had a military airforce of approximately 40,000 planes, *eight times that that of the United States,* and while the United States could only produce 2,000 planes a year, Goering had the capacity to manufacture 18,000. In 1940, the Nazis had 10,500 tanks, 20 motorized divisions, 135,000 trucks and 60,000 motorcyles. The United States had 500 tanks. The Nazis had a battle-tested, efficient army of 7 million. The United States had 370,000 soldiers in arms, and another 170,000 in reserves.

In 1940, supplies in U.S. arsenals were so low that the newly created "Citizens Army" trained with wooden guns. The soldiers "fired" field pieces which had stovepipes for barrels. Almost anything on four wheels served as a tank in war games. Half the 100 million pounds of gunpowder were left over from World War I. Today, the United States is once more gravely ill-prepared for war.

How the buildup was directed

From the beginning bold action was taken to launch the war effort. Roosevelt first of all activated a centralized credit

How skills were upgraded in the U.S. war effort

In 1941, a Training-Within-Industry Branch was set up within the Labor Division of the Office of Production Management (OPM), then transfered to the War Production Board when the OPM was superseded in early 1942. The Branch made surveys and recommendations for training in the plants of more than 2,000 war contractors and subcontractors. Along with this, a job-instructor project was devised. By February of 1942, the Training-Within-Industry program had instructed more than 3,300,000 workers.

How this training program worked is exemplified by what was done with training workers with the basic skills to be aircraft workers. The November 1941 issue of *Automobile Facts,*

"The training program begins with the introduction of a man to the metal which he must handle. He is first taught to drill it and form it accurately. If he manifests a marked aptitude for welding, his education is turned in that direction. But, since drilling, forming and riveting constitute the major portion of the operations, the trainees are schooled in these arts through a step-by-step progression from one workbench to another. Each day they are given about 90 minutes of classroom instruction in shop mathematics, blueprint reading, etc.

"After they have mastered metal forming, drilling, and countersinking, they are taught riveting—alone and in teams. Advanced to another subsection, they learn 'blind' riveting in two-man teams. This art is mastered by placing the members of a team on opposite sides of a plywood wall into an opening in which is fitted the alloy sheet to be riveted. After men have thus learned to set rivets by signals tapped on the wall, they are moved into a wooden 'dummy' fuselage fitted with similar small alloy sheets. . . . Next, they are introduced to the hundreds of jigs and fixtures being used to facilitate assembly of planes by semi-skilled men drawn from automobile production jobs. Unlike the supervisory men whose education has been long and thorough, the workmen are taught specific operations only, although opportunities are provided for their voluntary participation in the whole educational course.

"In this complete course, the final lessons are learned by actual construction of a complete bomber section. But, before the trainees build a plane section, they dis-assemble one previously built by a preceding class.

" 'It's the natural way to learn,' says one instructor.

"Though it was predicted last spring that workers could not be trained in less than 300 hours, these methods have already proved that good functional workers can be prepared in 80 hours," that is, learning a skill in one-quarter the time.

This process of learning skills affected not only men. The "Rosie the Riveter" phenomenon was a well-known World War II symbol. In fact, in aircraft production, 20 percent of all workers were women, and 39.2 percent of all workers on projects classified as "crucial" were women. Many drill presses and other equipment had to be specially equipped so that women could operate them, which benefited all those who handled them. The overall labor force participation rate of black workers rose dramatically, as did blacks' entry into industry. Not only did the manufacturing workforce increase by 70 percent during the war, but the skill levels were vastly upgraded—and this is one of the most important reasons for the higher productivity levels of the economy during the 1950s and early 1960s.

policy, using an instrument at hand, the Reconstruction Finance Corporation (RFC), which had been established in 1932, and under the leadership of Jesse Jones was working closely with the Commerce Department.

During the war, Roosevelt and various of his technical advisers decided where investment was needed, and the RFC was asked to write checks to the chosen area of investment as a loan bearing a 2 to 4 percent interest rate. It was that simple. The current proposal by Lazard Frères investment banker Felix Rohatyn to recreate an RFC as something amounting to a fascist instrument has only superficial connections to the RFC in the way it was used during World War II.

A Defense Supplies Corporation and Defense Plant Corporation were created within the RFC and their tasks were to funnel the loans. During the war the Defense Plant Corporation made loans which one source placed at $9.2 billion and another placed at above $10 billion. The RFC's Defense Plant Corporation's investment was allocated approximately as follows:

- $4.5 billion to aviation, including the airframe industry, and even more importantly to those sections of the auto industry that converted to aircraft production. For example, the RFC lent $176 million for the construction in Chicago of a Dodge plant to be used for aircraft production that was the largest single industrial plant in the United States (it covered 145 acres), where the engines for B-29 Superfortresses and B-32 Dominators were built.
- $1.5 billion to aluminum and magnesium producers. Both industries (although there was a small amount of aluminum output before the war), are products of World War II.
- $250 million to build 45 plants to produce high-octane gasoline to fuel airplanes.
- $1.223 billion to build and upgrade 183 steel and pig iron plants, adding 11 million tons of new capacity.
- $715 million to build 51 synthetic rubber plants, which were wholly owned by the government. Before this, the United States had no synthetic rubber industry.
- $2 billion for machine tools.
- Hundreds of millions for new shipbuilding capacity.

Many millions more were lent or spent for various infrastructure projects, including the Big Inch and Little Big Inch pipelines to carry petroleum from Texas to the New York-New Jersey metropolitan area; the construction of tugboats and barges for river transporation; new buses and streetcars and feeder railroads to transport defense workers and materials.

To get U.S. companies to expand capacity, Roosevelt often had to conduct drag-out fights. In the steel industry, the Morgan-led U.S. Steel and Bethlehem Steel resisted the government's efforts to expand badly needed steel capacity, because in their view, "once the war is over we will have overcapacity which will cut earnings." Roosevelt had the RFC's Defense Plant Corporation begin to build the steel plants itself. The steel companies relented. However, the U.S. government owned some of the steel plants and sold them back to private industry after the war, as it did with rubber, aluminum, magnesium and other plants.

At the same time, Roosevelt leaned heavily on the Fed to keep the discount rate down to 1 percent in the interest of national security. The prime rate never exceeded 1.5 percent during this period.

Roosevelt set up a series of administrative boards, each with increasing authority, to direct the war mobilization. In early 1942, Roosevelt created the agency that was to have the greatest amount of authority until the end of the war: the War Production Board. To head the WPB, Roosevelt appointed Donald Nelson, director of marketing for Sears Roebuck department store, and part of the faction known as the "all-outers." In his book *Arsenal for Democracy*, Nelson stated: "There is but one conclusion to be drawn from the examination of any and every phase of our war production effort—whatever this country wants to do it can do. Nothing is impossible for America."

The WPB did not function like the Soviet Gosplan, the apparatus that regiments the Soviet economy. Rather, the system functioned as Japan does today. The economy remained capitalist. What was imposed was an industrial policy: those activities not conducive to real physical output were discouraged, or where possible, stopped. Certain broad guidelines for production and resource allocation guidelines were issued. Then industry went out to fill the orders, make the investments, and arrange the work shifts as it sought fit. Industry made use of its normal purchasing channels, continued on a profit basis, and so forth.

In 1941 there was some sizeable increase in investment, but the real explosion occurred in 1942, when the United States had entered the war. It was realized that in order to get an economy to grow, one has to invest in what is often the smallest but undoubtedly the most important area—*capital goods that produce capital goods*. Hence the heavy wartime investment in machine tools, without which no capital investment can take place. The machine tool investment took place at the same time that a "war sector" was built virtually from scratch. These were the two priorities, along with investment in certain strategic raw materials in short supply. However, heavy investment in intermediate goods, including metals, occurred more or less during the second stage.

Investment was slowed down in consumer goods sectors, except where necessary for military buildup (such as apparel for military uniforms). Entire sectors of the civilian economy were converted to war production, often shifting investment to heavier and more sophisticated production than the workers were originally engaged in. For example, the Steinway and Baldwin piano makers produced military gliders; one of the country's largest silverware producers shifted into magnesium production. Starting in 1942, production of cars and washing and drying machines was stopped entirely, while output of a whole array of other consumer products was sharply curtailed, ranging from bobby pins and nylons to rubber tires.

Though there was some privation because of the conver-

sion of certain consumer sectors to war production, general health, food consumption, housing, and other living standards were considerably improved by comparison with the Depression years. Though some farmers left the farm to serve as soldiers or work in factories, farm productivity shot up, because of capital investment in tractor production, as well as the significant increase of electricity on the farm—only 11 percent of all farms had electricity in 1935, but more than 95 percent had electricity by the mid-1950s, and a large part of the change occurred during the war years. This process was helped by the efficient use of the parity price system. Food consumption in the United States rose in most categories, especially meat consumption.

Finally, the United States took advantage of one of the most fundamental adages in all military history: the strength of a military economy rests on the strength of the civilian economy. A large industrialized economy gives a nation far better ability to gear up quickly. F.D.R. and others in the military, industry and labor spheres leading the war effort knew one thing: the United States had a larger economy than Germany. In 1940, it produced two and a half times as much steel as Germany—67.0 million versus 28.2 million net tons. It had an infinitely larger automobile industry: in 1939, it produced 2.867 million out of the world's 3.661 million autos. The United States was the world's largest producer of oil. The United States generated 130 billion kilowatt hours of electricity, the highest level in the world.

Thus the task was to awaken and transform the depressed U.S. economy.

Non-linear effects

The non-linear processes characterizing the wartime growth of the U.S. economy are exemplified by two sectors in particular: the aircraft industry and the Manhattan Project crash effort to develop a bomb based on a nuclear reaction. The former was an established industry, the latter an entirely new one; both propelled the war effort forward. With these two sectors as the bellwethers, investment policy was geared to bring about the most dramatic change in the map of U.S. industry. An examination of the matrix of the hundred leading industries before the war and after the war would show a sharp change—about as great as any change effected in the United States since the second half of the 19th century. This shift in the matrix of technologies, industrial processes, and labor skills, fueled by a cheap credit policy, is the most important characteristic of the World War II economy.

To outline this matrix shift, we examine the aircraft industry; the raw materials and metals industry; the machinery industry; the military sector; the science and medical sector; the investment and electricity sector; and the labor force. A subsequent installment of this report will tell the glorious history of the Manhattan Project.

Aircraft: During World War I, the airplane played almost no role. It traveled at a top speed of 100 miles per hour. During World War II, the airplane of course played a major role; it traveled at top speeds of 250 to 300 miles per hour, and used such revolutionary World War II discoveries as radar. Thus, tremendous wartime advances were made in the theory and practice of aerodynamics.

The changes in the production methods of aircraft were equally startling. The existing aircraft industry was considerably geared up; above all, the consumer automobile sector was closed down and converted to aircraft production. In October 1940, auto executives and their top production men had a meeting in a meat market hall in Detroit. The meeting was chaired by Bill Knudsen, former chairman of General Motors. Displayed throughout the hall were parts of planes: airframes, engine parts, and so forth. Those present were asked to examine the various parts and when they went back home, to draw up blueprints to see what parts could be produced at their plants. On Jan. 20, 1942, the War Production Board ordered the cessation of all auto production. The last passenger car came off the assembly line Feb 10. And, because of advance planning, within three months, war materiel came rolling off those lines.

The conversion of the auto industry was more than just changing the order of a few assembly lines, or replacing certain machine tools. The conversion meant in many cases ripping out all the assembly lines, replacing 70 or 80 percent of the machine tools, extending the size of the building, ripping up and replacing the concrete floor, and the like.

In many respects, the aircraft industry functioned as the leading or second most important science driver (depending on how one assigns the nuclear industry) during World War II. At its peak in November 1943, the army of aircraft-plant employees grew to 2.1 million, or 12.4 percent of the total manufacturing employees of the entire nation. (Imagine that 12.4 percent of all manufacturing employees were put into laser beam and other related industries, compared with the 0.001 percent currently so employed.)

More was involved than the sheer increase in employment. The production of aircraft had previously been a cottage industry operation. Assembly lines weren't in widespread use; almost everything was hand-crafted—just as it is in the nuclear industry today. For example, a Rolls Royce aircraft engine, used in some of the Spitfire aircraft the United States produced for Britain, required six months to produce by hand. American engineers took it apart, analyzed every step, and figured out how to mass-produce it in less than half the time.

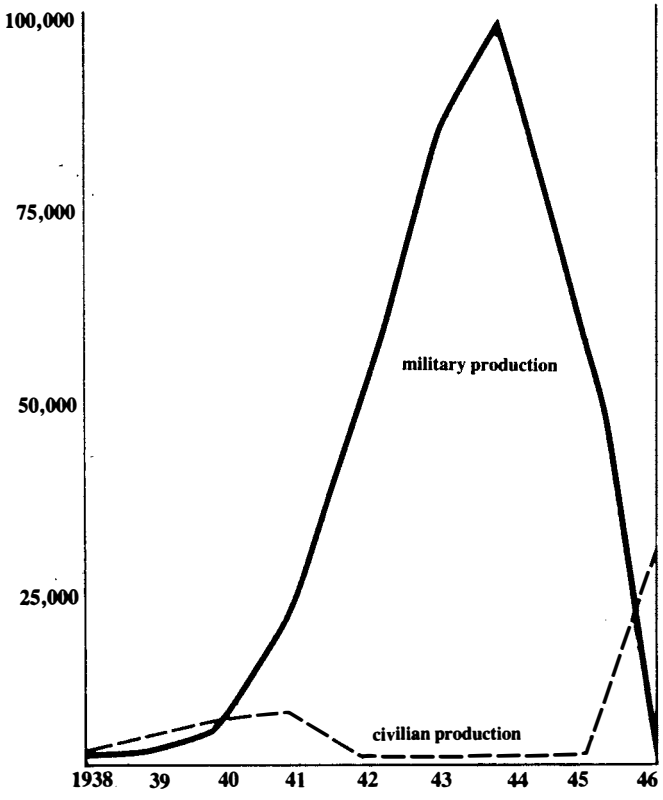
Planes were put on overhead assembly tracks. Fuselages, and other parts were standardized to a degree never existing before. New welding techniques were applied as we shall see below. Methods were devised for stretching the aluminum "skin" over the wing of a plane, to end the tugging and assembling process.

The results were spectacular. In 1939, the United States produced 5,865 planes of both military and civilian varieties. In 1941, President Roosevelt called for 50,000 planes to be produced over three years.

There were intense debates. Some said it couldn't be done. Others, the "all-outers," said it could be done in 21

Figure 5

1938-47 U.S. airplane output, military and civilian



months, instead of 36 months. But nobody predicted what a super-charged U.S. economy would actually produce. In 1944, the United States produced 96,000 planes in one year; the original Roosevelt proposal called for 16,667 planes per year. Had the "all-outer" plan been adopted, it would have meant 28,571 planes per year.

In 1944, the expanded aircraft industry produced 3.4 times the "all-outer" plan, 5.8 times Roosevelt's original plan, and 16.4 times the 1939 level of production (see **Figure 5**).

Each individual worker became more productive. One partial measure of this, the "Average Airframe Weight Accepted Per Employee" (the amount of metal, materials, etc. worked upon per worker) shot up from 22 pounds per worker in January 1940 to 96 pounds per worker in March 1943. Some of this increase simply represents the fact that heavier planes were being built, but a good part of the increase represents greater productivity. As a result, during the war period, the cost of a four-engine long-range bomber dropped from $15.18 per pound to $4.82, a saving of more than $500,000 on each plane.

Development of raw materials and metals

Aluminum: Aluminum was known as early as 1825, when Hans Oersted first produced pure aluminum metal. But production of aluminum is very energy intensive and U.S. output never exceeded 100 million tons until the war. Aluminum's lightness and toughness made it preferable to steel in World War II aircraft engines and bodies. As a result of the U.S. government's construction of brand-new aluminum plants, aluminum production shot up to 2,782 million tons in 1943, a 28-fold increase over 1939 levels.

Magnesium: Humphrey Davy had isolated metallic magnesium in 1808, but although the first commercial production of magnesium started in 1918, magnesium, even more so than aluminum, is a World War II discovery. Magnesium has two-thirds the weight of aluminum, is nearly as strong and abundant in nature, and is produced by a similar process. Magnesium production was less than 15 million pounds per year in 1939; by 1944, it was up to 366.5 million pounds, a twenty-four-fold increase.

Synthetic rubber: Synthetic rubber production is entirely a result of World War II. Without the war, the United States might have continued to rely on the British-Dutch-controlled International Rubber Regulation Committee, based in Malaya and the then-Netherland Indies, to supply its raw rubber needs. This cartel controlled 97 percent of the world's rubber supply. But after the Japanese invasion and occupation of this area, the U.S. government built 51 synthetic rubber plants, fighting Standard Oil of New Jersey, joint holder with I. G. Farben of Germany of patents on synthetic rubber production, patents which Standard refused to release for the U.S. war effort.

In early 1942, the United States had announced its synthetic rubber program. Within two years of that announcement, synthetic rubber production had gone from less than 2,000 tons per year to 700,000 tons per year, a 350-fold increase. One of the first synthetic rubber plants was built and put into operation in 287 days—the quickest construction engineering job in history. By the end of the war, synthetic

Figure 6

Machine tools—shipments and unit price

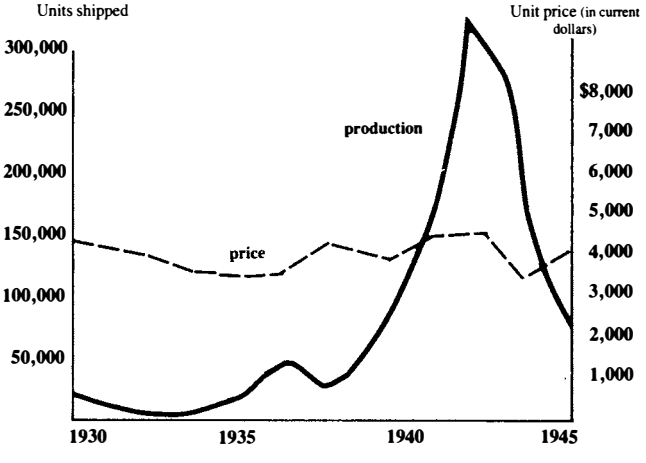


Figure 7
Productivity growth per unit of capital investment

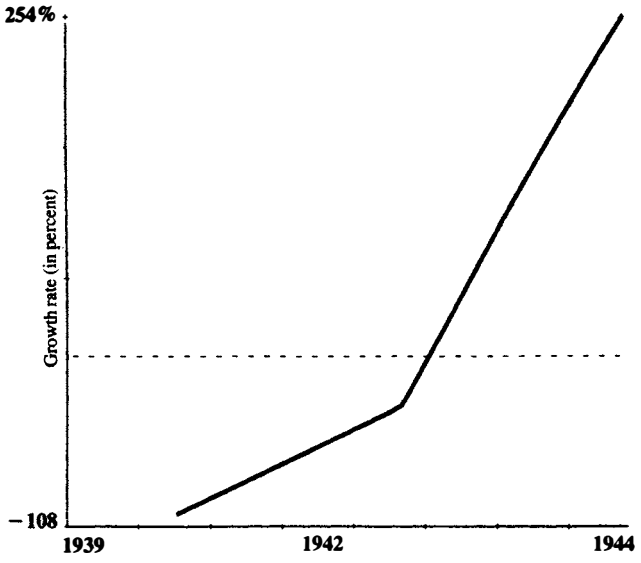


Figure 9
Value added, wages, and capital investment

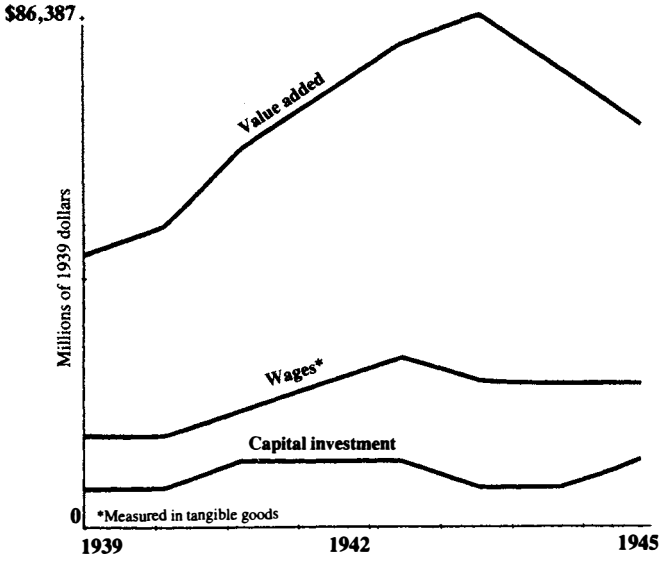


Figure 8
Productivity (tangible output/labor) by sector

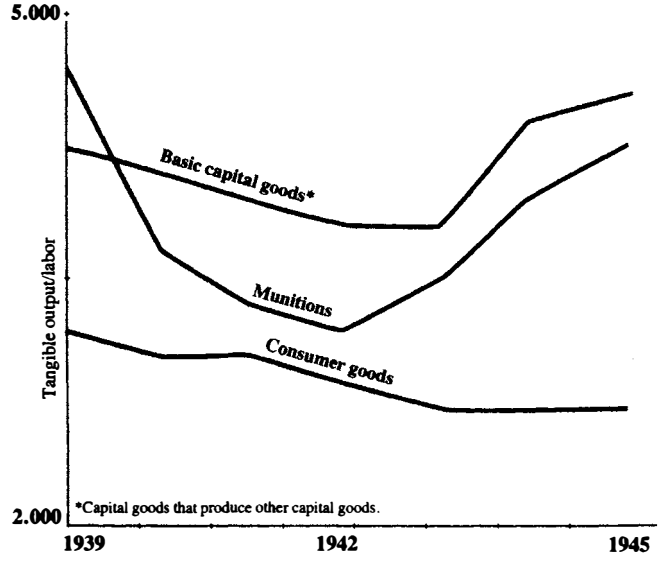
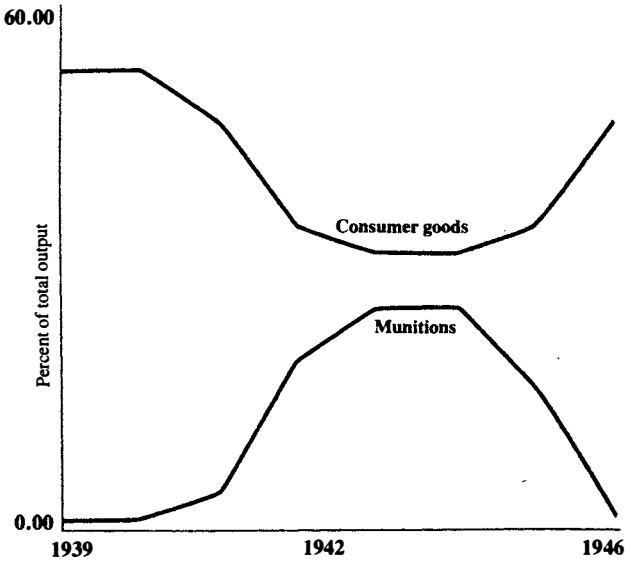


Figure 10
Output of leading sectors as a percent of total output



EIR's LaRouche-Riemann economic staff has conducted the only available computer-based econometric analysis of the World War II performance of the U.S. economy. A small sample of the findings is published here.

Figure 7 shows that in 1940 and 1941, years in which investment in the war buildup first slowly started and then in 1942, when the war investment got under way on a large scale, the productivity of each unit of industrial capacity then being installed was negative, but the situation improved in each successive year. Then, starting in 1943, when the new capital investment was in place, and even more was coming on line, the rate of productivity was spectacular, rising to 254 units of surplus produced for each unit of new capital investment in 1944.

Figure 8 shows the productivity (S/V) for three sectors, that is, how much surplus (S), is produced for each unit of productive labor (V) invested in. The productivity for capital goods that produce capital goods falls during the early years of the war buildup and then rises to 4.5. The productivity rise of the munitions sector, whose relatively skilled labor is using the newest and most productive equipment, is greatest of all.

Figure 9 shows wages of the productive workforce increasing 50 percent, and new capital investment (the scale seriously under-represents the rate of increase). These two changes produced a near doubling of value added, or the amount of value added to an item during the course of production.

Figure 10 shows that there was disinvestment and conversion of the consumer goods sector, quantified in terms of a decline in consumer goods output as a percent of total economic output from 55 to approximately 40 percent. Munitions production rose correspondingly. But while the consumer goods output became a smaller proportion of the total, the total grew, and the amount of consumer goods output did not decline.

rubber provided 87 percent of U.S. rubber needs.

Synthetic resins, plastics, and fibers: The entire range of such products, including plastics and synthetic fibers, which we take for granted today, was developed commercially during World War II.

Machinery

Machine tools: In 1938, the United States produced 34,000 machine tools. During World War II, investment was poured into machine tool plant capacity to produce more machine tools, because without them—boring, cutting, polishing, bending machines, and so forth—no plant and equipment could be constructed. By 1942, the United States was producing 307,000 machine tools, nearly 10 times the level of 1938, and 50 times the level of 1933.

But machine tools were also made far more productive. This was of crucial importance, especially in producing aircraft. For example, the engine for the Wright Cyclone 14 aircraft was composed of 3,500 differents parts, totaling 8,500 pieces, requiring an estimated 80,000 machining operations. Therefore, new machine tool techniques as well as machines were developed. In the Oct. 1, 1942 issue of *Automotive and Aviation Industries* magazine, George H. Johnson, then president of the National Association of Machine Tool Builders, provided an example:

"One of the most difficult and important assignments given the machine tool industry was the design and building of hundreds of special-purpose machines needed to convert the aircraft engine industry from small-lot to mass production. At the right is [a picture of] a specially designed machine which drills, countersinks and spotfaces 224 identical three-eighth-inch holes in an aluminum airplane engine crankcase. It works simultaneously on 32 holes from two different directions. These operations previously took two hours 12 minutes. This one machine now completes the job in 23 minutes," thus doing the job in five-sixths less time.

This increased productivity is reflected in another fact: as **Figure 6** shows, from 1930 through 1945, the average price of a machine tool, at $4,000, remained the same.

Industrial operations: Productivity gains were made in a variety of industrial operations, such as welding. From 1939-45, according to "Wartime Technological Developments," which was produced by the United States Senate's Military Affairs Committee Subcommittee on Mobilization in May 1945, industrial welding operations, which can take up to 10 to 15 percent of total construction time in the construction of plants or in assembly, were made 15 to 2000 percent more efficient and faster.

Military breakthroughs

Radar: The advance in aircraft included not only better and faster production methods, but, as cited above, advances in the aerodynamics and performance of aircraft, which called for better production methods and new technologies. Radar, which had been known since the 1920s, was only fully developed and exploited on a meaningful scale during World War II to guide planes on bombing runs, through foul weather, etc.

Vacuum tubes: Vacuum tubes are another World War II development, used in radar, but which also revolutionized radio transmission and receiving, and opened the door for the discovery of the computer.

Shipbuilding: The shipbuilding process, from keel-laying to completion of the ship, was standardized. Pre-assembled parts as well as new welding techniques were used. In World War I, at the height of the shipbuilding program, the construction of a Liberty ship with a displacement of 7,000 deadweight tons had taken 10 months. In July 1942, the average construction time for a Liberty ship with a displacement of 10,800 deadweight tons took 105 days (3.5 months). By mid-1943, the construction time of the same displacement Liberty ship took 40 days, a savings of 60 percent from the 1942 levels and 90 percent from the World War I levels.

The productivity gains in shipbuilding were so prodigious that the deadweight tonnage of the United States went from 10.5 million tons in 1939 to 53.0 million tons in 1945. By V-E Day, the United States had turned out the equivalent of two-thirds of the entire oceangoing merchant marine of all the Allied nations.

Medicine and science

Penicillin—Identified in the 1930s, the "wonder drug" penicillin is entirely a World War II drug. Because of the exigencies of war, it was introduced to U.S. troops in 1941, and supplied on an even larger scale for the armed forces starting in 1944, replacing sulfa. In 1945, penicillin began to reach civilian markets.

Electron microscope—The instrument that has opened man's eyes to the interior of the cell and the atom was developed during World War II.New investment and electrification In 1939, the value of U.S. plant and equipment was placed by the Commerce Department at $39.4 billion. During the five years of the war buildup it increased by $29 billion, or more than 75 percent.

That leap reflected not only high industrial investment but specifically the application of electricity, in both the construction of new capacity and the utilization of capacity which had been idled or underutilized in the 1930s. Between 1939 and 1945, the amount of installed electrical capacity increased by 20 percent. Using both this new capacity, and the electrical capacity which had been established during the 1930s—such as the Tennessee Valley Authority and the Grand Coulee Dam, whose capacity represented an existing, but largely untapped resource, it was possible to increase the amount of electrical kilowatt hours consumed by manufacturing from 79.0 billion in 1939 to 144.3 billion in 1945.

This use of electricity represented "free energy" in a higher form that could enable the economy to suddenly realize its potential. This allowed Americans to attempt industrial processes they had never tried, nor thought possible.