Wartime Production Achievements

AND THE

RECONVERSION OUTLOOK

Report of the Chairman

WAR PRODUCTION BOARD

OCTOBER 9, 1945

WAR PRODUCTION BOARD

WASHINGTON, D. C.

November 2, 1945

DEAR MR. PRESIDENT:

At the hundredth and final meeting of the War Production Board, held on October 9, 1945, I presented the attached report on wartime production and the reconversion outlook. This is indeed the record of a great American achievement, but lest we lose the lesson it has taught us, I wish to warn again against any complacency regarding the ease of mobilizing this Nation for war—a warning in which members of the War Production Board join. In the recent war the United States was not a belligerent until two years after the invasion of Poland. We were able to borrow precious time in which to prepare for the vast production of munitions that doomed the Axis to defeat. This tooling-up period will not be vouchsafed us again. Therefore, we must take steps now to capitalize on the know-how gained in this war to maintain up-to-date plans for rapid mobilization for the next emergency.

As you know, I have already arranged for an objective analysis of the history of the Board, which will provide a starting point for defense planning. In addition, and to me most important, the Government must have a skeletal peace-time organization, charged specifically with development of plans for the wartime industrial mobilization. Just as you have military agencies under your direction developing the strategic plans to cover the eventuality of war, it is essential that you have a civilian agency in the Executive office to develop and keep current a practical plan for promptly mobilizing the economy in case of emergency. The broad questions of public policy that will confront such an agency are too important to leave for decision at lower levels of the Government; and they go too much to the very structure of our society to permit their removal from immediate civilian control.

Such an agency as I propose would obtain the advice and active collaboration of men who have played important roles in the mobilization of the economy in World War II. Their appraisals of the Nation's recent experience and their recommendations as to better ways of meeting mobilization problems in the future should carry great weight. Acting with the advice of wartime officials, other Government agencies, and outside groups, it would develop and keep up to date specific plans for mobilization of the economy, calling to the attention of the President and the Congress any measures that should be taken in peacetime to insure against fatal production delays at the beginning of a national emergency.

Upon the adequacy of our preparations for mobilization of the economy may depend the fate of this Nation.

Respectfully,

J. A. KRUG, *Chairman*

THE PRESIDENT
The White House

Contents

PART I

PART II

LIST OF CHARTS AND TABLES

Part I

GENERAL SUMMARY

As we move back along the road toward peace, it seems to me that there are two things we ought constantly to bear in mind. One is that this country has just demonstrated a degree of resourcefulness, of strength, of productivity far greater than many of us dared imagine a few short years ago. The second is that, despite all our problems in reconverting to peacetime production, the very fact that it is reconversion—a going back to the kind of things we know best how to do—makes it a far less difficult task than the one we have performed so well in the past five historic years.

It will be a long time before we can appraise in proper perspective the changes in our economy which these five years have brought—before we can write the definitive history of the United States war effort and the part which the War Production Board played in that effort. What I intend to do in this report is to give a brief preview of that history. I shall also take the risk of offering some predictions as to what we may expect during the remainder of the reconversion period.

CIVILIAN WELL CARED FOR

We have heard a great deal about total war and full mobilization. It may not be generally realized that, great as our war effort was, at no time during the struggle did it absorb more than two-fifths of our total national output. And we continued to provide the civilian economy with a greater total amount of commodities and services than in such good prewar years as 1937 or 1939.

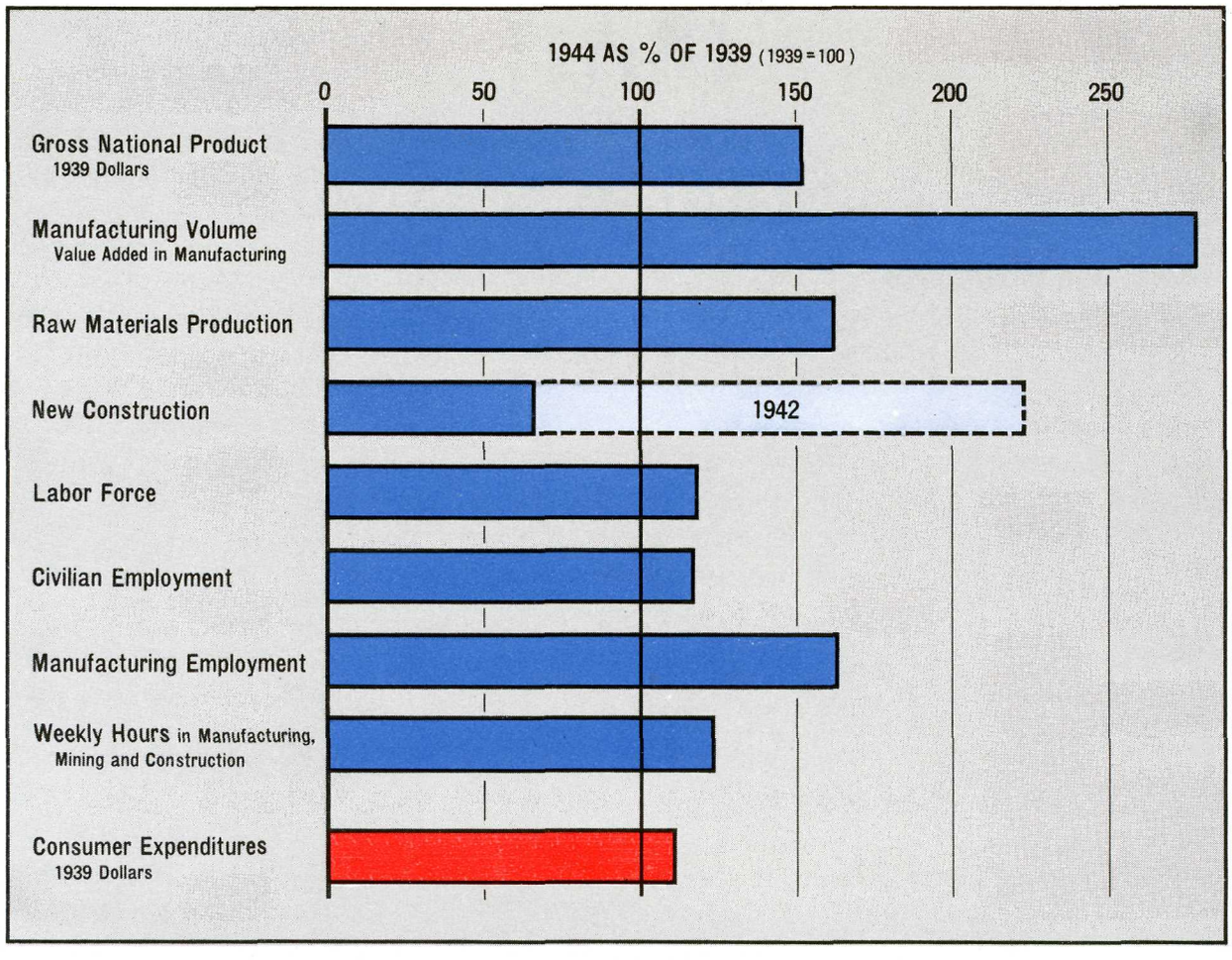
We did this by working harder and more efficiently—by superimposing war production on our normal production job, instead of by substituting guns for butter. In the case of consumer durable goods, there were some cuts, but we supplied larger amounts of soft goods and services to make up for the new automobiles and electric appliances and aluminum cooking utensils we had to deny ourselves. Throughout the war, the people at home were subjected to inconvenience, rather than sacrifice.

Look for a moment at the chart on page 2 ("Wartime Expansion in the U. S.—1939 to 1944"). It shows that, between 1939 and 1944, the gross national product of the United States—the total output of goods and services—rose by something more than 50 percent after allowance for price changes. (In dollars, before price adjustments, the increase was almost 125 percent—from $88,600,000,000 to $198,700,000,000.) Volume of manufacturing far outpaced the general rise: It nearly tripled in those five years as our plants poured out planes and guns, ships and shells, tools and trucks—plus civilian goods in huge volume. Output of raw materials increased by 60 percent.

New construction volume mounted sharply in the early war years as we hurried to build new war plants, military camps, housing for defense workers. In 1942, it was at more than double the 1939 level. After the most urgently needed facilities had been provided, however, manpower and materials had to be concentrated more on current production and less on facilities for still greater production in the future. By 1944, new construction volume was one-third below 1939.

The tremendous increase in gross national product at a time when manpower was being steadily drawn into the armed forces would not have been possible if we had not called on the housewives of the nation, the youth of school age, the oldsters who had earned retirement, and the physically handicapped to supplement—and in part

WARTIME EXPANSION IN THE U. S.—1939 to 1944



to replace—those who would normally have staffed our industries, trade, and services. The labor force increased in five years from 54,100,000 to 64,000,000—up almost 20 percent. Out of these 10,000,000 new workers, plus all but a few hundred thousand of the 9,000,000 unemployed of 1939, came the manpower—and womanpower—to replace the 10,000,000 added to the military services and to add 7,500,000 to civilian employment. Most of this addition went into manufacturing plants. Agriculture and, later, construction actually lost workers.

Even 7,500,000 more workers would not have been enough for the job actually done had they not been willing to work longer and harder. Between 1939 and 1944, the average work week increased from 37.7 to 45.2 hours—20 percent—in manufacturing, from 32.4 to 39.5 hours in construction, and from 32.3 to 43.9 hours in mining. At the same time, productivity—output per man-hour—climbed sharply, as volume increased, manufacturing methods improved, and workers responded to appeals to move the munitions to the fighting fronts faster and faster.

The last bar on the chart shows that consumer expenditures last year, after adjustment for price changes, were still slightly higher than in 1939; the munitions production which defeated the Axis all came out of additions to the country's output. Yet this increment was considerably greater than the total munitions output of our enemies; it was also greater than the munitions output of our allies.

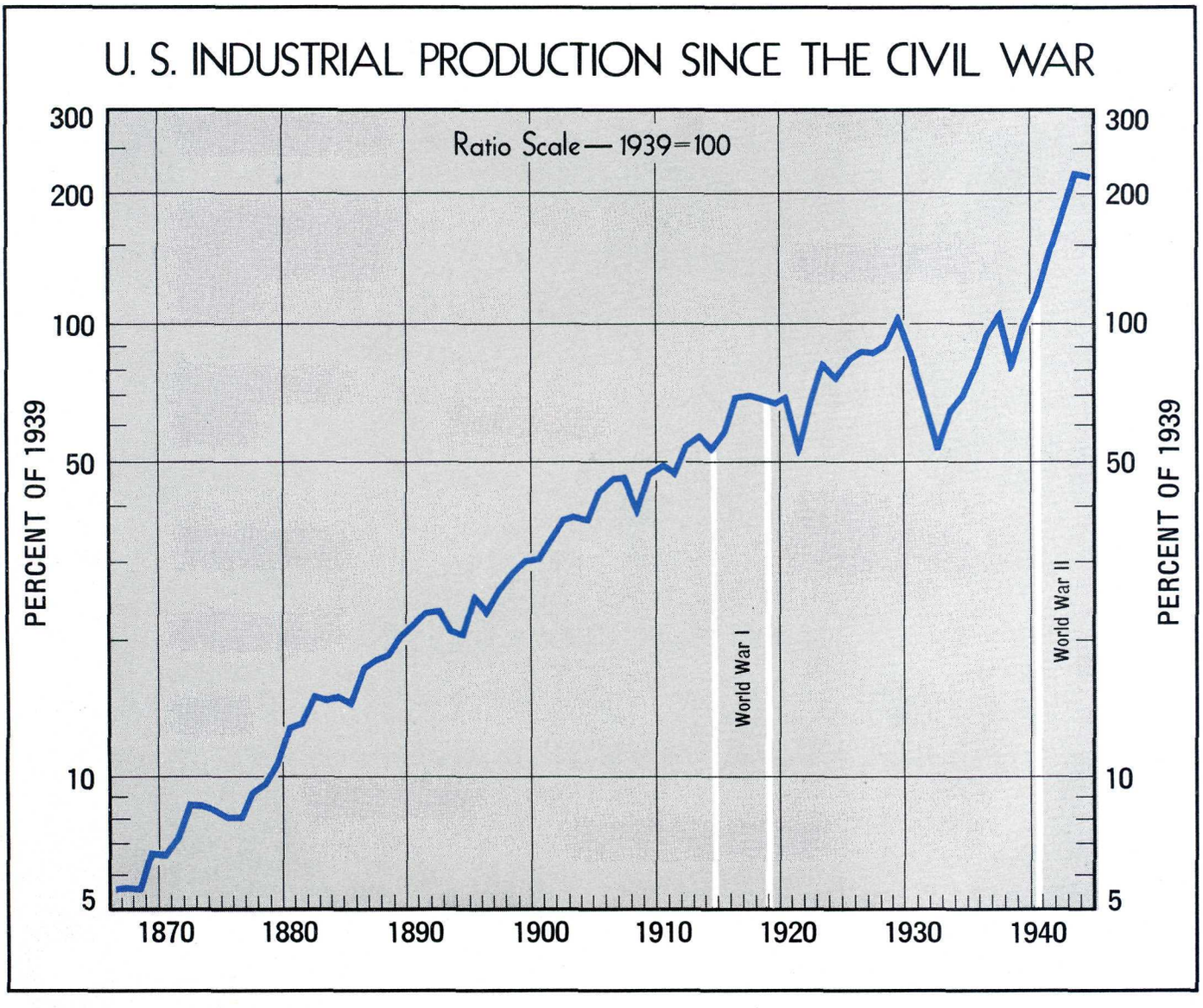
I think we can all be immensely proud of the ability

of this peaceful nation to make itself preeminent in military production and at the same time provide so well for our people at home. I hope I may be pardoned a special measure of pride in the part which the War Production Board played in mobilizing these resources and guiding them into the proper channels.

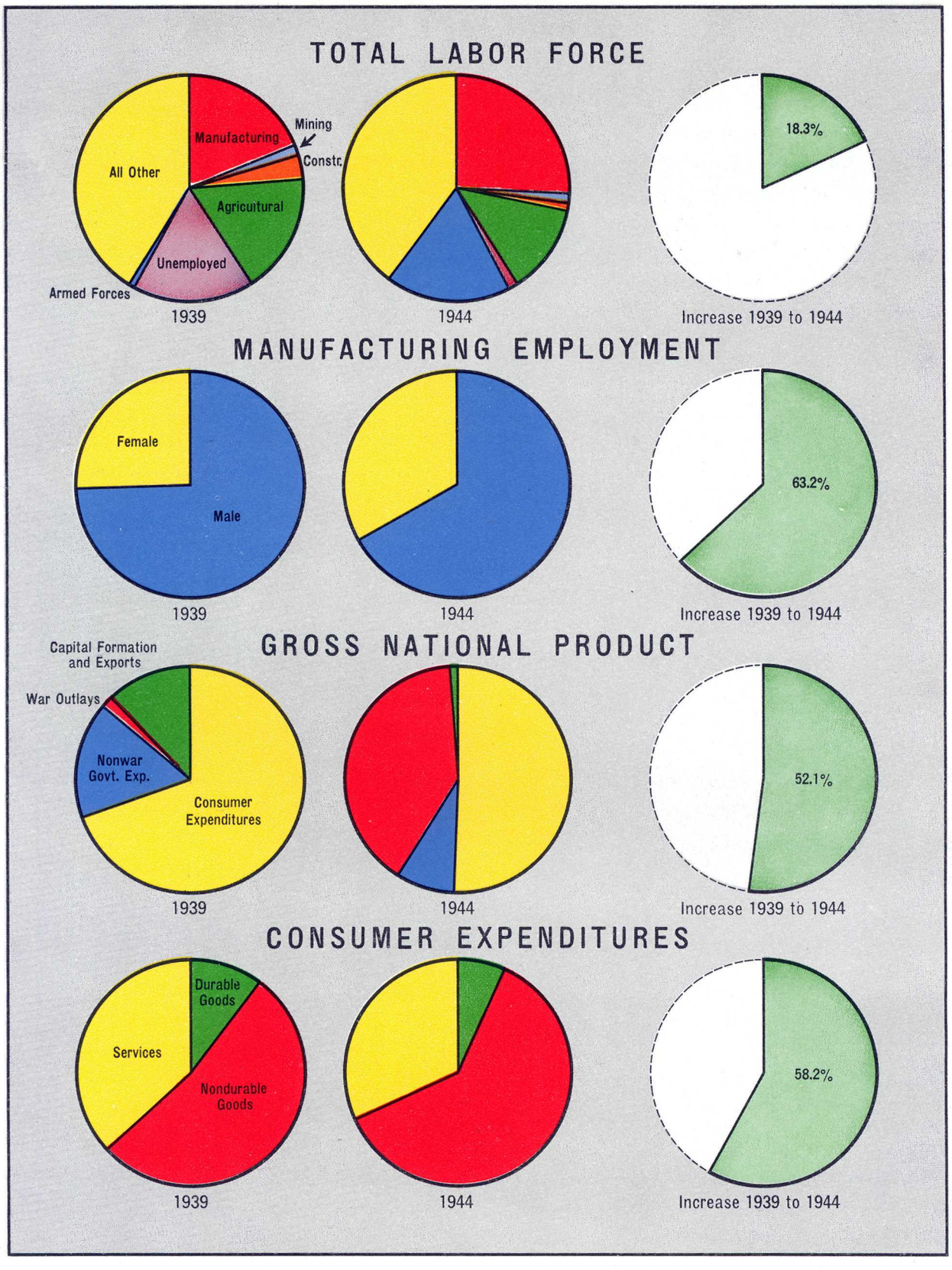
WARTIME SHIFTS

The rise in industrial production (manufacturing, mining, and construction) during the war broke all precedents. In the five years from 1939 through 1944, industrial production more than doubled, rising at the rate of over 15 percent a year. Even in the recovery from the deep depression of the 1930's—previously the fastest rise on record—the gain was only 12 percent a year. And in the 1930's, we were merely recovering lost ground, instead of pushing forward to successive new highs.

As the accompanying chart ("U. S. Industrial Production Since the Civil War") shows, from the end of the Civil War to the year when Hitler's armies marched into Poland, the average rate of industrial expansion in this



SOME WARTIME SHIFTS IN U. S. ECONOMY



country was only 4 percent a year, and the rise during the last World War averaged only 7 percent annually. If we had maintained the long-term average rate, 1944 production would have been only 60 percent of what was actually achieved.

So sharp an expansion in so short a time naturally required drastic readjustments in the economy. Some of these readjustments are graphically illustrated in the next chart ("Some Wartime Shifts in U. S. Economy"). Look, for example, at the shifts that took place within the labor force. Manufacturing employment increased from 10,151,000 in 1939 to 16,558,000 in 1944 and it expanded its share of the labor force from 19 to 26 percent. The manufacturing industries as a group provided work for almost a third of all civilians gainfully employed in 1944, compared with less than one-fourth in 1939.

All of the other segments of the labor force except the armed services reduced their percentage of the total, though there was an increase in absolute numbers in miscellaneous civilian employment, which includes finance, trade, services, and government. A good part of the increase in manufacturing, as the second panel on the chart shows, was achieved by getting more women to take factory jobs. The number of female factory workers almost doubled between 1939 and 1944 while the number of male workers was increasing only 35 percent. As a result, the percentage of women on factory payrolls increased from one-fourth in 1939 to one-third in 1944.

These comparisons are by industry, rather than by product, and it is difficult to segregate employment directly related to the war effort from that contributing to the support of the civilian economy. The best estimates indicate that about 57 percent of manufacturing employment in 1944 was on war work, compared with one or two percent in 1939. That means that the number of factory workers producing for civilians declined by something like 30 percent in the 5 years.

A better picture of the diversion of our efforts to war is shown in the lower part of the chart. In 1939, the year following Munich, this country devoted less than 2 percent of its total national output to war, and about 70 percent to satisfying immediate civilian wants, the remaining 28 percent going to civilian government expenditures, private capital formation, and exports. By 1944, war outlays had mounted to 40 percent, and the civilian share—though just as large in physical quantity and 58 percent larger in dollars—represented only half of our total output.

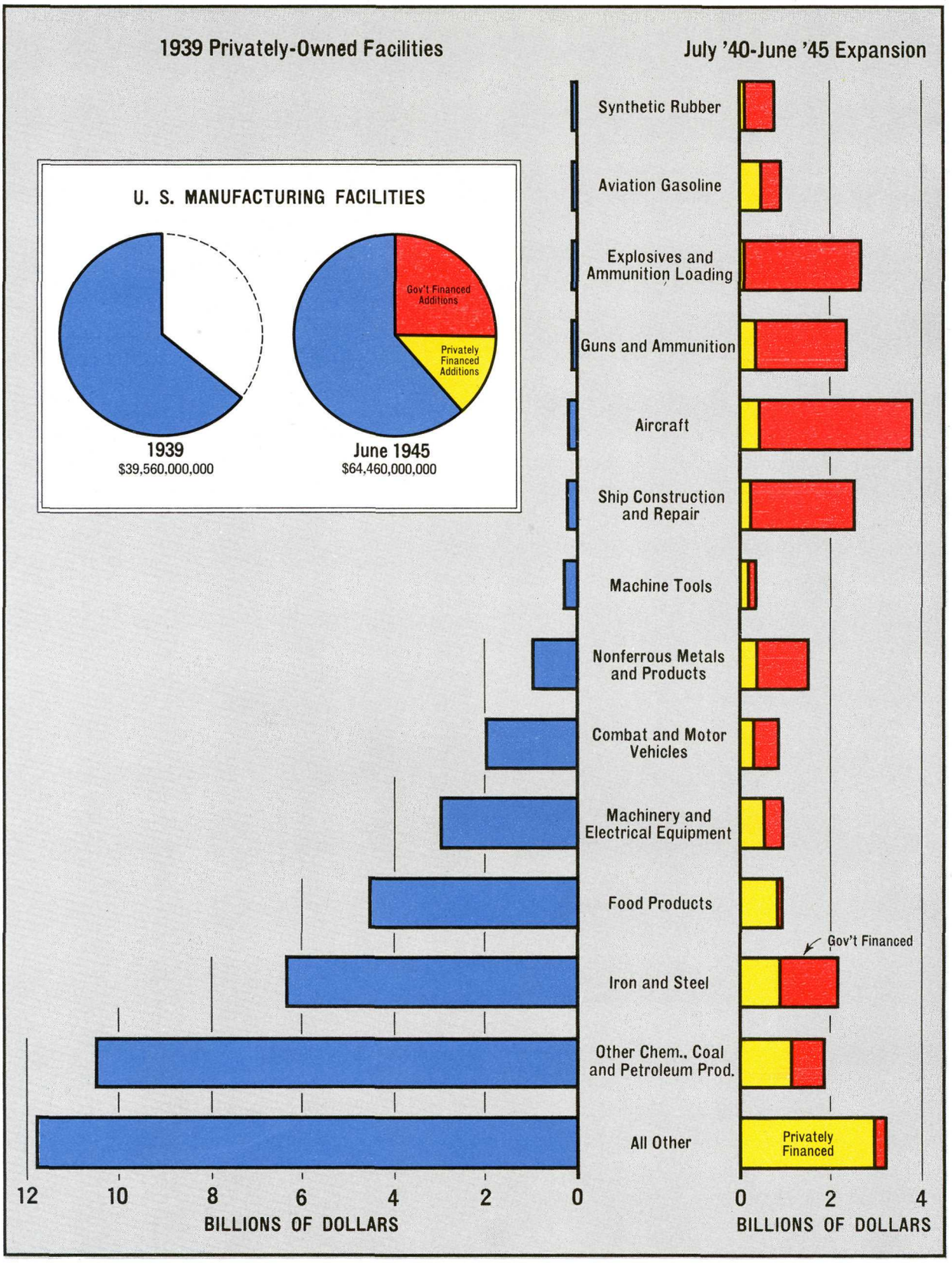
How little change the war made in our buying habits is indicated in the final panel on the chart. In 1939, one-tenth of total consumer expenditures were for durable goods. By 1944, war restrictions on durable goods production had cut this by only one-third, largely because production of furniture, repair and maintenance parts, and health and safety supplies was at record levels. The increase in nondurable goods more than compensated for the drop in hard goods. We had almost as much clothing—the textile squeeze did not hit us badly until 1945, and its duration will be short—as much food, though not necessarily the kinds we should have preferred to buy, as large a volume of services, and more miscellaneous goods than before the war. And because the goods we could not buy were durable goods—goods that last—the deprivation was even less serious than it appeared. Automobiles developed squeaks and rattles, but most of them stayed on the road. Electrical appliances needed more frequent patching, but they could be kept in service.

GOVERNMENT GUIDANCE

One other far-reaching change in our economy should be mentioned here. To an extent unprecedented in our history, even in previous wars, the national economy has been guided by Washington. Every industrial plant built in the United States in these past few years has had to have government authorization. Scarcely a ton of steel or copper or aluminum could be fabricated without government approval. Over a large area of production, the decisions as to what should be produced, who should produce it, and to whom it could be sold were government decisions. Prices and wages were controlled by government, and government helped to guide the movement of labor from plant to plant, from industry to industry, and from region to region.

Fortunately, this country never had to impose upon itself the degree of regimentation to which our enemies

MANUFACTURING FACILITIES—WARTIME GROWTH



and our allies were subjected. But the burden of restrictions and regulations—on production, on distribution, on prices, on wages, on personal liberties—was large for a nation accustomed to so much freedom. Enforcement would have been impossible had not our people accepted with good grace the necessities of war and cooperated wholeheartedly to make the system work, confident of a prompt return to our traditional liberty of action.

BASIC PROBLEMS

The job of the War Production Board and its predecessor agencies, stated in the simplest terms, was to keep our economy strong and mobilize the nation's industry to assure the fighting forces of the material they needed to win the war as quickly as possible. That job resolved itself into two parts: first, to build up production, and second, where production could not be built up rapidly enough, to divide the shortages so that those requirements least essential to the war effort stood at the end of the queue.

In the effort to build up production, there were three basic problems with which we were continuously struggling throughout the defense and war periods: (1) to provide the raw materials from which to fabricate military and essential civilian products; (2) to provide the plant and equipment to process these materials and assemble end items; and (3) to staff the plants adequately.

There was never a time, in war or peace, when materials supplies, plant facilities, and manpower were in perfect balance. During the war, when demand for manufactured products was virtually insatiable, a surplus of one of these elements inevitably created a shortage of the other two.

The timing varied for different products and different industries, but in general the acute shortage as the defense effort first got under way was in facilities for finished munitions products—plants, equipment, and above all, machine tools. As we expanded capacity for munitions production, by construction of new plants and conversion of old, by spreading contracts and subcontracts to thousands of small companies, and by an all-but-incredible expansion in machine tool output, we passed on to a second phase. We could no longer produce raw materials fast enough to satisfy the voracious appetites of the new manufacturing plants.

Finally, as we increased supplies of industrial raw materials, and Selective Service took its toll of workers, it became increasingly difficult to find the men and women to feed these new supplies into the new machines, so that they could keep pouring out more and better munitions products.

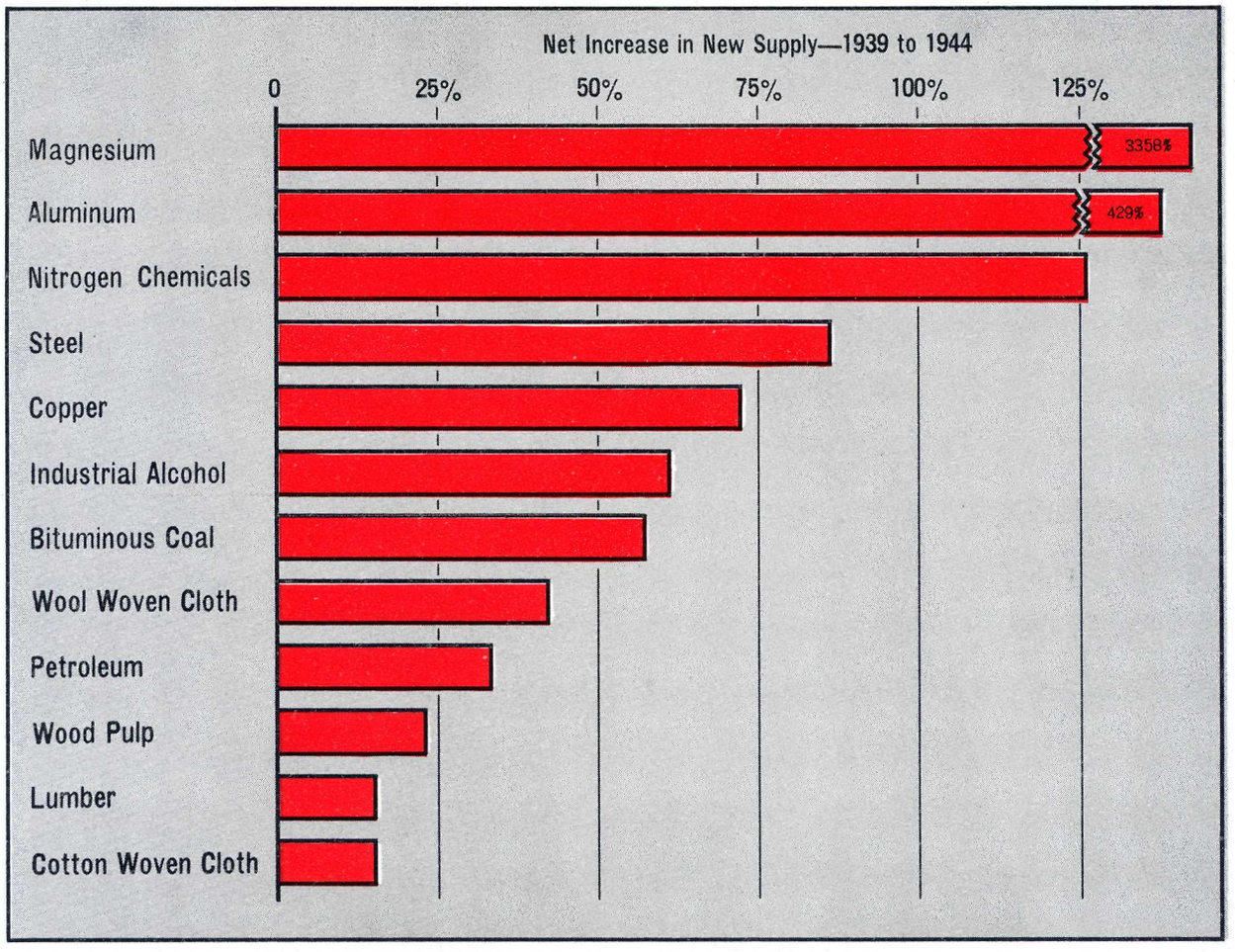
The chart ("Manufacturing Facilities—Wartime Growth") indicates the job that was done in providing new manufacturing facilities. The total manufacturing capacity of the country in existence in 1939 (excluding government arsenals and Navy yards) had cost about 40 billion dollars to build. To that capacity, in the next 5 years, was added some 25 billions of new plant and equipment, including expenditures to convert peacetime industry to war. Making due allowance for such factors as depreciation in prewar plant and higher wartime construction costs, it is a fair estimate that manufacturing capacity in the past 5 years was increased by close to one-half. Two out of three dollars of the cost of this expansion was borne by the Treasury, and on a good part of the remainder the Treasury paid the bill indirectly through accelerated amortization under certificates of necessity.

As the chart also shows, several new industries were built virtually from scratch. Before the war, we had no synthetic rubber or aviation gasoline plants of any size, and the explosives, gun and ammunition, aircraft, and shipbuilding industries were pygmies when measured against wartime needs. Some of the big expansions in other industries—aluminum, magnesium, certain plastics, plasticizers, and other chemicals, combat tanks—are hidden in the group averages.

The greatest growth in facilities came early in the war years; more than half of the total additions during the 5 years had been completed by 1942, and more than three-fourths by 1943. The peak in raw materials production came later; for industrial raw materials in the aggregate, supplies continued to expand until early 1944.

For a bird's-eye view of the growth in new supplies (domestic production plus imports) between 1939 and 1944 of a representative group of industrial raw materials, look at the next chart ("Industrial Raw Materials—Growth in Supply"). Magnesium was, of course, a

INDUSTRIAL RAW MATERIALS—GROWTH IN SUPPLY



star performer. It was just beginning to get into industrial use, at the rate of 10 or 11 million pounds a year, before the war. By 1944, total installed capacity was 586 million pounds annually. Demand passed its peak at the end of 1943, but requirements for bombs, aircraft, and other uses were still large enough in 1944 to justify production of some 366 million pounds. The big gain in aluminum—which had also passed its peak in 1943—directly reflected the growth in aircraft output. Nitrogen chemicals were needed both for explosives and for increasing food production. Industrial alcohol went to make butadiene for synthetic rubber.

The net gains in lumber and cotton cloth were small production expanded sharply in the early war years and then steadily declined. Because of the low wage scale in textile mills and in some sections of lumber production, these industries passed their manpower peaks fairly early in the game; by late 1942 they were unable to recruit enough workers to offset their losses to Selective Service and to more glamorous and better-paying munitions plants. As the manpower chart ("Manpower—Up and Down") shows, the coal industry was under the same handicap. By early 1944, the steel industry, too, was losing workers.

Other industries had the same experience, and by late 1944, the manpower recruitment drive was a race in a squirrel cage. Men were desperately needed, not only in the textile mills and lumber camps and coal mines and steel mills, but also in the tire plants, lead mines and smelters, ship repair yards, rocket and shell loading

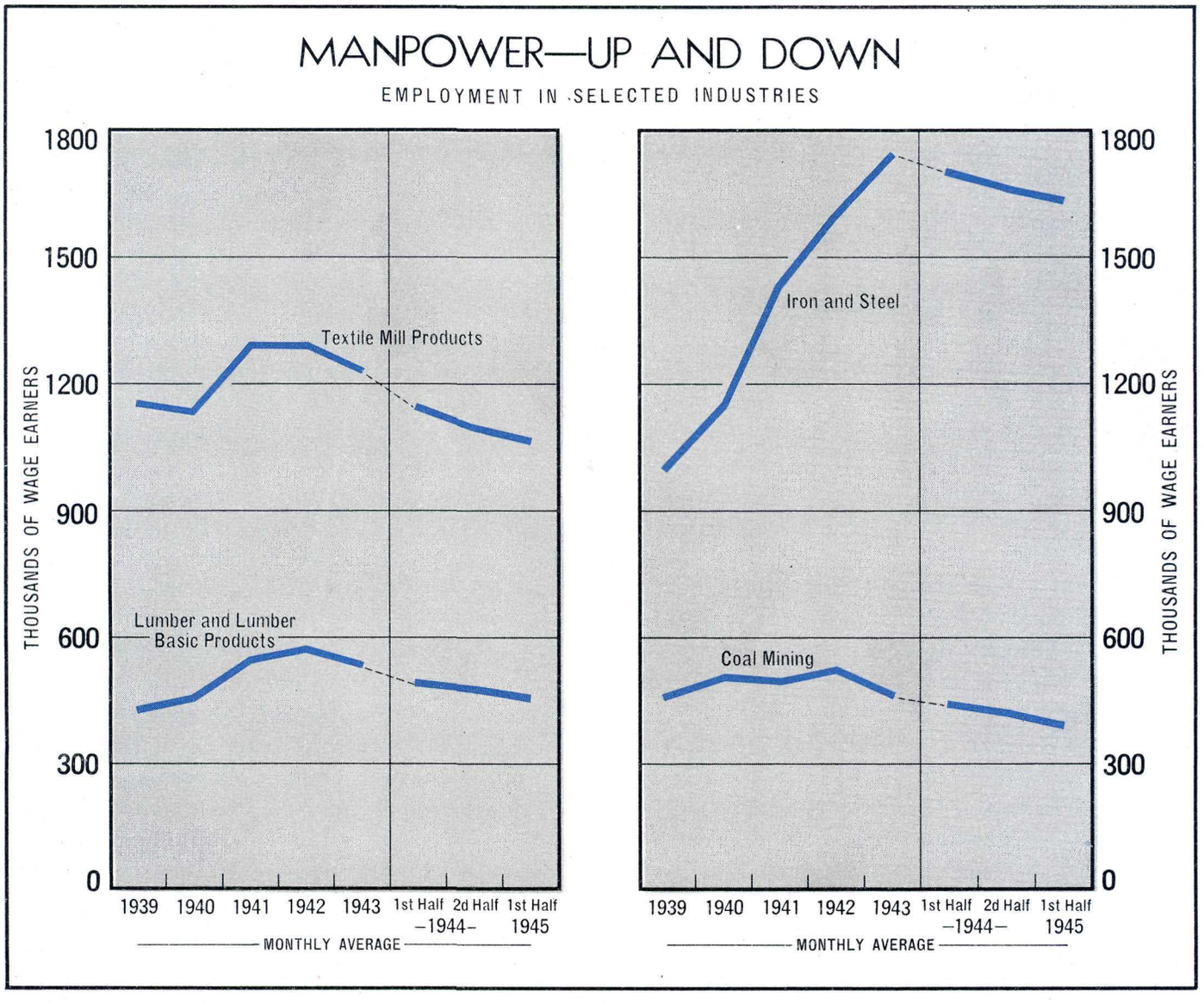
plants, foundries, many chemical plants, most of the aircraft plants, and elsewhere. By early 1945, after the German offensive in the Ardennes and the step-up in Selective Service withdrawals of previously deferred industrial workers, there was scarcely an industry which was not short of manpower or afraid it was about to lose its skilled workers. The German collapse staved off what might have been a desperate manpower shortage.

OTHER GENERAL PROBLEMS

Facilities, raw materials, and manpower were the three basic problems in war production. But they were not the only problems.

One of the most difficult, and one that was never fully solved, was to determine exactly what production goals to aim at. As the procurement agencies and the War Production Board gained experience, requirements estimates came closer and closer to the mark, but it was never possible to make an exact science of such calculations, even as applied to military needs. And the extent to which the civilian economy could be squeezed at particular points without adversely affecting the war effort could not be precisely calculated; it had to be determined by trial and error.

The inability to nail down requirements complicated the problems of planning facilities expansions, determining priorities, and scheduling production and shipments. That the priorities and scheduling operations



worked as well as they did is a tribute to the cooperative spirit in which the military services, the other war agencies, and industry accepted a necessarily complicated control system.

Fortunately, it proved unnecessary to establish any very extensive policing system to assure compliance with WPB orders, regulations, and directives. Occasional chiselers there were, and when we discovered them we cracked down hard. But we depended for enforcement primarily on the patriotism and the conscience of the American people, and the American people did not disappoint us.

INDIVIDUAL PROBLEMS

In this brief summary of the part which the War Production Board played in the victory over which we are now rejoicing, I shall not discuss the multitude of individual problems which we faced, or the manner in which we solved them. I am, however, supplementing this report with a number of examples of the more important of them—the construction and facilities program; the expansion of production and control of distribution of steel, textiles, and a number of other representative raw materials; and the performance of several of the major industries. (See pp. 31 and following.)

THE MUNITIONS PROGRAM

In the beginning, the military services had too little of everything, and their needs were out of all proportion to immediate production possibilities. No procurement schedules were developed in the defense period before Pearl Harbor; instead, there were merely statements of the quantities authorized to be purchased under existing appropriations.

In 1940 and 1941, the Services were procuring munitions in an economy which was also engaged in unrestricted civilian production. As the defense appropriations were enacted, their efforts were directed toward the quickest possible obligating of all available funds and the rapid procurement of equipment to clothe, house, and train the growing "civilian" Army and Navy. This was the period of broomstick guns and tarpaulin-armored tanks.

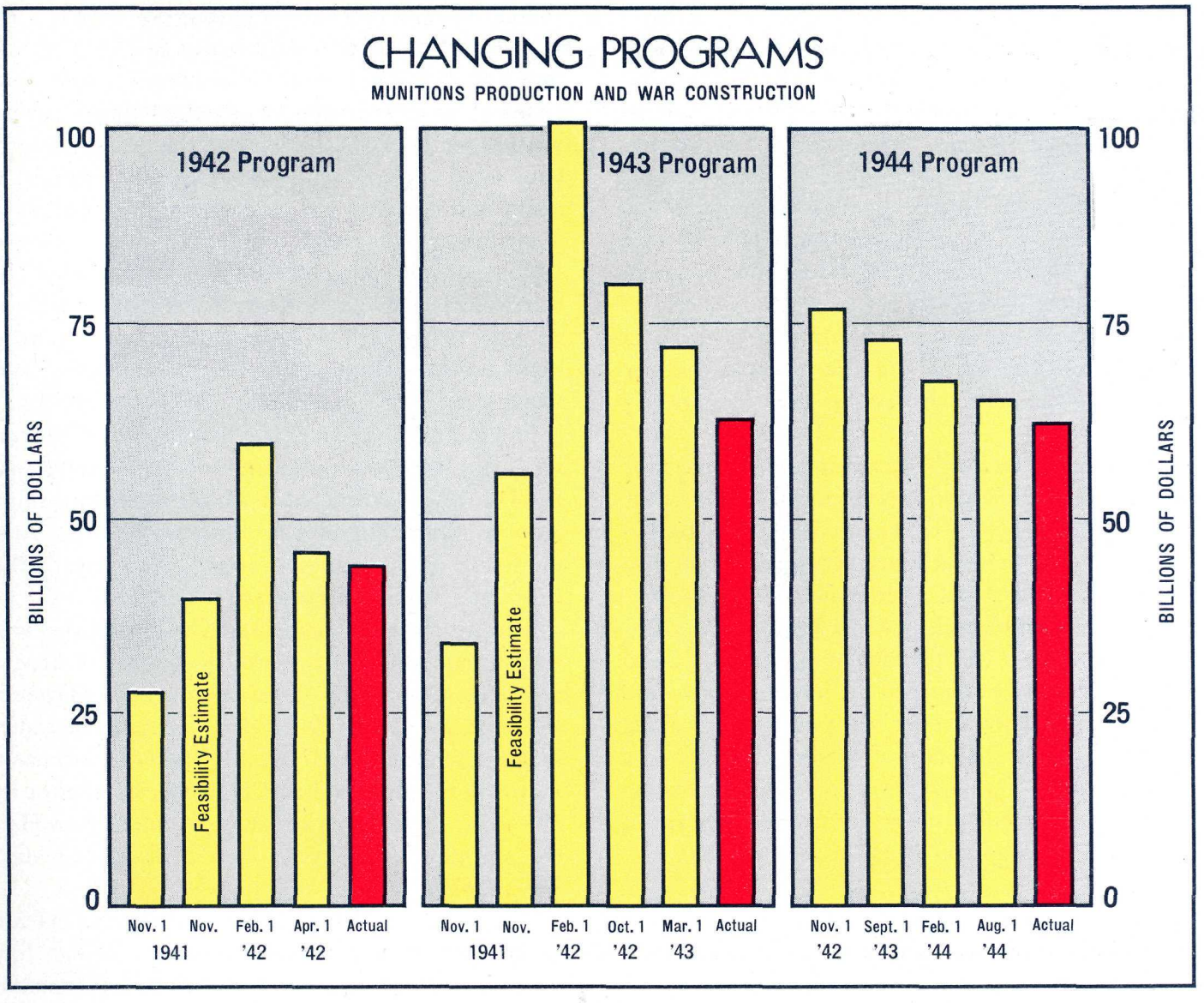
When industry could not meet the expanding needs, purchases were made "off the shelf." The Quartermaster Corps, for example, was supplying the new recruits with thirty-odd types of shirts, purchasing anything that was reasonably close to regulation color and of any obtainable quality. Orders were superimposed on each other with no real assurance that deliveries would be made as scheduled. The absence of fixed fiscal dates during which funds had to be obligated led to a looseness of procurement, and those who were guiding the operations of the War Production Board's predecessor agencies spent many sleepless nights trying to develop a program concept which would relate military requirements to a definite time interval.

The first munitions summary evaluation, which covered the 1941–42 fiscal year, was developed by the War Production Board from information on budget requests of the military, plus fragmentary information on schedules. With both production plans and production reports then far from reliable, this program was a crude one.

From that time on, methods of planning were successively improved and concepts of feasibility were continuously revised. But the process was slow. Even after a production record had been built up and some measure of the adaptability of American industry was available, it was a difficult enough task to estimate operational and pipeline needs in a war which was being fought on four continents and on all the oceans of the world—a war in which needs for cargo ships depended on the degree of success of the enemy's submarines and torpedo planes, needs for bombers were subject to the efficiency of enemy fighters and antiaircraft, needs for radio tubes could be suddenly skyrocketed by a lucky German bomb hit on a British tube factory. And, of course, production plans were constantly being revised by changes in models, designs, and specifications growing out of inventions and the lessons of battle experience.

CHANGING SCHEDULES

In November 1941, munitions production and war construction scheduled for 1942 totalled about 28 billion dollars at present munitions prices. (The program fig-



ures for earlier years in this discussion have all been adjusted to present standard prices, for consistency with the record of munitions production, which has been maintained in these "standard" prices). However, Donald Nelson at that time estimated potential production for 1942 at 40 billions—more than 40 percent above the schedule—and figured the 1943 potential at 56 billions (60 billions at 1941 prices). He urged the Military Services to develop programs consistent with these higher limits.

A month later, with the attack on Pearl Harbor, the President directed the Services to procure to meet their requirements for an all-out war. In a message to Congress, he set goals for key items that dwarfed any previous figures—60,000 airplanes, 45,000 tanks, 20,000 anti-aircraft guns, and 8,000,000 deadweight tons of merchant shipping for 1942, with far higher goals still for 1943.

The requirements program presented immediately afterward was received with considerable skepticism, since it called for total munitions production and war construction equivalent to 60 billion dollars for 1942 and 101 billions for 1943 (see chart above, "Changing Programs"). It was immediately evident that these programs were far above feasible limits.

As reviews were made, and as considerations of feasibility forced changes in the program, the projected levels were gradually reduced. By April 1942, the 1942 program for munitions and war construction had come down from 60 to about 50 billions, and the actual total for the year was 44 billions.

669713 O - 45 - 2

In the same two months—from February to April 1942—the 1943 program moved down from 101 to 75 billions. In the following months, as the Navy and Maritime programs expanded steadily, it was built up until, in the fall of 1942, it approximated 80 billions. When Donald Nelson again insisted (in October 1942) that this total exceeded the economic potential of the country, estimated at 66 billions (75 billions at 1942 prices), the Joint Chiefs of Staff reviewed the program, and adjustments brought it down to approximately 70 billions. By March 1943, it had again crept up to 72 billions. The total of munitions production and war construction actually achieved for the year was 63 billions.

Part of the reason for the apparent failure to meet the program was the planned overstatement in most of the military schedules. "Incentive scheduling" was used in the belief that it would achieve greater production than schedules based on actual expectations. This policy created inevitable problems in material and manpower allocation, which were only partially minimized by general recognition of the existence of the incentive factor and the consequent allowance for overstatement in making allocations against the material requests of the services. With the gradual, though never complete, elimination of incentive scheduling, more precise measurement of materials and manpower needs became possible.

CRITICAL PROGRAMS

After mid-1943, when military needs for some classes of goods were being fully satisfied, the period of production for quantity's sake came to an end. For the remainder of the war period, the major problems were in special items or materials—in what we later came to call the critical programs. These critical programs were constantly shifting; at one time or another they included a long list of common components (engines, turbines, electric motors and controls, friction and antifriction bearings, valves and pipe fittings, heat exchangers, compressors, etc.), and such items as aircraft carriers, destroyer escorts, landing craft, synthetic rubber, aviation gasoline, many types of aircraft, tires, trucks, various classes of ammunition, attack transports and cargo vessels, and of course, the atomic bomb.

The peak of the munitions program was reached in the last two months of 1943 (see chart "U. S. Munitions Output"). Thereafter, the "capital goods" of war, such as guns and tanks, were in sufficient supply to permit cuts in total production while continuing and increasing output of the more desirable weapons. Ship production was still on the increase; output of the heavier, longer-range types of planes continued to rise; and expendable items, such as bombs and ammunition, were called for in increasing quantities.

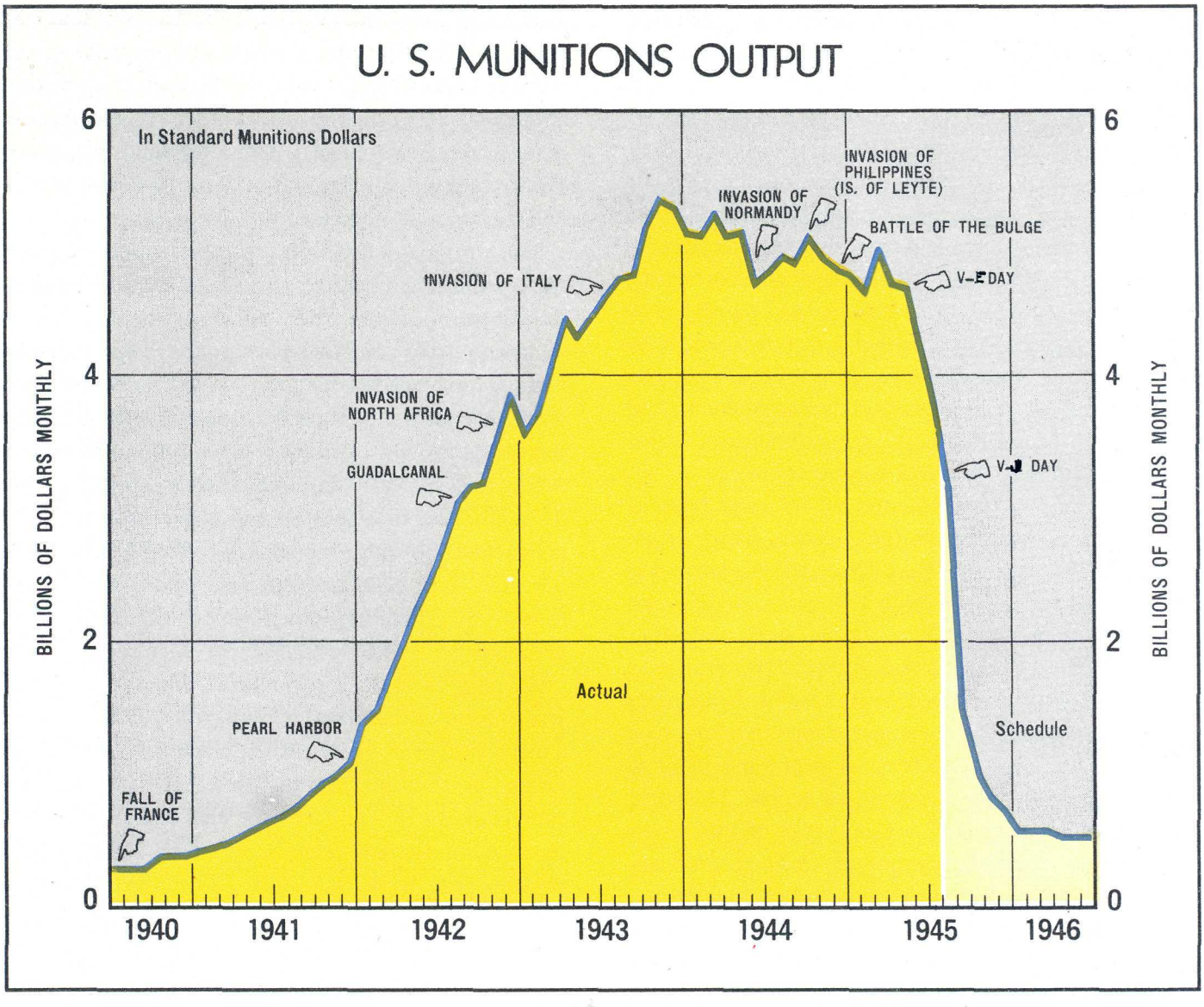
The munitions program for 1944, estimated at 72 billion dollars in late 1942, had been scaled down by February 1944, to less than 65 billions. Successes in Europe led to a gradual further reduction in the program, and actual munitions output for the year was 59 billions.

Effects of the December 1944 "Battle of the Bulge" on munitions programs are recent history. Losses of matériel sustained in the German advance led to intensified action to increase output of critically-needed items. And the decline in total munitions output which began at the end of 1943 was strongly reversed in March 1945.

By April, the imminence of the German collapse was evident, and production began to decline. Cutbacks gained momentum as V–E Day approached and passed, and with the unexpectedly early Japanese surrender, military schedules faded away. The latest estimates, shown in the chart, are that military procurement by mid-1946 will be below the rate at the time of Pearl Harbor, and these estimates are more likely to be revised downward than raised.

Total munitions production in the 5 years of defense preparation and war—from July 1, 1940, through July 31, 1945—amounted to 186 billion dollars, at standard munitions costs. (As noted above, these standard costs have been used in valuations of war production, in order to show a continuing picture not distorted by price changes. While they varied somewhat from contract prices, the over-all figures provide a fairly close measure of actual output.)

Included in this huge total were 86,333 tanks; 296,400 airplanes of 2,474,000,000 pounds airframe weight; 15,300,000 rifles, carbines, and sidearms; 319,000 pieces of field artillery and mortars; 4,200,000 tons of artillery shells; 41,600,000,000 rounds of small arms ammunition; 64,500 landing vessels, 6,500 other Navy ships, and 5,400 cargo ships and transports, and similarly staggering amounts of other matériel. From July 1, 1940, through July 31, 1945, the United States merchant fleet was quadrupled. Navy firepower has increased tenfold since



1940, and today could hurl 4,500 tons of steel at an enemy in 15 seconds. Annual and cumulative production of a large number of individual munitions items are shown in the tables on pages 105 through 110.

DEVELOPMENT OF CONTROLS

The beginnings of the War Production Board control system antedated the War Production Board itself. I shall leave for the detailed history of WPB, now in preparation, the story of how the Board grew out of SPAB, OPM, NDAC, and even more remote ancestry, how the legal foundation for its authority was established, and how it struggled to perfect a workable organization to administer its controls.

The basic philosophy under which the control system was set up was a simple one. We were determined to impose any controls within our authority which would contribute significantly to speeding victory. We were equally determined not to impose any restrictions or any burden of paper work on business unless we were confident that it would hasten the winning of the war. And we have consistently followed a policy of modifying or dropping controls promptly if they proved unworkable or outlived their usefulness.

We were human and fallible, and we made mistakes. But we learned from them, and we did not often repeat them.

The first priority controls, established in the summer of 1940 by an ancestor of the WPB, were limited to preferences for Army and Navy prime contracts. As the defense program expanded and supplies became more tight, preference ratings had to be extended to essential nonmilitary orders, and to all levels of subcontracting. Voluntary priorities in some areas had to be replaced by mandatory preferences. Blanket preference orders, assigning a rating for the procurement of needed production materials to a whole general class of products, had to be substituted for individual rating certificates, which were snowballing to an unmanageable volume.

Priorities had to be supplemented by other types of controls. The conservation (M–) orders which began to appear in the spring of 1941 prescribed the permitted or nonpermitted uses for each material covered—first aluminum, then magnesium, copper, steel, and other metals, chemicals, textiles, and others. The limitation (L–) orders which followed, beginning in the summer of 1941, were aimed both to conserve materials and manpower and to force conversion of peacetime plant to munitions production. In contrast to the M–orders, which tpyically restricted use of a raw material, the L–orders restricted the output of finished products. The first few L–orders cut down, and eventually prohibited, production for civilian use of automobiles, trucks, refrigerators, washing machines, electric appliances, and other consumer hard goods.

QUANTITATIVE CONTROLS LACKING

As this system of priorities, preference rating orders, conservation orders, and limitation orders grew, it became evident that what it lacked was quantitative controls. As a result of this lack, our preference rating currency was constantly losing its value. Manufacturers' books became so crowded with A–1 orders that they had to be splintered into A–1–a through A–1–j. The A–1–a band then became so crowded that the AA series had to be superimposed. Even after the establishment of the AA bands, there was a tendency for all essential orders to crowd up into AA–1, but by that time we had developed some quantitative controls.

Inflation of the rating structure was not the only result of the absence of quantitative controls. Without such controls, integration and scheduling of programs was extremely difficult, and unbalanced or even contradictory allocations were possible. The burden of paper work on manufacturers was huge. And a premium was placed on competitive expediting by the procurement services and their various branches.

The struggle to establish a comprehensive system of materials balancing bore its first fruit in the Production Requirements Plan—PRP—which was initiated on a voluntary basis in November 1941. This permitted manufacturers to present to the War Production Board a detailed picture of their operations in relation to the war program and essential civilian needs, and to state production material requirements for these purposes. Thus, for the first time, priorities were integrated to production schedules specified in advance; previously, schedules had been laid out and priorities used as a means of expediting when procurement difficulties appeared.

As long as a large segment of American industry was outside of the plan—manufacturers who could get a better deal through a P–order which gave them a high rating, or through PD–3A preference rating certificates issued by the military—the plan could not be effectively administered; wide areas of requirements and consumption were unknown. Therefore, beginning with the third quarter of 1942, PRP was made mandatory for all except the smallest manufacturers, and for the first time an attempt was made to bring together all of the information on requirements for critical metals and to allocate the prospective supply.

This basic concept of a periodical cutting of the material pie was continued a year later, but a new procedure was instituted when the Controlled Materials Plan was substituted for PRP. The chief difference was that CMP was a vertical allocation plan, under which allotments were made by programs and passed down through the chain from procurement agency to prime contractor to sub- and sub-sub-contractor, whereas in PRP direct applications had been received from all levels in the subcontracting chain.

The principle of adding up all claims and parcelling out the supply was essentially the same, though the method was different. The vertical allotment plan lost the direct inventory control of metal users which PRP

had permitted, but it substituted the more important control of programs. CMP thus made possible a more accurate appraisal of feasibility and of relative essentiality, and a consequently more equitable and effective distribution of materials. Unbalanced allotments could be avoided by establishing programs on the basis of the limiting material and keeping all allocations in line with these programs.

At the same time, CMP forced the procurement services to cut their coats to fit their cloth. When allocations were made through the claimant agencies, instead of through their contractors, each procurement branch knew how much material it would have to work with in a given quarter, and it had to tailor its required delivery schedules accordingly. Military contracts were cut back to something like feasible limits, indirect military and essential civilian requirements were protected, and competitive expediting was reduced.

CMP continued through ten quarterly periods, and it did its job well. Because it was limited to three basic metals, it had to be supplemented by other allocation systems for other materials, some patterned after CMP, others adapted to the peculiarities of the product they covered. Among the more important of these were the controls over pulp and paper, lumber, textiles, tires, and chemicals.

I shall not go into any detail on the other types of control which WPB developed, such as inventory restrictions, standardization and simplification orders, quotas and set-asides, but I do want to say just a word on scheduling, because the WPB scheduling controls have been much misunderstood. The War Production Board never directly scheduled more than a small proportion of industrial production, or even of shipments. It laid down the rules, but it relied on the manufacturer to set up his own shop schedules and delivery schedules, within those rules, on the basis of his own order books and operating problems. Except in the raw materials field, where schedules were often worked out cooperatively by WPB and industry, the various WPB scheduling orders provided primarily for *review and modification* of schedules thus established, and for the "freezing" of shipping schedules so that production would not be lost either in the component plant, by frequent schedule revisions, or in the assembly plant, by unbalanced receipts of components.

I am sure that if we were starting now, with the knowledge we have gained in these past five years, we could devise far more perfect instruments for mobilizing industrial production for war than those which we actually utilized. The fundamental reason why these imperfect instruments did the job was that we succeeded in gathering together, here in Washington and in the War Production Board field offices, a body of men and women with the intelligence and imagination, the initiative and flexibility, the industry and perseverance to make them work. This is as good a place as any to express my appreciation and the nation's gratitude to the thousands of people who served their country so loyally in the War Production Board.

COOPERATION

As the war approached, and after it had begun, a large number of new government agencies were established, in addition to the ancestors of the War Production Board, and responsibilities of existing agencies were greatly modified. In the rush to build up and equip our armed forces, there was not always the time to define clearly the responsibilities of each agency, and there was inevitably some overlap.

That there was so little confusion was due to two things. First, where a clear conflict appeared, responsibility was assigned to one or the other agency by mutual agreement, formal or informal. Second, the War Production Board established a general policy of taking no important actions which would affect the field of jurisdiction of another agency without prior consultation with that agency.

For example, in contrast to the British policy of centralizing munitions procurement in civilian hands, procurement in this country was handled by the military services, which received direct appropriations from Congress. But procurement policies were determined cooperatively by the Procurement Policy Board, on which WPB sat with the military. Through this Board, the WPB made special efforts to secure such distribution of both prime and subcontracts as would promote maximum use of the nation's materials, labor, and facilities.

In addition, the product specialists in the industry divisions worked with military representatives on specific procurement problems, helping them to place difficult contracts and advising them on contract distribution on the basis of their intimate knowledge of facilities, schedules, and order loads of individual companies.

The function of labor recruitment, which was assigned to the War Manpower Commission after April 1942, was of vital concern to the War Production Board in maximizing production, and the two agencies worked together constantly. To assist WMC in guiding labor to where it was most needed, the WPB established and periodically revised the Production Urgency List. WPB assisted Selective Service to determine which workers in war industries were most essential. It also, from time to time, certified to the War Labor Board requests for wage increases which it considered necessary to assure an adequate labor supply to essential plants.

WPB found it necessary to consult constantly with OPA to support requests for price increases where low prices were retarding production, and it depended on OPA to distribute, through its ration boards, supplies of scarce products set aside for civilian use. At the same time, it assisted OPA in its price control job by allocations of materials, which eliminated competitive bidding, and by orders which simplified or standardized products and limited production of high-priced goods.

In many other activities, WPB assisted other agencies or enlisted their help: in stockpiling and foreign procurement; in assuring transportation for raw materials and finished products, both on the seas and on land; in obtaining housing and local transportation for war workers; in getting special treatment on food supplies for new war plant communities and for lumber camps; and in any number of other instances.

REQUIREMENTS COMMITTEES

One of the best examples of interagency cooperation in actual operations is the War Production Board Requirements Committee. When this committee was first organized, in February 1942, it included representatives of WPB, Army, Navy, Maritime Commission, Lend-Lease, and BEW. It was later expanded to include all of the claimant agencies under CMP. This committee was the major forum for determining how supplies of scarce materials and products were to be distributed. On the basis of carefully documented studies of prospective supply and of the relative essentiality of various claims, it was usually possible to reach a general agreement on how the pie was to be cut. Even though the size of the pie was often disappointing, there was, throughout WPB history, very little dissatisfaction with the way it was divided.

The same operation was performed on a smaller scale in the Divisional Requirements Committees, and the experience was similar. There were, of course, a large number of appeals from decisions of the Divisional Requirements Committees, but more often than not they simply represented the wish of a claimant representative to have his superior in the main requirements committee accept responsibility for consenting to an allotment far below stated requirements.

OTHER JOINT ACTIVITIES

The War Production Board itself includes representatives of all the major government agencies concerned with production, and its board of strategy—the Production Executive Committee—is an interagency body. Any number of other joint activities have been carried on by temporary or continuing interagency committees, including, in most recent months, the committees which have drawn up the plans for demobilization of WPB controls.

INDUSTRY AND LABOR

Cooperation with business management has been continuous, and has contributed as much as anything else to the success of the war production effort. Industry Advisory Committees were organized by OPM early in the defense period, and their advice has been sought on all major problems of production and control. The committees are carefully selected to represent large and small companies and to cover all sections of the country. Most committees include 10 to 20 representatives, with a government chairman. Over 700 of these committees have been formed, and while their function is solely advisory, they have been of the greatest assistance both in preventing possible mistakes and in making positive suggestions.

Manpower was a direct responsibility of the War Production Board and its predecessors until the War Man-

power Commission was set up in April 1942. The National Defense Advisory Commission and the Office of Production Management were charged with mobilizing manpower in defense and war industries and coordinating the activities of a dozen peacetime agencies dealing with job finding and training.

During this period, WPB's predecessors took the lead in establishing as government policy:

1. Encouragement of migration of workers to defense jobs, by voluntary means.

2. Promotion of upgrading of workers to their maximum skills, and of intensive in-plant training to raise the level of skill.

3. Settlement of disputes between management and labor which endangered production in defense industries.

4. Distribution of defense contracts to areas where workers were unemployed, and withholding such contracts from overburdened labor markets.

5. Improvement of housing and other community conditions so that workers could turn out maximum production.

6. Encouragement of widespread employment of women in all types of industry.

Establishment of the War Manpower Commission separated the mobilization of production from the mobilization of manpower. Because there was no such separation in industry, the War Production Board and War Manpower Commission promptly established cooperative relationships, and the policies which OPM had developed were maintained. Because of the importance of labor understanding and labor support of WPB policies, the Board continued the Labor Advisory Committees which had been set up by OPM. WPB also took the lead, through its Production Drive Division, in the formation of joint labor-management committees, which worked effectively to reduce absenteeism and labor turnover and to promote worker-suggestion plans.

PLANNING FOR RECONVERSION

As the agency which had taken the lead in mobilizing industry for war, the War Production Board obviously had a direct responsibility for planning and guiding the demobilization process.

As early as the spring of 1943, the Board began to explore some of the important underlying problems and to make some tentative judgments on basic policies. Because diverting the country's attention to reconversion would have been unwise at a time when the war was still far from won, these discussions could not be carried on publicly, but formulation of plans for demobilization of controls and for positive action to assist industry in preparing for reconversion proceeded at a rapid pace. The program had reached a high state of maturity at a time when newspaper editorials and public figures were still viewing with alarm the lack of preparation for victory.

The first step in reconversion planning was taken in April 1943, when Mr. Ernest Kanzler was asked by Chairman Donald M. Nelson to make a study of the whole problem of reconversion. From that time on, the study of steps to be taken in the transition period, both to remove restrictions that were no longer needed and to get industry ready for resumption or expansion of civilian production, was a continuing process.

The most comprehensive examination of the problem was that undertaken by the WPB Bureau of Planning and Statistics in September 1943. The report which it issued in July 1944 established the basic principles which guided the committees later set up to work out detailed procedures.

DEMOBILIZATION OF CONTROLS

In the summer of 1944, when the collapse of German resistance seemed to be imminent, the pace of reconversion preparation was stepped up. One step was the formation of a Committee on Demobilization of Controls after V-E Day—known familiarly as CODCAVE. This committee developed a complete program for reconversion controls, which was approved by the War Production Board on October 3, 1944, and was held in readiness for a German surrender.

When that surrender was delayed by the Battle of the

Bulge, a new Committee on Period One (CPO) was established in February 1945 to review this program and keep it up to date. This committee continued to function up to V–J Day. When Germany collapsed, it had a complete program for relaxation of controls, which had been discussed and cleared with other affected government agencies, ready to be put into effect at once. Despite the unexpectedly short period between V–E Day and V–J Day, it had a similarly complete plan, ready for clearance, when the Japanese put up the white flag.

As might be expected, the thinking in regard to desirable policies for relaxation of controls had evolved only gradually. As industrial production expanded and the prospect of over-all materials shortages in the reconversion period lessened, the tendency was to recommend speedier demobilization of the control structure and greater reliance on the resourcefulness and initiative of private industry in reconverting.

PREPARATORY STEPS

Even before establishment of CODCAVE, some preparatory steps had been taken to smooth the path of industry in reconversion; and the further steps to be taken when military cut-backs made resources available had been definitely programmed well in advance of the time when it became possible to put them into effect.

Beginning in May 1944, a joint WPB–military review of proposed contract cut-backs had been instituted. This review had the double purpose of assuring satisfaction of remaining military needs and minimizing unemployment. On the basis of recommendations of the Production Executive Committee Staff, and of the Production Readjustment Committee which succeeded it, cut-backs were selectively placed to free plants which could reconvert to civilian production, whenever that was consistent with military requirements.

In July and August 1944, the so-called Nelson Program was adopted, removing restrictions on the use of aluminum and magnesium, permitting manufacturers to build experimental models in preparation for peacetime operation, removing prohibitions from the placing of unrated orders for capital equipment and permitting the placing of such orders for reconversion tooling, and establishing the Spot Authorization Plan for absorbing pools of unemployment created by military contract cut-backs.

The effectiveness of these orders was limited for a time by the renewed tightness in labor and materials which resulted from the German offensive in December and the increased military procurement which followed. But they have served to reduce considerably the time element in reconversion.

Issuance of these orders was followed by an active campaign by the War Production Board to get manufacturers to formulate their reconversion needs for plant and equipment, to get the equipment orders placed, and to get construction plans submitted for approval so that authorization could be granted as soon as the resources could be spared. In the spring of 1945, positive assistance was given to the orders for reconversion tooling in the form of AA–3 preference ratings, and criteria for authorizing plant construction were relaxed. A series of surveys of industries with reconversion problems were undertaken, and wherever facilities bottlenecks were evident, intensive—and usually successful—efforts were initiated to break them by expediting action or other means.

When V–E Day arrived, therefore, industry's preparations for reconversion already had a head start. These preparations were gradually accelerated, with continuing WPB assistance, as resources were freed by declining military production, thus hastening the time when peacetime production can go ahead full speed.

PRESENT POLICY

The present policy of the War Production Board toward the control structure for the reconversion period has been made abundantly clear. It is, first of all, to get rid of all orders which are no longer needed, and second, to maintain those controls which are essential to assure an orderly transition to peacetime operation.

The Controlled Materials Plan, which was open-ended after the defeat of Germany, went out of existence at the end of September. More than 200 orders and regulations in effect at V–E Day were lifted before V–J Day, and since then the pace of revocation has been stepped up, so that there are now no more than a handful left. Remaining controls have only these limited purposes:

(1) To prevent speculative buying and hoarding of materials and products, which would result in inequitable distribution and thus handicap reconversion.

(2) To restrict consumption of items which are still

in tight supply, such as tin, natural rubber, hard cordage fibers, lead, certain textiles, and a few others, until normal supplies are again available.

(3) To assure the meeting of remaining military needs, through use of the MM preference rating.

(4) To break reconversion bottlenecks by expediting and by limited priority assistance to nonmilitary production through use of the nonextendible CC preference rating.

(5) To maintain temporarily certain powers which may be needed to insure equitable treatment for small business, for veterans, and for meeting export commitments, or to assist continuing controls of other government agencies.

These few controls will also be dropped the moment they are no longer needed, and the War Production Board will go out of business as fast as is consistent with the President's instructions in regard to reconversion.

RECONVERSION TO DATE

The reconversion problem is one that involves only a handful of industries, though they are highly important industries. Blast furnaces turn out the same pig iron in peace or war, cotton spindles the same yarn; and the changes in specifications of the finished steel or fabric do not involve anything in the nature of a wholesale conversion or reconversion. Much the same situation holds in lumber products, in foods, in containers, in leather products, in construction machinery, in machine tools and plant equipment, and in most of the rest of the American economy. Reconversion here means primarily a change of customers, and the only serious problems are whether the new customers will buy as much as the old and whether costs can be held in line with prices.

To the automotive and refrigerator and other consumer durable goods industries, and to a lesser degree to some of the other metal-working industries, however, the conversion to war meant tearing apart production and assembly lines in order to tool up for production of guns, shells, aircraft engines and wing assemblies, combat vehicles, and all the other special machinery of war. In getting back to civilian production, these industries must reverse the process, and full reconversion really means volume production of passenger cars, of washing machines and refrigerators and domestic sewing machines, of stoves and electric appliances and metal furniture.

Some reconversion was permitted in the consumer durable goods group even during the war. As early as August 1943, requirements of military agencies for typewriters necessitated resumption of production in typewriter factories which had previously been making shell fuses and other munitions items. In October 1943, it was found necessary to resume limited production of electric ranges to provide for essential housing needs. Similarly, in December of that year, the acute need of the civilian economy for electric irons made it advisable to authorize production of a limited number.

The Spot Authorization Plan helped to absorb some local pools of unemployment, but it was only a limited factor in reconversion because of the tightening in materials and manpower soon after the first authorizations had been issued in the fall of 1944. By spring of this year, however, the shortages of some types of consumer durable goods had become so great, after three years without new supplies, that we were allotting materials for such items as washing machines and refrigerators for the third quarter, despite the fact that V–E Day had not yet officially arrived when the allotments were first tentatively calculated.

Even with V–E Day, and the open-ending of CMP on July 1 to permit purchase of controlled materials on unrated orders after authorized allotments had been met, possibilities for expansion of civilian goods production were still limited. The V–E Day cutbacks were large, but for the most part they affected deliveries scheduled for late summer and autumn. When Japan surrendered, munitions production was down little more than 10 percent from the spring peak, and only a small fraction of the resources which had been devoted to war had been made available to the civilian economy.

The resources that were freed did not stand idle; they were used, to the maximum extent possible, on nonmilitary orders. Despite layoffs in some munitions plants, unemployment increased but slightly, and at V–J Day was barely over a million—far less than a normal between-jobs float. Order books of raw material produc-

ers continued full, and there was little space into which requirements for resumption of production in the major civilian goods industries could be fitted.

The situation was particularly bad in sheet and strip steel suitable for autos, washing machines, refrigerators, stoves, office furniture, and similar items. Despite reductions in over-all military programs, there appeared to be little margin in sheet and strip steel for civilian use except for those items officially programmed. And aside from steel sheet and strip, there was a long list of other bottlenecks to resumption of civilian production—tin and lead, protective coatings, lumber, and all types of containers, to name only a few.

Thus, it was not until after V–J Day, when the cutbacks began to free large amounts of resources, that reconversion could pick up momentum. Meanwhile, however, many companies had been saved months in the preparatory phase by virtue of the experimental model order, the authorization for reconversion tooling, and the steps which WPB had taken to get plant construction started and equipment orders scheduled. Some millions of dollars of tools necessary for resumption of civilian production had already been delivered, and more were far along in production when V–J Day came.

Today, scarcely a month after final victory, and only four months after the end of fighting in Europe, it is too soon to measure the progress of reconversion in terms of shipments of hard goods to civilian customers. Early this year, nonmilitary shipments had already expanded substantially from the low point in the final quarter of 1943, when the munitions program reached its peak. In July, the latest month for which comprehensive data are available, there was some recession because so many plants shut down during the holiday week, and civilian production was still far below prewar levels, as the following table, based on a representative sample, clearly shows:

AVERAGE MONTHLY PRODUCTION

[Millions of dollars]

	1939	Second quarter 1942	Fourth quarter 1943	First quarter 1945	Second quarter 1945	July 1945
Automotive industry:						
Military	.....	396	800	731	686	493
Civilian	336	91	61	99	108	105
Total	336	487	861	830	794	598
Other consumer durables:						
Military	.....	144	330	347	333	271
Civilian	102	84	58	57	64	58
Total	102	228	388	404	397	329

Reports for August have not yet all come in, but it is evident from those received that civilian production increased very little, if at all. In the case of many companies, V–J shutdowns (in some instances lasting a whole week) caused a further decline in civilian production below the July level. With the widespread labor disturbances in the automotive industry, and in such other important industries as refrigerators and electrical goods, it is hardly likely that September showed much of an increase over August.

THE BRIGHTER SIDE

But there is a great deal more to reconversion in the consumer durable goods industries than rolling automobiles off the assembly line. The statistics on shipments

do not show it yet, but reconversion has been going ahead. Inventories of war goods—goods in process, components, and materials unusable for civilian production—are being cleared from the plants. Special-purpose war tools are being moved out and replaced. Production and assembly lines are being rearranged, and in the tool plants, the finishing touches are being put on the new equipment which will fit into those lines—equipment which cannot be built overnight and which has a normal peacetime production cycle running anywhere from a few weeks for jigs and fixtures to as much as a year for the heaviest hydraulic presses.

Pipelines are being filled with raw materials and components, and the components factories are going through the same process as the assembly plants. In the months it takes to turn a gun factory back into an automobile engine plant, an aircraft wing fabricator into a producer of refrigerators, substantial numbers of people are employed, and substantial amounts of actual production are achieved, but shipments of finished products are small. Hard goods shipments in this period are coming principally from industries which have been producing some of their normal products for military or war-supporting use, plus shipments of repair parts which have continued in production through the war.

In industries other than consumer durable goods, reconversion has been much more rapid. Some industries, of course, must curtail rather than reconvert—aircraft, special ordnance plants, shipyards, for example. But the textile and apparel trades are already turning out civilian goods on the same spindles, looms, and sewing machines that were making military cloth and uniforms a few short weeks ago. The petroleum industry is making gasoline for your car and mine, instead of for B–29's. The rubber companies are now building tires for civilian trucks and passenger cars in the same plants which were recently struggling to meet military tire needs.

It would be easy to become discouraged by the current level of shipments in what we call the "reconversion industries" if they are not viewed in their proper perspective. Perhaps that perspective can be supplied by the chart on the next page ("Keys to the Future").

A FEW KEY STATISTICS

Look, for example, at the trend of steel operations. In the spring, ingot output was running above 95 percent of capacity. With the V–E Day cutbacks in military programs, operations began to drop off, but just before V–J Day they were still at around 90 percent. The V–J Day holiday caused a sharp drop, to 60 percent, but the line has been steadily creeping upward since then and is currently around 80 percent—only slightly lower than in the second week of August.

And steel is a material that is produced to fill orders; steel producers do not build stockpiles. The recovery in operations can only mean that the civilian industry pipelines are being filled, and that substantially increased civilian production of finished metal goods is just ahead.

The figures for electric power output tell the same story. There is, of course, a substantial amount of current used for nonindustrial purposes. But it is worth noting that since V–J Day power output has been running only about 10 percent below the peaks of the past six months (excluding the Labor Day week).

Freight carloadings are a less sensitive indicator, because of the time lag between production and transportation, but the picture here is similar.

And the people who back their judgment of business prospects with money, the investors in common stocks, are evidently happy about reconversion progress and reconversion prospects. The stock market has just reached the highest point since 1937, with a 10 percent advance in the past six weeks.

The speed with which we have relaxed WPB controls is a measure of our own confidence in the ability of industry to make the adjustments necessary to achieve high peacetime production. I feel that this confidence is fully justified.

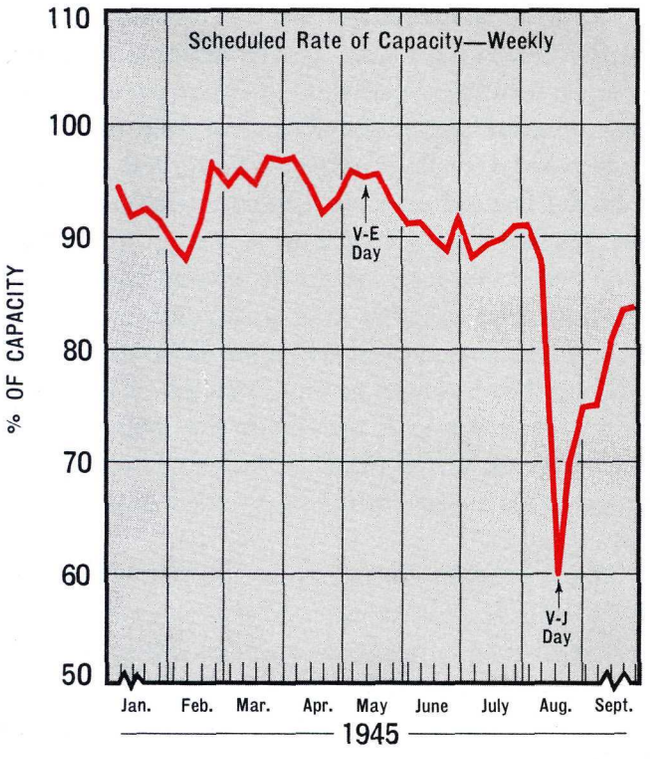
TECHNOLOGICAL PROGRESS

We have come out of the war knowing a great deal more about how to produce efficiently, speedily, and cheaply than we knew when we went in. Much of this knowledge which we gained from war can serve us well in peacetime.

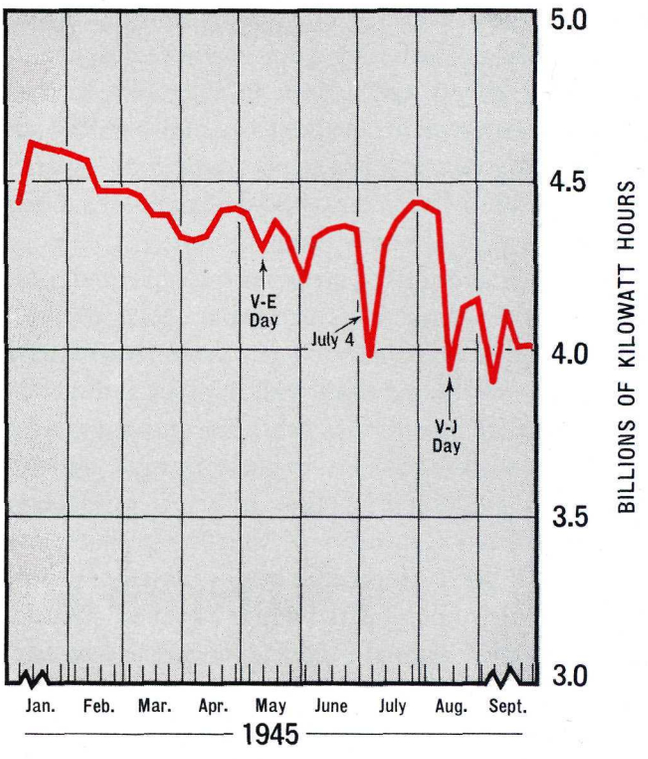
The miracle of atomic fission, the spectacular achieve-

KEYS TO THE FUTURE

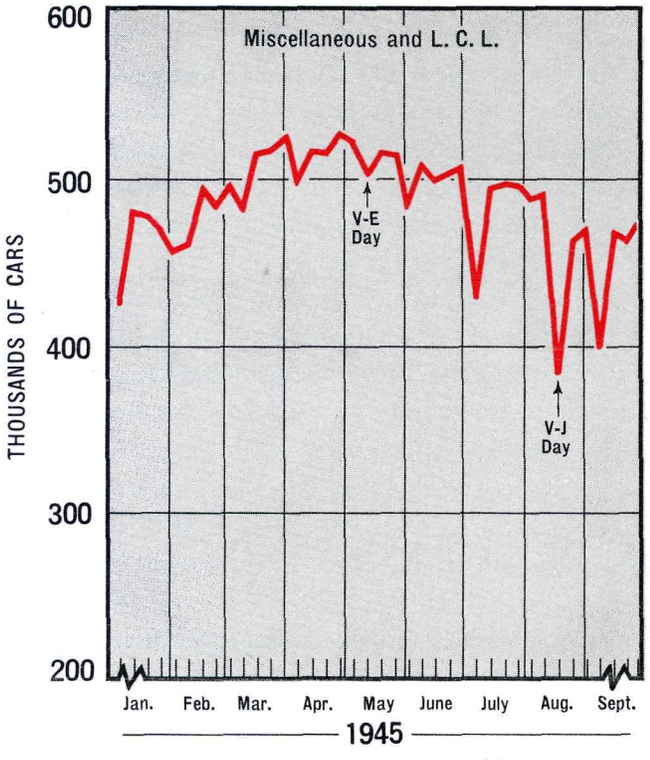
STEEL INGOT OPERATIONS



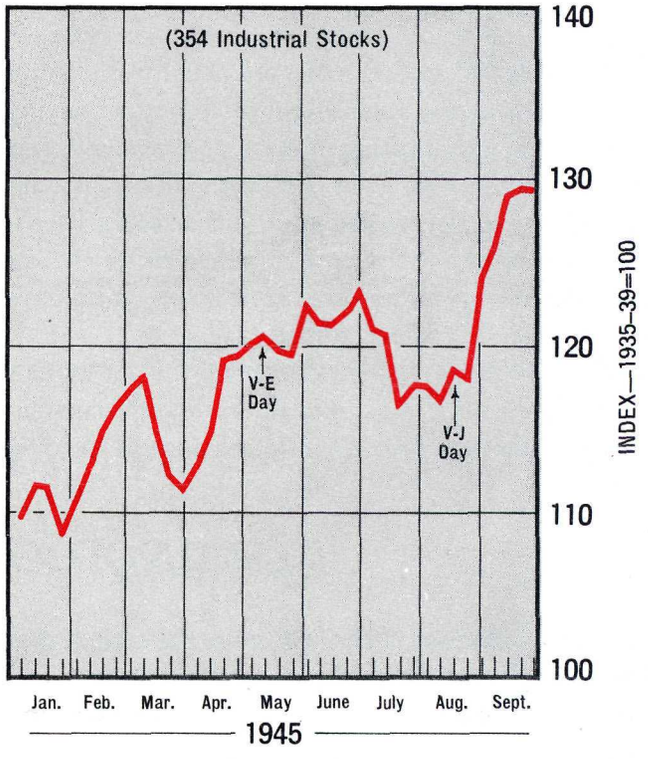
ELECTRIC POWER OUTPUT



FREIGHT CARLOADINGS



STOCK PRICES



ments of radar, have tended to make us forget the more prosaic developments in science and industry in these past few years. I am thinking, for example, of such things as the education of many hundreds of manufacturers in the techniques of working to very close tolerances, or the speeding up of metal-working by the widespread use of tungsten carbide cutting tools. The tremendous development of the electronics industry in process control and inspection operations; the advances in production volume and fabricating know-how in the light metals; the widespread experimentation with substitutes for scarce items which led to the development of new, and in many cases superior, raw materials (such as plywood or plastics, for example), the tremendous improvement in packaging and shipping techniques—these are only a few of dozens I could mention.

CONSTRUCTION AND FACILITIES

Manufacturers are eager to put their increased knowledge to use. That requires plants adaptable to the new techniques, and adequate modern equipment. Expansions, alterations, and additions to manufacturing plants are now under way on a large scale. It is already evident that despite the fears of pessimists, who pointed to the large number of surplus war plants and the large stocks of surplus tools which would overhang the market after the war, a substantial volume of factory construction and equipment purchase is in prospect.

Not that facilities surpluses do not exist or that we should condone the economic waste in scrapping any of them which can be usefully employed to provide jobs and produce goods for which there is a market. But in a partial sample of 4,000 companies in 41 industries recently, we found that facilities expansion totalling over half a billion dollars was under way or planned for completion within the next twelve months. On the basis of this sample, it is estimated that there will be close to a billion dollars' worth of new privately financed factory construction in 1946, the highest rate to date. Expenditures for plant equipment and tooling, if they maintain the ratio of the past, could raise total 1946 facilities expansion to 2 to 2½ billion dollars.

Aggregate new construction—factory, residential, commercial, public works, and all other types—is now expected to run to about $6,500,000,000 in 1946, which would be 44 percent above 1945 and almost double 1944. This is exclusive of maintenance and repair activities, which in 1946 are likely to exceed 4 billion dollars. Such figures suggest very active operations in all of the building materials industries—at least as high as in 1939 and 1940 if sufficient manpower can be recruited—even without allowance for the additional business to come from restocking dealers, distributors, and construction and contracting companies.

CAPITAL EQUIPMENT INDUSTRIES

Production in the capital equipment industries before V–E Day was running at about four times the prewar rate, but most of the increase was in production of munitions items. Output of civilian products by these industries—for civilian and military use—in July 1945, was just about equal to the rate immediately before the war.

Within the group there were, naturally, wide variations. In the railroad passenger car industry, for example, production in July included none of the normal product, and such industries as this have reconversion problems similar to those in consumer durable goods. In contrast, output of civilian-type products by the manufacturers of commercial and industrial refrigerating and airconditioning equipment in July was at almost twice the prewar rate, though the military services were the largest customers. Reports for the four months through July 1945 from a large number of capital goods producers showed that shipments to civilian users were above 1939 rates in such lines as mechanical power transmission equipment, machine tools, metal working machinery, food products machinery, pumping equipment and air compressors, and mining machinery and equipment, by margins ranging from 10 to 100 percent and more. Industries in this position have only sales volume, costs, and prices, not production problems, to worry them in the reconversion period.

For the capital equipment group as a whole, it is estimated that production of civilian-type products dropped about 10 percent in August as military orders were can-

celled. Civilian orders, however, have already begun to take up the slack, and the industry's own expectation, based on a sample survey, is that it will be operating at 116 percent of the prewar rate by December and 234 percent by mid-1946. Obviously, this would still leave a large gap between peak wartime production and the postwar level, but it will represent a marked net expansion of the industry since the prewar period.

CONSUMER DURABLE GOODS

The big question mark, and the key to how fast total reconversion will proceed, is in the consumer durable goods industries, particularly the automotive industry.

It is difficult to make predictions as to automobile production until the Detroit labor situation clarifies. Before V–J Day, manufacturers had been shooting at permitted ceilings tentatively set at 250,000 passenger cars in the fourth quarter of this year, 400,000 in the first quarter of 1946, and a probable peak rate of around 200,000 cars a month, to be reached by mid-1946. Every effort was being made, both by the manufacturers and by the War Production Board, to remove obstacles to resumption of production to permit meeting this timetable.

With the surrender of Japan and the easing in flat-rolled steel, plastic finishes, tires, and other parts and components, the goals were stepped up. Manufacturers scheduled a gradual rise to 224,000 cars in December and 504,000 in June 1946, compared with an average monthly rate of 314,000 in 1941 (passenger cars only).

So far, they have made only a start. In July, when the first new autos rolled off the lines, only one company was in production and it turned out only 359 cars. In August, it is estimated that the industry's production was about 2,000. Even without the strikes which have occurred, it would have required herculean efforts to reach the December rate of 224,000.

For other consumer durable goods, where labor difficulties have been less widespread, the prospect is brighter, but total output of these industries is dwarfed by the potential output of the automobile industry.

A survey of a large representative group of manufacturers in 14 of the principal metal consumer goods manufacturing industries—passenger autos, stoves, refrigerators, watches, vacuum cleaners, washing and ironing machines, sewing machines, bicycles, etc.—was made last month, to determine the manufacturers' own expectations as to the speed with which they could reconvert. With one exception, these industries all indicated that they were aiming at production by the end of this year at two-thirds of the prewar rate or higher; six of the 14 expected to be above the prewar rate. By June 1946, every one of the 14 expected to be producing more goods than before the war, beginning to satisfy the demand accumulated during the past three years. In a few industries—domestic water heaters, watches, washing and ironing machines, electric ranges, oil burners, and electric fans—the companies surveyed foresaw markets more than double those of prewar years.

The survey revealed two other striking facts. First, in a number of these industries, the smaller firms are counting on increasing their share of the market; they predict substantially larger percentage increases than the big companies. Many of these smaller companies have greatly expanded and modernized their productive capacity in the past few years, as a result of large war contracts, and they expect to make aggressive use of these new facilities in a period when old brand preferences may be latent or forgotten. Secondly, each of these industries expects a higher output per employe than before the war, with the forecast gains in productivity particularly striking in those industries which anticipate the largest increases in volume. Even in the automobile industry, which had carried mass production techniques so far before the war, a gain of 11 percent in output per employe was predicted.

ACCUMULATED DEMAND

The high forecasts of production in consumer durable goods are, of course, based on estimates of large demand accumulated during the years when production was prohibited or limited to small amounts. Some of the market has been lost because the goods were not available, but there will have been three to four years of interrupted supply before normal amounts are again available, and this could readily warrant operations well above

prewar levels in these industries for some years ahead.

It may not be generally appreciated that there is also a large volume of accumulated demand in other types of consumer goods. Not everyone complied with the wartime plea to "use it up, wear it out, make it do," but many did voluntarily, many refrained from buying because of the ersatz quality of much of the wartime merchandise, and many perforce did without because of the wartime disruption of our distribution system.

I do not have any statistical measurement of the extent to which cutbacks in military textile requirements will be offset or exceeded by demands for civilian clothes from demobilized servicemen, for tablecloths and sheets and curtains and upholstery fabrics by those who married during the war and are only now setting up housekeeping, for new shirts and dresses and pajamas by those who have had trouble in these past months in finding them in the stores. However, I do not believe anyone will quarrel with the statement that it will take the textile industry a long time to satisfy this demand.

Similarly, demand has accumulated for furniture, for shoes, for floor coverings—even for dishes and glassware. I have spoken of the accumulated demand for construction—factory buildings, housing, roads, commercial structures—and for building maintenance and repair, including painting.

EXPORT DEMAND

Added to the accumulated domestic demand is a huge foreign demand which it would tax our resources to satisfy. Not all of this demand can be made effective, chiefly because of financial considerations—the limited dollar assets of foreign countries. But many countries—particularly western hemisphere countries—have large dollar balances and can pay for huge amounts of needed United States goods if we can supply them. We have made commitments to some of the liberated areas, and until their own economies are rehabilitated, they will be asking for more than we shall be able to ship.

During the war, our exports soared to more than four times the 1939 level. As the chart on page 26 ("Lend-Lease and Foreign Trade") shows, however, all of the increase was in lend-lease shipments, which have now ceased. It is not surprising that cash exports dropped as shipping became short, markets were cut off, domestic shortages became more acute, and normal commercial exports were shifted in part to a lend-lease basis; the surprising thing is that they dropped so little.

The increase in imports was largely in raw materials to feed the war machine; in the last years of the war, general imports actually exceeded cash exports, building up dollar balances abroad. While these imports will now drop off, the decline will be more than offset by new imports from reopened markets.

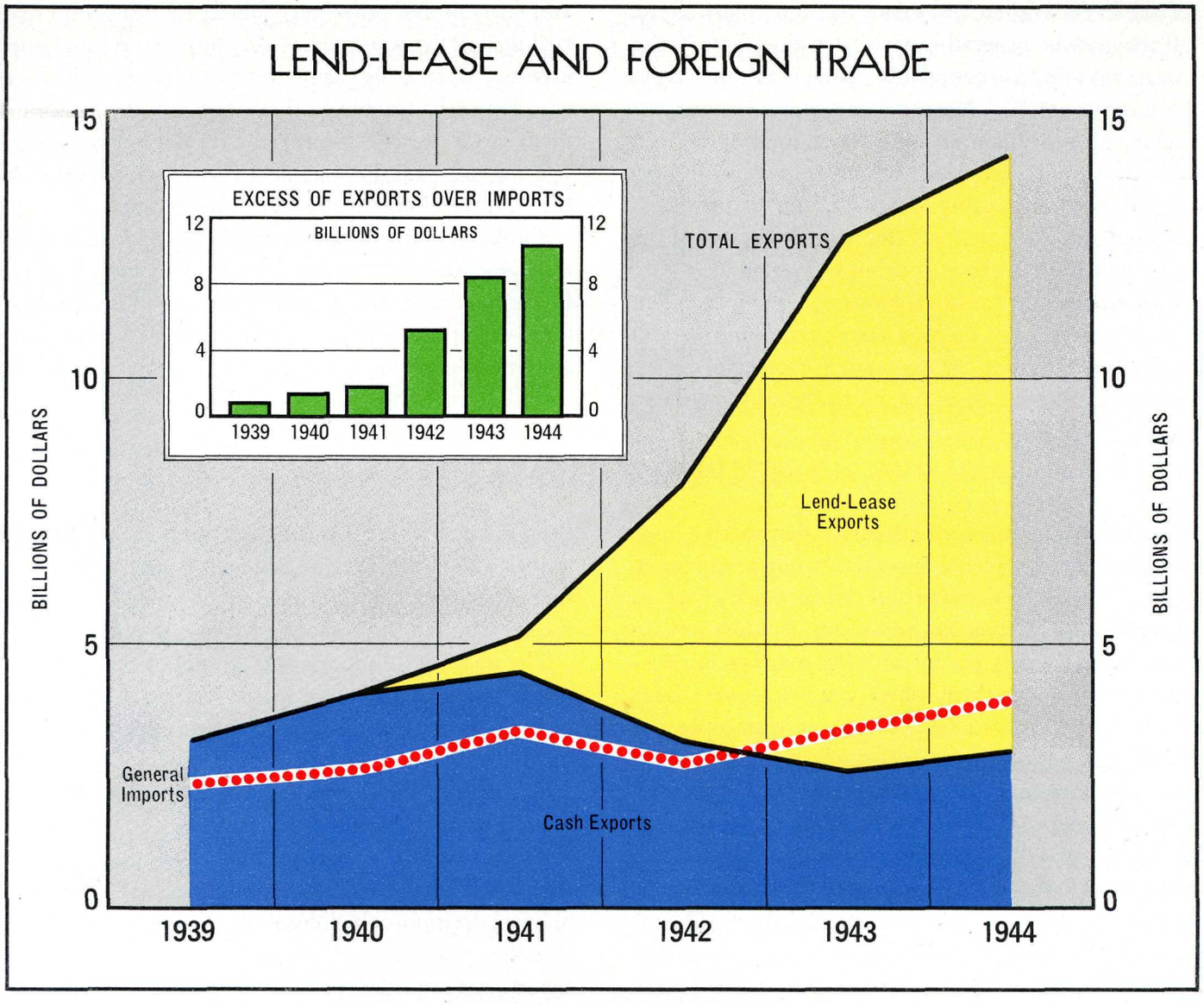
The actual level of foreign trade, both during the reconversion period and in the long run, will depend on political decisions which have not yet been made. It is, however, reasonable to expect a prolonged period of exports and imports for this country considerably higher than before the war.

POTENTIAL BOTTLENECKS

In the short run, at least, the pace of reconversion—and the rate at which released war workers will find jobs—will be determined less by the market for civilian goods, here and abroad, than by the obstacles which industry encounters in trying to satisfy that market.

There is, first of all, the time element. For those industries which must alter or expand their plants, or build new plants, to reach maximum production, we are seeking to eliminate bottlenecks by the use of expediting techniques learned in building up war production, and where all other means fail, by the use of preference ratings where needed. It is a definite War Production Board policy during the reconversion period to favor those activities which will result in the greatest expansion in employment. That means, basically, that construction of factories which will supply jobs will get preferential treatment when their needs are in conflict with other construction; that a plant which needs a machine to set a production line in operation will be helped to get it, if necessary, while a plant which wants a similar machine merely as replacement waits a little longer.

That does not mean, however, that we anticipate any large amount of such expediting action or any large volume of preference ratings. It has already been demon-



strated that industry can go ahead largely on its own. The major delays in reconversion are the result of the time cycles in construction, in the production of capital equipment, and in plant alteration; and these time cycles can be hurried very little by government action. Even in peacetime, it takes six to nine months to build and install a turbine-generator, three months or more for most general-purpose machine tools, up to five months for a heat-treating furnace, six months for an automatic telephone exchange.

MATERIALS AND COMPONENTS

With the surrender of Japan, the period of widespread shortages in materials and components came to an end. We have more capacity for aluminum and magnesium than we know what to do with. There is enough copper and steel, in virtually all shapes and forms, to satisfy demand if there is no hoarding, and our inventory controls are designed to prevent that. Motor vehicle production will not be delayed for lack of tires, though it will take a little time before replacement needs of all vehicles on the roads can be satisfied. There is now an adequate supply of cattlehide leather in the United States, and it will show up in due course in in-

creased quantities of civilian shoes. Fourth quarter lumber supply is estimated at a billion board feet—more than 15 percent—above requirements for consumption, and a couple of months more drying time will cure the present tightness in seasoned lumber if the labor difficulties in the industry are not prolonged.

In the case of paper and paperboard, new supplies of pulp from Sweden are now relieving the shortage except in newsprint, which for a little time must continue to be restricted to recent levels of consumption. This is a handicap to newspaper publishers, but it will not have any significant effect on the speed of reconversion of industry. In cotton textiles, a world-wide shortage continues, and not all demands can be met. But it is estimated that civilians in this country will receive about two billion linear yards in the fourth quarter of 1945, about one-third more than they were allotted for the third quarter. The only potential handicap to reconversion here is a probable tightness in bagging for the next few quarters, and every effort is being made to prevent any acute bagging shortage.

The most serious remaining shortages are in lead, and in products normally imported from the Far East—Manila and sisal fibers, tin, antimony, and natural rubber. All five of these are international problems, and the extent and duration of shortages will depend on agreements for international distribution which cannot be predicted. It is certain, however, that for some time to come, supplies available to the United States will not be adequate to meet unrestricted demand.

With careful allocation and restriction of less essential uses, it is expected that these shortages will be prevented from impeding reconversion. Lead can be supplied for batteries for new automobiles, but it may be necessary to continue for some time to restrict use of white lead paints in order to make this possible. Other pigments are available as substitutes, but there is no substitute for lead in automotive batteries. Similarly, jute rope will have to be continued in some uses because of the inadequate supplies of Manila and sisal fibers.

In antimony, as in lead, the impact of the shortage on reconversion can be minimized by careful distribution of the available supply. Rubber companies can continue to substitute synthetic in uses in which natural rubber would be more desirable, until larger quantities of natural rubber arrive.

The tin situation is perhaps the worst of all, and the shortage will hit many of the reconverting industries—automobiles, refrigerators, radios, washing machines, electrical appliances, telephones, gas meters, and many others. Amounts of tin needed by individual users are small, but the uses are highly important, and substitution is often difficult. With the need for allowing adequate quantities for food cans, some of the other users will have to find substitutes, and all uses must be kept under strict control for some time. The War Production Board is expediting equipment needed to get Far East sources in production as soon as possible and taking other steps to relieve the shortage.

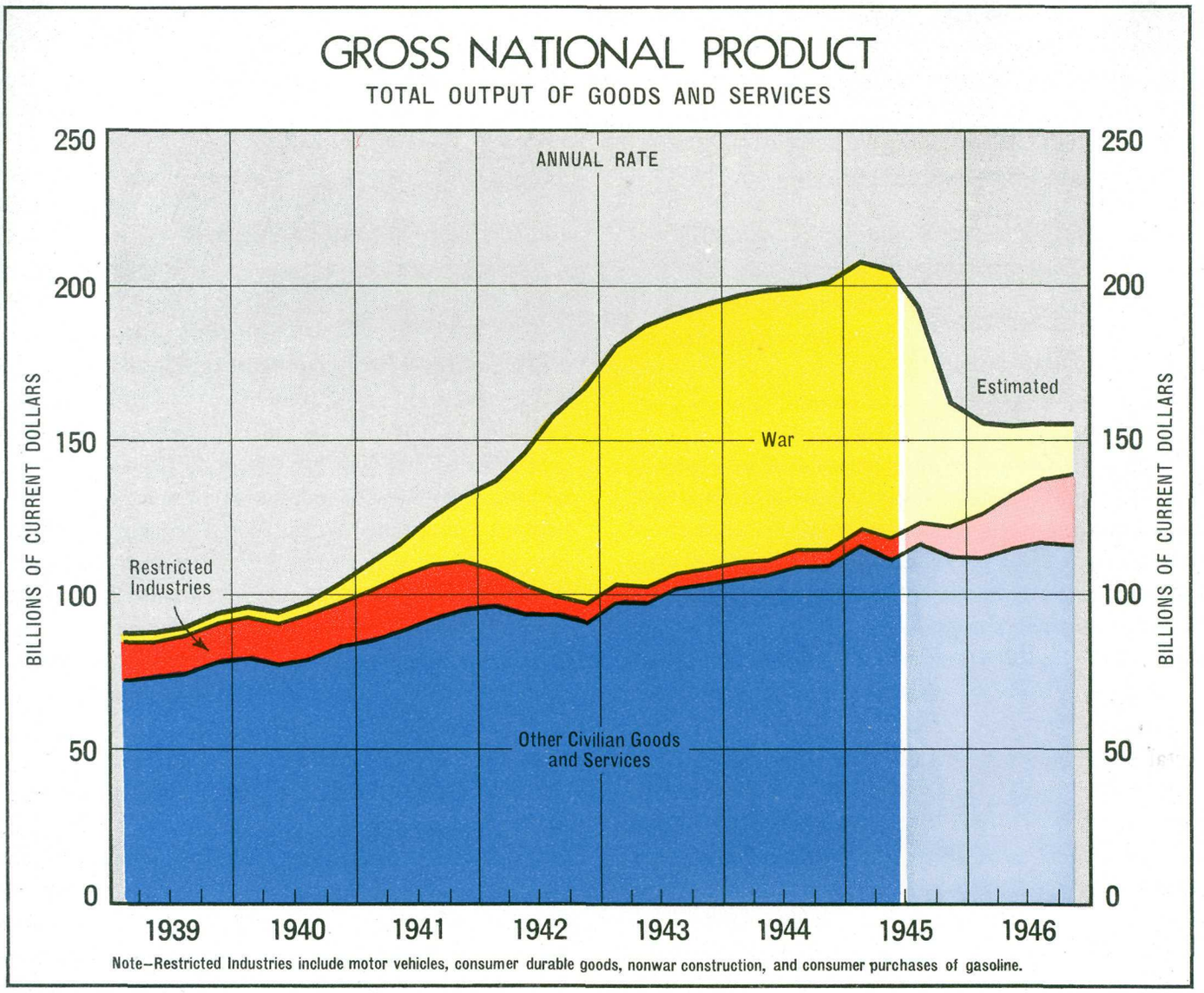
One other group of materials in which the current situation is exceedingly tight is building materials and plumbing and heating supplies—a field in which, strangely enough, the shortages did not become acute until almost the end of the war. In cast-iron soil pipe, brick and other clay products, asphalt roofing, gypsum board, building hardware, flooring, plumbing fixture fittings and trim, and a number of others, dealer stocks have been so depleted and current production is so low in relation to demand that they will, for a time, prove limiting factors on the volume of construction. Active steps are being taken by the War Production Board to expand output of these materials, including expediting of production equipment, support of some requests for price increases, and support of wage increases in such industries as soil pipe and brick, where manpower shortages are attributable to unattractive wage rates.

EMPLOYMENT PROSPECTS

There is as yet no adequate statistical basis for reliable month-by-month forecasts of employment during the reconversion period.

However, with 85 to 90 percent of the scheduled decline in munitions production already effected and civilian production in some lines already beginning to pick up, it is safe to conclude that employment is close to, if not already at, its low point. That does not mean that unemployment has passed its peak, since it is not expected that employment will pick up in the

669713 O - 45 - 3

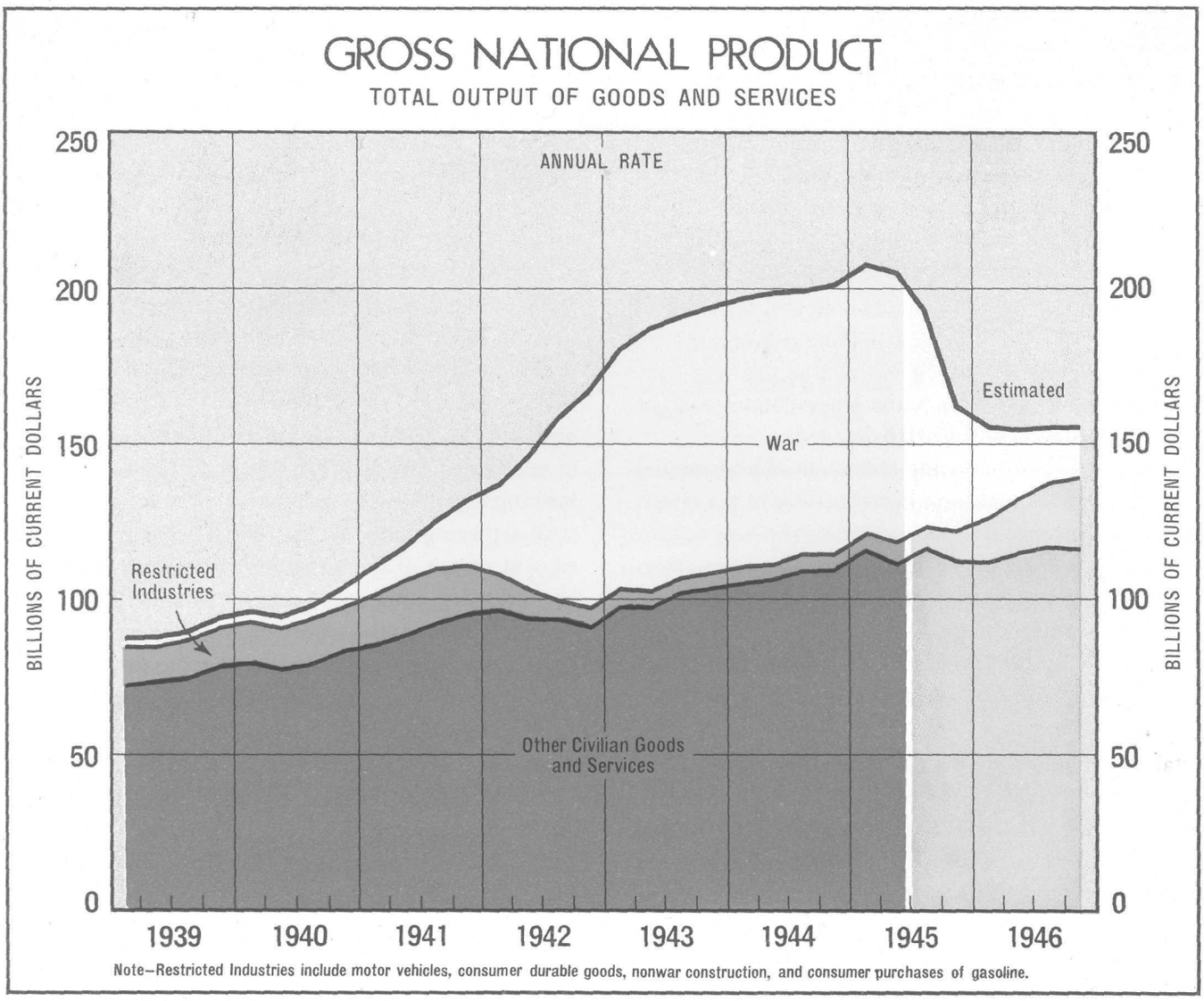

GROSS NATIONAL PRODUCT
TOTAL OUTPUT OF GOODS AND SERVICES
ANNUAL RATE
BILLIONS OF CURRENT DOLLARS
250
200
150
100
50
0
Estimated
War
Restricted Industries
Other Civilian Goods and Services
1939
1940
1941
1942
1943
1944
1945
1946
Note—Restricted Industries include motor vehicles, consumer durable goods, nonwar construction, and consumer purchases of gasoline.

near future as fast as men are released from the armed services. But there is every prospect that by spring the situation will be reversed and unemployment will decline.

Unemployment in the week ended September 8, three weeks after the Japanese surrender, was estimated at 1,700,000, and in the past month there has been little, if any, increase. There are some 8,000,000 men still to be released from the services. I shall not make any estimate of the unemployment peak, but it seems to me that if adequate allowance is made for the withdrawals from the labor force of wives of service men, other women who have left their kitchens only as a temporary war expedient, youngsters who are returning to school and oldsters who will now retire, the business prospect as here outlined does not justify the more pessimistic of the forecasts which have been widely publicized—particularly the anonymous ones.

RECONVERSION SUMMARY

The general outlook, as well as we can visualize it at the moment, is summed up in the accompanying chart "Gross National Product." Forecasts of the gross national product are always subject to a considerable mar-



gin of error and the one here presented, prepared by the WPB Staff, is only one of many now circulating. It is fair to say, however, that at least among the Federal agencies making such estimates there is a considerable degree of unanimity in the appraisal of the outlook for the rest of this year and for 1946. Among these estimates, the figures illustrated in the chart are rather on the conservative side.

It should be emphasized that whatever forecasts are made in this report are based on the assumption of an orderly reconversion and would have to be modified in the event of prolonged and widespread labor disputes, extensive inventory hoarding, serious disruption of the price structure, or other unforeseen circumstances.

The gross national product of the United States in dollar terms (without allowance for price changes) mounted from less than a 90-billion-dollar annual rate when Hitler's armies marched into Poland to a 207-billion rate just before Hitler's collapse. As the chart shows, seven-tenths of that rise was accounted for by war outlays.

Government outlays for war purposes are now expected to fall from an annual rate of 86½ billion in the first quarter of this year to 40 billion in the fourth, with a further decline to about 15 billion in prospect for 1946. (These are not Treasury expenditure figures, but rather reflect the extent to which war outlays are reflected in gross national product.) During this period, some 17 million workers and potential workers will have been released from munitions production and the armed services. This necessarily involves far-reaching readjustments in in our entire economy, and the readjustments will inevitably hurt.

Yet there are good reasons for expecting that the decline in industrial production and national income will be halted by early in 1946. For one thing, government expenditures in early 1945 were far beyond anything required to generate full employment under peacetime conditions and with peacetime hours, even with private capital expenditures at the low levels which prevailed at that time. For another, there are the large accumulated backlogs of demand in automotive equipment, housing, etc., in addition to the deficiency in private capital expenditures to be made up, and the need for refilling business inventories. And there is, in addition, the factor which I mentioned at the beginning of this report—the demonstration which the United States has just given of its ability to achieve a far higher level of production than was considered feasible in the past.

The liquid position of both business and consumers is far better than in prewar years, and consumer reserves will be supplemented by demobilization allowances and unemployment benefits. This will stimulate the willingness of business to invest and the inclination of individuals to consume a high proportion of their current income.

Finally, a large number—perhaps as many as four millions—of the displaced war workers will be withdrawing from the labor market.

Not all of these influences will be felt immediately, and for the rest of 1945 government expenditures will shrink faster than business and private outlays can increase. We must, therefore, expect a period of hesitation, confusion, and uncertainty. But the basic economic factors are favorable, if not to an immediate full recovery, at least to establishing early in 1946 a floor on production and employment through the remainder of the reconversion period.

As the chart indicates, the gross national product, according to our estimates, is expected to level out, beginning in the first quarter of 1946, at around 155 billion dollars at expected 1946 prices. By that time, the further slow shrinkage in government expenditures for war purposes is expected to be fully offset by the expansion in other segments of the economy, particularly in those industries which were restricted during the war, such as motor vehicles, consumer durable goods, nonwar construction, and consumer purchases of gasoline. The effect of inventory accumulation will continue, and by early 1946 capital expenditures will be gaining momentum. I do not doubt that the country will still be facing difficult economic decisions in late 1946 and beyond, but the problems will no longer be war production or reconversion problems.

Part II

INDIVIDUAL PROBLEMS

The following pages are devoted to discussions of a few of the typical problems which faced the War Production Board in expanding production facilities and in other construction; in aiding such special programs as lend-lease and the atomic bomb; in expanding and controlling electric power capacity; and in providing and distributing a number of important materials and components. There are brief comments on postwar prospects in a number of these areas. For a list of these individual discussions, see the table of contents.

There is also appended a tabulation of production of a large number of selected munitions items during the period from July 1, 1940, through July 31, 1945 (pages 105 through 110).

CONSTRUCTION AND FACILITIES

When the war came along, construction activity was already in the sixth year of one of its long cyclical upswings. It had recovered all the ground lost in the middle '30s, though it was still one-third below the boom-time peaks of the '20s. War gave it a boost which carried it back to the old peaks in 1941 and beyond them, to new record heights, in 1942, when new construction reached 13.4 billion dollars (chart, page 32).

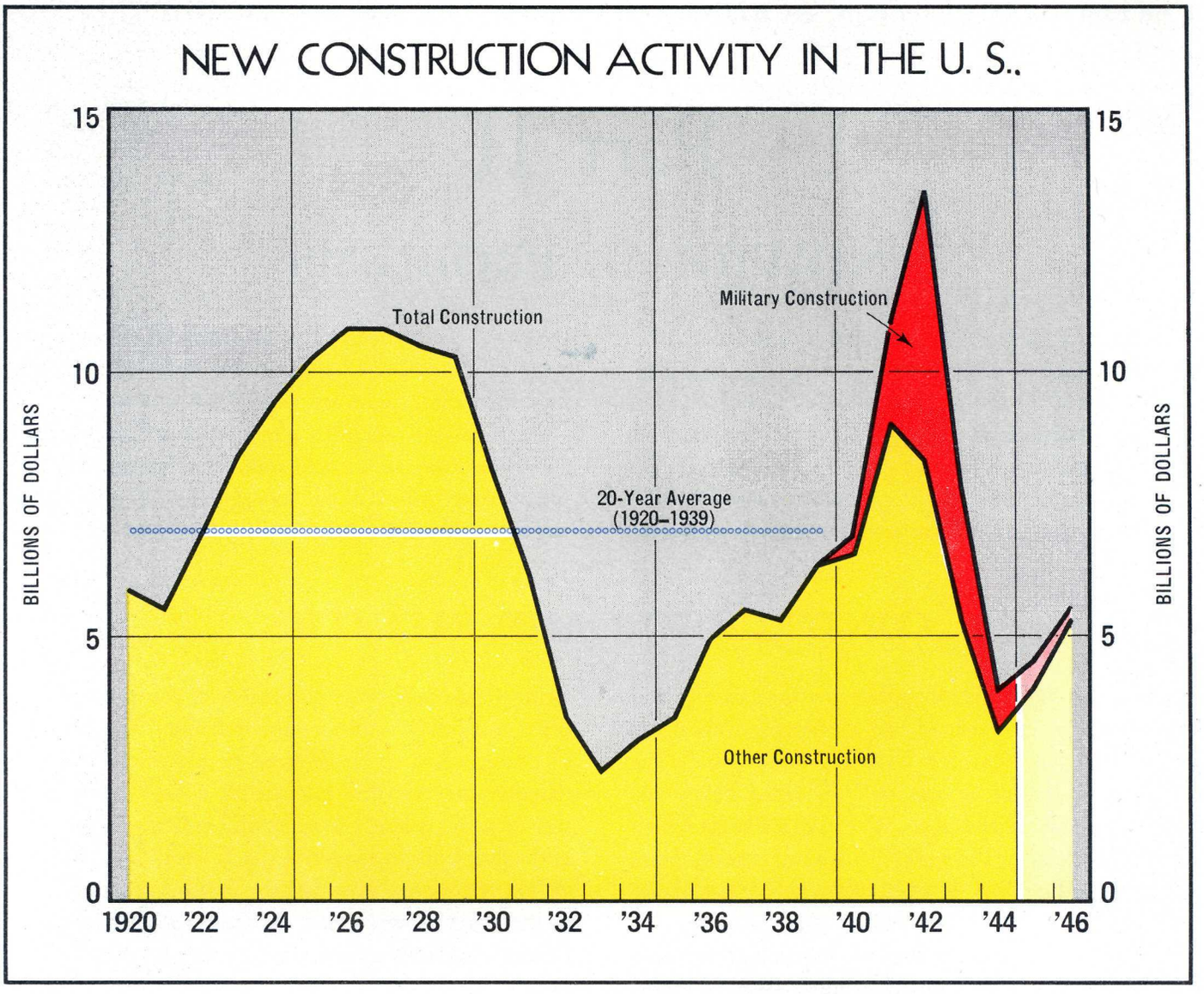
The most spectacular part of the expansion—because it included such large individual units—was in industrial plant. But excluding the 15 billion dollars spent to equip the new plant, actual industrial construction in the 5 years from mid-1940 to mid-1945 accounted for less than 10 billion out of more than 40 billion dollars of new construction. Direct military construction—camps, depots, barracks, air bases, etc.—ran over 10 billions, more than industrial facilities. Indeed, had it not been for this direct military building, total new construction in the defense and war period would have averaged less than in the 20 years preceding the invasion of Poland, as the chart shows, even with the huge expansion in industrial plant and the large expenditures for war housing.

Despite high total construction in the early war years, therefore, there has actually been a substantial accumulation of construction demand. In many construction fields—highways, other public works, commercial buildings, and public utilities—for example, large numbers of projects had to be deferred because they could not demonstrate wartime essentiality. And much of the war housing, plant construction, military construction and other building served only a temporary need and will be abandoned now that the fighting is over. Thus, as the chart shows, a new expansion in construction is foreseen, and its beginnings are already evident.

NEW CONSTRUCTION

In 1939, the United States began in a somewhat modest way the expansion of military installations, the majority of which were within the continental United States. A substantial volume of other new construction was undertaken during the year, but it was largely of a normal peacetime nature; private capital represented 94 percent of total financing in industrial construction and 98 percent in housing. Some plant construction resulted from orders placed by the British and French purchasing missions for aircraft and aircraft components.

Even when our own defense program began to gather momentum after the fall of France, its construction needs were modest at first, and the industry was able



to absorb them without difficulty. As a matter of fact, unemployment among construction laborers and craftsmen prevailed past the middle of 1941. Construction materials were in free supply, with inventories of all types at very high levels. This was true even though total construction activity in 1941 rose to almost 11 billion dollars, an increase of 5 billion over the previous year, with military and industrial construction showing the largest increases (table, opposite). This increased activity, however, did have the effect of seriously depleting inventories of most types of materials and components for construction. Accordingly, as the production swung from one of defense prior to Pearl Harbor to one of frantic production for war thereafter, construction programs in early 1942 ran headlong into serious shortages, not only of materials but of manpower in the specialized crafts as competition mushroomed in war industries.

By the end of 1941, it was entirely clear that unlimited nonessential civilian construction could not be allowed to go ahead without serious interference with essential war programs. This made imperative controls over both construction projects and the materials of construction.

ORDER L–41

The Supply Priorities and Allocation Board attempted to meet this problem by depriving nonessential construction of priority assistance, but this was not effective, and

NEW CONSTRUCTION ACTIVITY IN THE UNITED STATES, 1939–1945

[Millions of dollars]

	1939	1940	1941	1942	1943	1944	1945 (est.)
TOTAL CONSTRUCTION	6,302	6,830	10,758	13,434	7,732	3,935	4,500
Total Public	2,411	2,574	5,442	10,669	6,144	2,353	1,985
Total Private	3,891	4,256	5,316	2,765	1,588	1,582	2,515
Military	119	337	1,756	5,060	2,423	720	515
Army	89	270	1,411	3,934	1,559	319	260
Navy	30	67	345	1,126	864	401	255
Industrial	241	569	2,028	3,806	2,198	982	1,280
Public	14	145	1,350	3,485	1,973	748	640
Private	227	424	678	321	225	234	640
Housing	2,483	2,560	3,360	1,895	1,318	691	735
Public	76	204	480	600	702	192	85
Private	2,407	2,356	2,880	1,295	616	499	650
Nonresidential Bldg.[1]	1,267	937	971	460	230	275	550
Public	762	375	330	239	134	131	200
Private	505	562	641	221	96	144	350
Other Public	1,440	1,513	1,526	1,285	912	562	545
Highways	869	896	850	670	410	310	320
Conservation	318	328	356	356	244	142	110
Various [2]	253	289	320	259	258	110	115
Other Private	752	914	1,117	928	651	705	875
Farm	226	246	315	200	160	170	220
Utilities	526	668	802	728	491	535	655

[1] Includes commercial, educational, recreational, religious, hospital, public administration, and miscellaneous buildings.
[2] Includes sewer and water facilities and miscellaneous projects financed by State and local funds.

in April 1942, the WPB issued Limitation Order L–41 to control construction.

The order, as amended later that year, prohibited the beginning of any construction whatsoever costing more than $200 for residential buildings, $1,000 for farm construction, and $5,000 for other restricted construction without specific approval from WPB. (Authority for approval of certain types of construction was delegated to other Government agencies—housing to FHA, military construction to the Army and Navy, and highway construction to the Public Roads Administration.) While the order was effective in preventing nonessential

construction, neither construction nor facilities expansions could be put on a program basis, and bottleneck-breaking was an ever occurring job.

It can be seen from the table on page 33 that, with the exception of the "Industrial" category, which was almost entirely war-created, construction activity took a decided and progressive drop from the time of the issuance of L–41. Total construction activity for 1944 was $3,935,000,000 compared to 1941's $10,758,000,000 and 1942's $13,434,000,000.

After V–E Day, a number of minor upward revisions of the dollar limitations in L–41 were made. The permitted value of work on residences and farmhouses was increased from $200 to $500, on commercial buildings to $5,000, and on industrial buildings to $25,000. Shortly thereafter, limitations on highway construction were removed. After V–J Day, all dollar limits on industrial construction were eliminated, and the remaining restrictions of L–41 have been revoked (as of October 15).

CONSTRUCTION MATERIALS

As the tempo of the war effort quickened, construction, along with all other programs, began to encounter serious difficulties early in 1942 in the procurement of such materials as aluminum, steel, copper, lead, and zinc. All short supply materials, of course, were separately controlled by various means, and these shortages led to a number of substitutions and improvisations in the construction industry. For example, galvanized coated metal disappeared from the market and was replaced by sherardized or bonderized metal. Flashings were manufactured of asphalt coated fabrics as a substitute for sheet metal and copper. Many plumbing fittings were made of plastics instead of the conventional steel or brass. Where plastics were not satisfactory, brass fittings and casting were replaced with steel or iron in victory-type plumbing facilities. The use of copper was reduced to the absolute minimum. Structural designs were lightened; in residential construction, the weight of all metal per dwelling unit was reduced from a prewar average of 8,300 pounds to 3,200 pounds by mid-1942.

Oddly enough, a number of materials which never presented a problem during the war are now in such short supply that they may limit construction during the early part of the reconversion period. Included in this group are brick and other clay products, cast iron pipe, asphalt roofing, gypsum board, hardware, flooring, plumbing fixture fittings and trim.

THE CONSTRUCTION FUTURE

Present estimates, admittedly tentative, project a construction activity of $4.5 billion in 1945, rising to $6.5 billion in 1946. Publicly financed activity dropped 13 percent in August as stop orders were sent out to a large number of active military and industrial jobs upon the surrender of Japan. Total war facility construction cutbacks are expected to hold the third quarter volume down to $1,272,000,000, since not all of the slack can be taken up by the rising volume of private work. An over-all volume of $1,167,000,000 is expected for the fourth quarter, of which $785,000,000 is expected to be for private account. New privately financed factory building will represent the greatest volume and is expected to reach $206,000,000 put in place. This will be almost three times the volume of the fourth quarter of 1944 and well above the $169,000,000 quarterly rate of 1941.

Of the 6.5-billion-dollar rate estimated for 1946, about 4.4 billions is expected to be for private account. Factory building and major alterations to existing plants are estimated at 950 million dollars, plus about 75 millions of publicly financed industrial facilities.

Unlike industrial building, privately financed residential construction will only begin to approach the top postwar level in 1946, even though the estimated $1,525,000,000 in this category is almost 2½ times the expected volume of 1945. This segment of the construction industry is notoriously sluggish in its response to new construction demands.

Even if production of the more critical materials is greatly increased, many months will pass before material and component inventories are built up at the local supply house level (the source of supply for many hundreds of small contractors) and building organizations dormant during the war are reconstituted. Government-financed residential work is expected to increase in 1946 by 75 percent over 1945. Nonresidential building in 1946 is expected to double 1945, but at this level it would be well below the rate of the good prewar years. It would also fall considerably short of the level necessary to make an effective reduction in the accumulated deficiencies of building in this category. Public high-

ways and new farm construction and utilities will show substantial gains in 1946 but will only begin to bite into the accumulated backlog. It is hoped that 1946 will see the employment of over 1,000,000 workers in new construction work.

INDUSTRIAL FACILITIES

The wartime expansion in industrial facilities is briefly summarized on page 7.

Since the conversion of peacetime industry was entirely inadequate to supply the voracious demands of global war, it was necessary at first to divert scarce materials, machinery, and manpower to building and expanding war plants and related facilities (even at the expense of current production) to permit the raising of the production level to the point required by the military services. From an annual rate in 1940 of about 2 billion dollars, facilities expansions more than doubled in 1941. In 1942, the pressures reached their peak, and the total reached an all-time high at almost 8.5 billions.

After the third quarter of 1942, the trend was downward almost without interruption. But despite the general downtrend, the rate of construction and equipment deliveries on the more urgent programs—synthetic rubber, aviation gasoline, aluminum, iron and steel, ammunition, aircraft—increased as the war effort went into 1943 and showed no very substantial drop until 1944, when most of the objectives had been attained. As the volume in the more urgent categories declined, expansions in those groups which had been sidetracked began to rise, but the over-all trend continued downward. By the first half of 1945, the rate was only 2.7 billion dollars annually—less than a third the average for 1942.

FEDERAL vs. *PRIVATE FINANCING*

The proportion of government-financed construction was naturally heaviest in those categories where there was the least assurance of postwar absorption of the facilities by the industrial economy. This means that a good deal of the federally financed plant is in a marginal position. Of the $3,840,000,000 invested in the aircraft industry during the war (89 percent Federal funds), a large part was in plants which are likely to be unusable in the postwar period. There will also be a considerable proportion of the $2,527,000,000 spent for shipbuilding and repair facilities and of the large amounts invested in explosives and shell-loading plants which must be written off.

The problem of disposal of Government-owned steel plants is already a thorny one. While $1,278,000,000 of public moneys went to building new steel-making capacity, the industry itself expended $896,000,000. The government plants have geographic location in their favor, but the industry would appear to be over-expanded from the intermediate range viewpoint. In the nonferrous metals group, also preponderantly financed by Government money, aluminum and magnesium bulk large, and their future is surrounded by question marks.

Private financing was heaviest proportionately in aviation gasoline, chemicals, coal, petroleum products, food processing, machinery and electrical equipment, and miscellaneous manufactures with peacetime outlets. With none of these does reconversion loom as a serious technological problem. The only problem lies in the extent to which expanded capacities can be utilized in the future.

GEOGRAPHICAL DISTRIBUTION

The location of manufacturing facilities added during the past five years is an important factor in appraising the fate of these facilities in the postwar era. As the huge expansion of facilities took place, there was a conscious effort toward dispersion, but this consideration was necessarily secondary to developing war production as swiftly as possible. As might be expected under these circumstances, the geographical pattern of industry is not greatly different from what it was before the war. This is particularly true when consideration is given to the postwar life-expectancy of the plants. The table on page 36 indicates by region the 1939 value of industrial facilities and the distribution of the more than 25 billion dollars of facilities expansions put in place since July 1, 1940.

Considerations of manpower availability, housing, proximity of materials and components, and integration with existing plants compelled a very large part of the facilities to be placed in regions already heavily industrialized. The East North Central region, which had 31.5 percent of the 1939 plant, has 29.7 percent of today's expanded total. The share of the Middle Atlantic states dropped only from 29.8 to 24.3 percent. Ex-

Region	1939 value	Percent	1940–45 put in place	Percent
New England	3,877	9.8	1,101	4.38
Middle Atlantic	11,788	29.8	3,941	15.66
East-North Central	12,461	31.5	6,773	26.92
West-North Central	2,176	5.5	1,688	6.71
South Atlantic	3,600	9.1	1,551	6.16
East-South Central	1,345	3.4	1,248	4.96
West-South Central	1,305	3.3	2,544	10.11
Mountain	435	1.1	818	5.26
Pacific	2,571	6.5	1,938	7.70
Undistributed	.....	.....	3,556	14.14
Total United States	39,558	100.0	25,158	100.00

pansions in the least industrialized areas were large only in relation to the existing manufacturing capacity in those regions.

There has, of course, been some tendency toward the dispersion of industrial capacity, though the largest expansions in dollar terms have been in the heavily industrialized states, and the top nine states of 1939 are the top nine today (New York, Pennsylvania, Illinois, Ohio, Michigan, New Jersey, Massachusetts, California, Indiana). Texas, Utah, Nevada, and Arkansas have made the biggest jumps, but a substantial part of their increase has resulted from Government-owned shipyards, aircraft plants, steel, aluminum, magnesium. In Nevada, for example, the Basic Magnesium plant represents 98 percent of that state's total. If the plant is utilized to any great degree in the postwar period, Nevada could become a rather important center of industrial activity. On the other hand, if the plant closes down, Nevada's position in the manufacturing scale reverts to where it was before the war. Another one-project example is the $200,000,000 Geneva Steel plant in Utah. Its postwar fate is still uncertain, and if it does not remain in steel production, Utah's wartime expansion will not have amounted to very much.

There has been since 1919 a long-time tendency for industry to move out of the Northeast both to the Far West and the South, and the apparent effect of wartime expansions has been to accelerate this trend. If this tendency continues in the postwar period, much of the new plant expansions which one would tend to write off in the somewhat narrow immediate view may be salvaged.

LEND-LEASE AND FOREIGN TRADE

In a little over 4 years, from March 1941 to July 1945 the United States transferred under lend-lease goods valued at more than 37 billion dollars, besides rendering some 4½ billion dollars of services to our allies. Shipments included almost 21 billions of ships and munitions, over two billions of petroleum products, more than 8½ billions of industrial materials and products, and 6 billions of foods and other agricultural products.

Impressive as these figures are, they do not fully measure the problems involved in supplying such amounts. Foreign demand was primarily for materials and components needed to supplement domestic production of the allied nations, and the emphasis was on specialty items which caused disproportionate impacts on United States production capacity. Thus, Soviet steel requirements were primarily for alloys and the more difficult carbon shapes. Both U. S. S. R. and United Kingdom requests for United States capital equipment were for

tools and machinery of a particularly elaborate and complex nature, and often quite different in design from what our factories were accustomed to produce. Electrical equipment, for example, had to be built in accordance with European standards; machine tools and various instruments had to be designed for metric measurements; special types of bearings, special wires, special nickel alloys, special brass and copper products—to name only a few—had to be supplied in quantities far in excess of anything ever before produced in this country. And the lend-lease requirements impinged heavily on capacity for common components in short supply for our own munitions programs—electric motors and other electrical equipment, bearings, Diesel engines, tires and tubes, and others.

The critical period for United Kingdom and Soviet lend-lease requirements was in 1941 and 1942, at a time when the United States was itself faced with the problem of converting industry from peace to war and building up its wholly inadequate armed strength. War matériel which had been lost as a result of the first quick rush of the German armies had to be replaced, and the British and Russians had to be supplied immediately with the critical materials they needed to hold off the Germans until our own war machine could be made ready.

Conflict between domestic and foreign requirements was inevitable. Each shipment abroad meant interference in some way with over-all war production schedules. Supply of machine tools to the U. S. S. R. and U. K. in the fall of 1941, for example, meant delay in tooling aircraft and tank plants here. Production of specialty bearings for Soviet-produced trucks and tractors meant a more-than-proportionate loss in potential output of bearings for U. S. aircraft and vehicles. There was considerable resistance on the part of manufacturers and others to shipment abroad of equipment and components known to be in short supply for our own military needs.

There were many aspects to lend-lease, but most of the production problems which could not be dealt with by the manufacturers themselves became the responsibility of the War Production Board, and the Board developed machinery and techniques which proved effective in handling the unique problems involved. Lend-Lease was a claimant before the Requirements Committees, and after the relative urgency of its needs was determined there, lend-lease orders were given such expediting and priorities assistance as was necessary to assure meeting those needs. Special sections to handle foreign problems were set up in those industry divisions which had substantial foreign requirements to deal with—Steel, Chemicals, Power, Tools, and Copper. A Foreign Division was established to coordinate programming of foreign requirements and to assist the industry divisions and the International Vice Chairman on questions of foreign procurement in the United States.

By early 1942, shipments to the United Kingdom and British Empire countries had reached large proportions, and the more critical needs of these countries were being met on schedule. Shipments to the U. S. S. R. in late 1941 and early 1942 were on a small scale, but a few key requirements, such as for barbed wire, aluminum, trucks, and certain chemicals, were supplied on an emergency basis. During the second and third quarters of 1942, however, production on Soviet account mounted to a heavy volume. From that time on, with few exceptions, there were available at ship side adequate supplies of all items included in the Russian program to make possible full loading on schedule of every ship available for dispatch to the U. S. S. R.

The bulk of lend-lease went to the U. K., the Empire countries, and the U. S. S. R. But there were other programs of importance which were successfully carried through. Lend-lease and commercial shipments to Latin America, while not directly connected with the fighting, were of real significance; it was necessary to supply goods to maintain the economies of these countries while minimizing the impact of demand—backed by large dollar balances—on U. S. production capacity. Canada was not a lend-lease recipient, but under general policies agreed to between the U. S. and Canadian governments, the economies of the two countries were largely integrated, greatly enhancing the productive capacity of both.

While the total production of this country for allied nations was only a small fraction of the total amounts of materials and products used by those countries in their war efforts, in many instances it represented the margin between a fatal shortage end military adequacy. U. S. production for allied nations was, therefore, a significant portion of our war effort.

POLICY AND CONTROL

WPB was responsible for production, for both domestic and export use, and the final determinations as to what could be produced for each were made in the WPB Requirements Committees. These determinations, however, of necessity were governed by international policy of the country, and control was maintained with the assistance of the Foreign Economic Administration and predecessors, through preference ratings assigned (within quotas) to lend-lease requisitions and export licenses.

The various Russian protocols specified amounts of various materials and products which the United States undertook to supply to the U. S. S. R., and to the extent to which production capacity could be provided, program determinations conformed to these undertakings. Guidance as to the distribution of production between the United States and the United Kingdom came from the Combined Production and Resources Board, on which the United States was represented by a War Production Board member.

IMPORTS

Beginning early in 1942, the Combined Raw Materials Board (the U. S. member of which was also a WPB representative) began to allocate between the United States and the United Kingdom (and among other allied nations) the world supply of critical raw materials available to those countries. This eliminated competition between the U. K. and the U. S. for materials, which might have caused inflationary price rises and disrupted world markets. To implement these allocations, the War Production Board issued its import control order, M–63, which served also to regulate imports with regard to the availability of shipping space.

Imports of many critical and strategic raw materials were limited to public purchases, under WPB directives (which also governed public purchase and stock-piling programs for materials produced domestically). Actual purchase of materials abroad under these directives was in most cases handled by the Foreign Economic Administration.

Foreign purchase programs for stockpiling had been authorized as early as 1939, under Public Act 117 of 1939, and in June 1940, Public Act 664 gave the RFC authority also to establish such programs for imports for immediate industrial consumption. Under this early authority were accumulated the stocks of such raw materials as Manila fiber, block mica, quinine, tin, and rubber which prevented what might have been a disastrous shortage when war came.

Stockpiling and public purchase programs under WPB directives have covered over 260 commodities, imported and domestic. With the end of the fighting, the total has now been reduced to about a dozen, chiefly involving subsidy payments and such scarce raw materials as cordage fibers, lead, natural rubber, tin, hides and skins.

THE OUTLOOK

During the transition period, the War Production Board is continuing to assist urgent foreign procurement programs through expediting action. And in recognition of the unique problems which frequently arise in export, it has provided for the assignment, in exceptional cases, of priorities assistance in advance of procurement, in contrast to the domestic policy of requiring that the necessity for rating assistance always be established before an application for a rating will be considered.

Prospects for our foreign trade in general, now that the fighting has stopped, have already been discussed briefly (on page 25).

THE ATOMIC BOMB

The job of the War Production Board in relation to the atomic bomb program was primarily to assist other programs, essential to maintaining the immediate flow of munitions to the battlefronts, whenever the overriding priorities of the Manhattan District Project got in their way. Only occasionally was it called on to give the atom bomb itself any assistance other than the blanket priority it had been granted.

These conflicts with programs of immediate urgency were felt at one time or another in virtually all of WPB's industry divisions, when producers' order boards were disrupted and carefully timed program deadlines set

back by Manhattan District demands for materials and equipment in exceedingly tight supply.

It was the job of WPB's Special Rating Division to resolve these conflicts—a task made infinitely harder by the secrecy surrounding the atomic bomb operations. Only a handful of men in the WPB knew what the project sought to accomplish; no one could talk about its operations while they defended its extreme urgency.

Before the attack on the French Coast, for instance, the landing craft program demanded top AAA ratings to meet its D–Day deadline. Urgency of this program was indisputable and the ratings were granted. But they were not high enough when they conflicted with Manhattan District orders. This project could assign its own AAA ratings, a privilege denied all other claimants.

Navy officers and industry divisions pushing through the landing craft program protested when Manhattan District orders got in their way. And at the same time Army officers, supported by WPB industry divisions, protested that these AAA orders were blocking their orders for guns and shells needed for tomorrow's—not next year's—battles.

The Special Rating Division, therefore, requested the assignment of a small staff of Manhattan District officers to work closely with it in evaluating the relative urgency of competing top priority orders. When this close relationship was established, the Special Rating Division was able to assist in rescheduling some of the atomic bomb orders without unduly interfering with the project, thereby removing bottlenecks from other top urgency programs. At the same time, Manhattan officers asked for and received the advice of the Special Rating Division before issuing overriding AAA ratings.

Despite this close cooperation, however, conflicts were inevitable. Two examples will show how WPB's Special Rating Division resolved them:

On August 2, 1944, Manhattan District announced it wanted to place AAA ratings on an order for 4,800 high-pressure blowers manufactured by Allis-Chalmers. The Special Rating Division found this would interfere seriously with urgent Army, Navy, Maritime Commission, and Office of War Utilities orders. A meeting of the claimants, Allis-Chalmers, and the General Industrial Equipment Division was called. The case for the atomic bomb could not be argued in detail, while the other claimants could put forth strong factual arguments against any disruption of their schedules.

But in the discussions it developed that the most urgent Army and Navy contracts would be only slightly delayed; that the Maritime Commission could place its contracts elsewhere and, with aid from the Navy, meet its schedules. The Office of War Utilities likewise agreed to shift its orders. And all of the blowers were delivered to Manhattan District on time.

The project did not always get the AAA ratings it desired, however. For instance, the Kellex Corporation, a prime contractor, requested an overriding directive for some large pipe sleeves and gaskets produced only by the Dresser Manufacturing Company. Such a directive would have conflicted with orders for Bofors guns, Navy torpedo rings, Navy steel rings, and other urgent military requirements. Manhattan was urged to try to find substitutes or another source of supply. An officer visited the Dresser plant and found some partly fabricated sleeves which, with slight alterations, would be entirely suitable. Thus, both the Navy's and Manhattan's orders could be met on time.

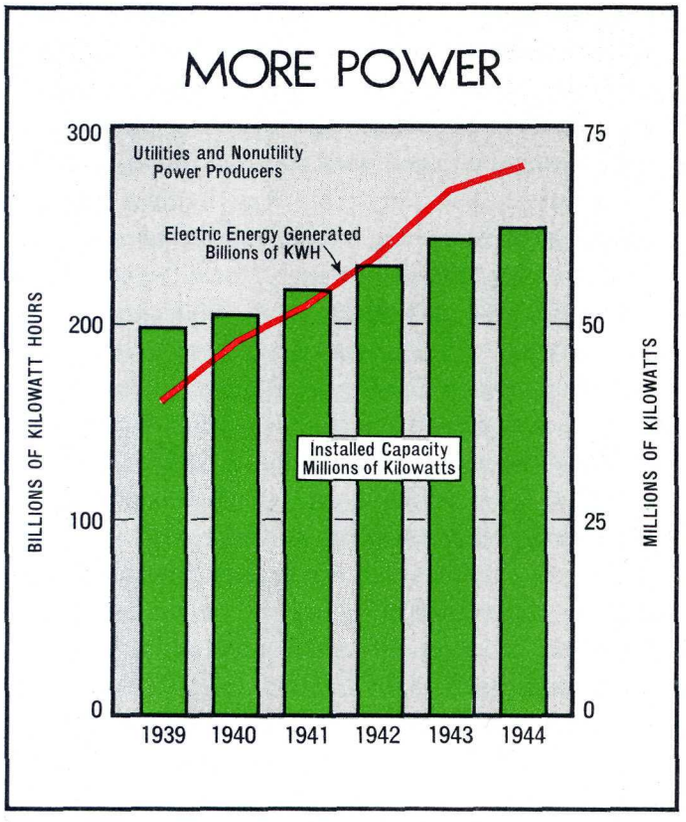
Many other WPB divisions aided the completion of the project. In virtually all scheduling, programming, and allocation of materials, components, and end products, Manhattan was given 100 percent of its stated requirements. Uranium supplies and uses were carefully controlled by the Miscellaneous Minerals Division through M–285 and through allocation of all imported uranium. The Urgency Rating Committee gave it top priority from the start, and it appeared at the head of every issue of the National Production Urgency List, which determined priority in local labor referrals.

In total, these measures speeded up by months the brilliant success of the first atomic bombing of Japan and thus helped bring the war to an earlier conclusion.

ELECTRIC POWER

Paced by such insatiable new consumers of electric energy as the atomic bomb plants, aluminum, magnesium, synthetic rubber, and the cross-country pipe lines, demands for electric power jumped from 161,300,000,000

kilowatt hours in 1939 to 279,500,000,000 kilowatt hours in 1944—an increase of 73 percent. In the same period, generating capacity of the nation's power plants was allowed to increase only 26 percent—from 49,400,000 to 62,000,000 kilowatts (see chart).



ACHIEVED THE IMPOSSIBLE

Yet at no time during the war was it necessary to curtail power consumption because of insufficient supply. The only curtailment of electricity—last year's "brownout"—was due, not to inadequate generating capacity, but to a shortage of coal. And the United States ended the war with lights burning, with every machine fully powered, and with electric energy to spare.

This climaxed the attainment of the impossible. Power engineers, proud of what has been accomplished, can show with cold statistical logic that the installed generating capacity of the nation was not adequate to carry the burdens placed upon it. And they point out that power companies, relieved of their tremendous war burden, are planning to spend $1,500,000,000 in the next 18 months for construction and equipment which is needed to carry the reduced peacetime load.

Neither the raw materials, the skilled manpower, nor the facilities needed for the production of this new electric plant could be spared while the United States was fighting on two fronts. Power plant expansion projects collided head-on early in the war with Navy and Maritime requirements for turbines, generators, boilers, transformers, switches, and other essentials.

Power plants in each of the new battleships, for example, can develop 225,000 horsepower, the equivalent of all the electric generating capacity to serve a city the size of Dayton, Ohio. A big aircraft carrier requires twice as much power. The generating capacity installed in Navy warships alone in the past four years is greater than the total installed electric power capacity in the Nation today.

Because of these demands, it was decided in 1942 to stop all but the most critically urgent of the land-based power plant expansion projects. This decision was reached despite dire predictions that a power shortage would be inevitable on the home front when munitions plants then under construction came into production. And this might well have happened if drastic action to pool resources had not been taken.

DISTRIBUTION PATTERN REALIGNED

So, under WPB direction, the power industry virtually realigned its historical pattern of production and distribution. All the Nation's power systems—private, municipal, county, State, and Federal—were, in effect, assembled, in great operating pools. Normal competitive development had to be halted. When it best served the war effort, some operators had to turn the job of supplying power to customers in their service areas over to competing firms, while their own plants shoved power across State lines to distant war plants. Companies which had carefully avoided interstate operations and thereby Federal regulation were granted temporary immunity by the Federal Power Commission to enter into these pools. Stand-by equipment and other emergency reserves were put to work. Plants and line were overloaded beyond the point engineers believed possible.

POWER POOLS UNDER L–94

This integration of power systems was accomplished through power pools and interconnections created under

the framework of Limitation Order L-94, which was adopted in September 1943. For example, all the power systems in Tennessee, Alabama, Georgia, Florida, North Carolina, South Carolina, and Kentucky were tied together and operated as a single network. And this network, through an intertie at Memphis, was linked with the great power pool in the Southwest, embracing the utilities of Oklahoma, Kansas, Arkansas, Texas, and Louisiana. Similar integrated pools were established in the Pacific Southwest, Pacific Northwest, Middle West, New England, and in the Middle Atlantic States. Thus a sudden demand for power in a Cleveland war plant which the Midwest pool could not fill has been answered by the automatic opening of flood gates at a hydro dam of the Southwest pool in Arkansas. Unused capacity in New York City went to work for an upstate aluminum plant which was also drawing power from Canada and from Niagara Falls, N. Y.

Grandfather of these war pools is the one in the Southeast. It was born in the fall of 1941, when a severe drought gripped the Tennessee Valley and loss of water power threatened to shut down aluminum plants. As an emergency measure, the WPB Office of War Utilities pooled the resources of 27 public and private systems and reversed the normal flow of power—poured it back to TVA's area of usual surpluses—until the emergency ended. Here the capacity of combined power resources in a broad area to cope with "impossible" loads through coordinated action was proven to even the most skeptical.

But pooling alone could not have done the job unless the location of new plants had been controlled. To prevent the massing of big power consumers in areas of tight power supply, the Office of War Utilities reviewed all sites for new war plants, often brought about a change in their location.

In some instances, however, it was desirable to locate a plant in an area of short power supply because other advantages were overriding. The big Defense Plant Corporation magnesium plant at Velasco, Texas, is an example. All available power in that area had been earmarked for synthetic rubber and high octane gasoline plants. For a time it looked as if the ideal location for extracting magnesium from sea water would have to be abandoned. It would have taken 18 months to build a power plant big enough to satisfy demands of the magnesium plant. And neither the time nor the productive facilities could be spared for brand new generating equipment.

But utility engineers and WPB's power staff solved the problem. Among the unused reserve generating capacity in New York City they located a 40,000-kilowatt turbo-generator and a battery of boilers. Another unused turbine was found in Detroit, and a half-completed turbine was found in the General Electric Company shops. The go-ahead on construction of the magnesium plant was given, and the makeshift plant produced so much power it was able to divert surplus current to the gasoline plants.

MORE IMPROVISATION

In another instance of engineering "make-do," two 75,000-kilowatt generators were diverted from their intended location at Shasta Dam in California to power stalls designed for 108,000-kilowatt units at Grand Coulee in Washington. The power house at Coulee was built and ready for operation, but construction was only partially completed at Shasta. A major complication was the fact that Shasta's generators were designed for right-hand operation and Coulee's power house had been designed for left-hand generators. But engineers found a way to make them work.

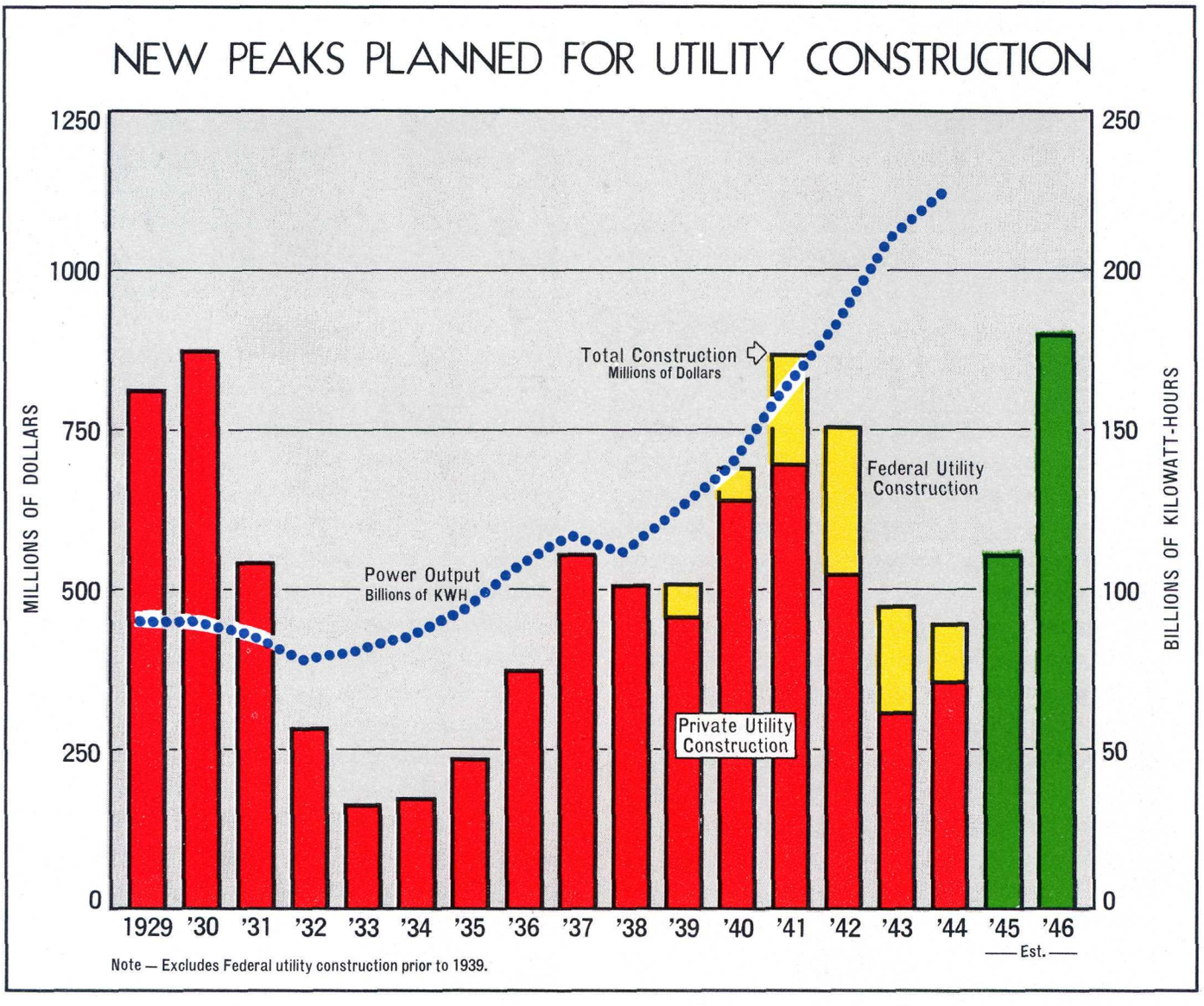
When Russia called for two 40,000-kilowatt 50-cycle units without delay, OWU stripped them from a power plant in Los Angeles—it would have taken 18 months to build them—and ordered the Los Angeles plant to draw its energy from the Pacific Southwestern pool until an uncompleted 80,000-kilowatt generator in Detroit could be redesigned and completed.

Similar improvisation and "swapping" were required to maintain the existing power plants. Early in the war, WPB established a central inventory of all unused equipment in the hands of the power companies. For the most part, the companies willingly shared this reserve equipment, although they were not compelled to do so. When needed items of equipment could not be found in the central inventory, OWU granted high-priority ratings for their production. But in every instance, need for new equipment was evaluated on an area basis; individual companies could not install additions or improvements unless it was demonstrated that without them the power needs of the area would suffer.

LARGE EXPANSION PROGRAM

This strict screening created a large dammed-up program for rehabilitation and expansion of power plants and transmission systems (chart, below). Four days after V–E Day, the Office of War Utilities paved the way for a start on this program by liberalizing the criteria governing power plant expansion. Instead of reviewing applications solely on the basis of area needs, OWU considered the hardships which denial of applications would impose on individual companies during the reconversion period. Under this liberalized policy, projects which will add another 2,000,000 kw. of capacity in 1946–47 were promptly approved. These authorizations virtually cleaned up pending applications for plant expansion, many of which had been on file since July 1942. But the power companies have made it clear that this was only the beginning. Before OWU removed the last of its expansion controls in August, they had reported that when construction was entirely open-ended, they planned to continue expanding at the rate of $1,200,000,000 a year.

Order L–94 was also revoked in August, but the Office of War Utilities urged power companies in areas of short supply to continue their pool interchanges at least until new equipment is completed and placed in operation. WPB retains powers to force reestablishment of pool connections if this should become necessary during the immediate reconversion period.



The surrender of Japan brought a sudden decline in power demands. By the end of September, the weekly rate of power output had dropped 300,000,000 kilowatt hours. Some further decline is expected, and weekly output will probably be down to about 3,550,000,000 kwh by the end of this year. However, this downward trend is expected to reverse itself next year, and in 1947 the utility companies anticipate power demands which will be even heavier than those made during the war years.

STEEL

Because of the key position of steel as a production material in almost every significant war program, the stimulation of steel supply and the direction of steel distribution, over-all and by alloys and shapes, were among the prime factors supporting this country's production record. I want, therefore, to discuss steel at some length.

THE PREWAR PHASE

Steel came into the limelight in early 1941, when President Roosevelt requested Mr. Gano Dunn to prepare a report on 1941 and 1942 steel supply and requirements. Until this time, there had been little dispute concerning the industry's ability to meet all demands. In this report, submitted on February 22, 1941, Dunn concluded that there would be a surplus of some 2,100,000 ingot tons in 1942, if furnaces then producing or under construction were operated at "reliable" capacity. At the same time, however, some contrary opinions were being expressed, and doubt began to be raised as to the adequacy of steel capacity.

Further growth in both the defense program and indirect steel demands lifted ingot production to capacity levels in the middle of the second quarter of 1941. Due to these considerations, the OPM, after careful study, recommended the addition of one blast furnace in Utah, and a large-scale integrated plant on the West Coast, and, by May 1941, had taken under active consideration projects located elsewhere in the country.

At this juncture, Dunn prepared a second report painting a much less favorable prospect. Owing to the marked growth in direct defense demands and the establishment of Lend-Lease, he concluded, 1941 ingot supply would fall short of demand by at least 1.4 million tons, and in 1942 the deficit would reach 6.4 million tons. In his balance sheets, direct defense needs were placed at 12.4 million tons for 1941, and 13.8 million tons for 1942, while the domestic civilian figures stood at 68.1 million tons and 73.4 million tons, respectively.

The second Dunn report had the effect of crystallizing much of the general thinking then current with respect to the whole steel situation. Upon its receipt, the President intimated broadly that (1) basic ingot production would have to be expanded, (2) full priorities might have to be applied in the case of steel, and (3) civilian supplies would have to be cut sharply. Shortly thereafter, quotas limiting production of automobiles, refrigerators, and other durable consumers' goods were set beginning in August 1941. On June 3, the OPM, in accordance with a presidential request, asked the Steel Industry Defense Committee to investigate the possibility of expanding ingot capacity by 10,000,000 tons per annum. One week later, the Committee replied that such an increase could be achieved, and by mid-year work had been initiated to develop a program on that scale.

Before this work had made much headway, however, the supply-demand position shifted rapidly from one of precarious balance to one of substantial and growing deficit. On the demand side, manufacturers of civilian products began pressing mills to accept orders in much heavier volume than had been foreseen. On the supply side, the growing shortage of pig iron and scrap combined with seasonal factors to hold steel-making operations well below the levels reached in late spring. As a result, producers began to experience extreme difficulty in meeting even a substantial fraction of their commitments for direct military, export, and war-supporting needs. In some products, notably plates, the situation threatened to become impossible.

Resolution of these difficulties, it was recognized, would require action much more immediate and more far-reaching than contemplated before that time. Six major steps were taken:

(1) Institution of a 6,500,000-ton expansion of blast furnace capacity.

669713 O - 45 - 4

(2) Establishment of a full allocation system for pig iron.

(3) Issuance of M–21, the general steel preference order.

(4) Placement of all Lend-Lease tonnage under allocation.

(5) Institution of a complete and mandatory priorities system for steel plate.

(6) Further substantial cuts in the production quotas for such major steel-consuming uses as automobiles, trucks, and refrigerators.

These measures, all put into effect during the first half of August 1941, constituted the first systematic attempt to cope with the developing steel problem in all its ramifications.

In early fall of 1941, activities in steel were concerned primarily with supplementing and rounding off the August moves. In September, the Iron and Steel Branch submitted a plan envisaging addition of 10,000,000 tons of annual steel ingot capacity, to be supported partly by the blast furnace expansion launched in August. Shortly, thereafter, SPAB approved of this program, basing its action in part upon revised estimates placing direct military requirements at 16.7 million tons in 1942 and 18.1 million tons in 1943. Scrap came under full allocation October 10, in a further effort to improve the gradually worsening materials situation. Production quotas for many civilian end-products underwent further reductions about the same time. And at the close of the month, work was in progress to increase plate rolling mill capacity by construction of sheared plate mills and conversion of those continuous strip mills best adapted to roll light plate tonnage.

PEARL HARBOR TO CMP

The war brought bewildering changes in the status of most metals, but for none perhaps more suddenly and more completely than for steel. All previous estimates of forward military and war-supporting needs were rendered almost worthless. Estimates of requirements for specific programs (aircraft) and products (plates) likewise became obsolete. And no one knew what value could be attached to the pattern of producers' forward bookings, upon which main reliance had been placed for a picture of near-term over-all demands and longer-term product "mix."

Within two months, however, the atmosphere had cleared sufficiently to make it evident that, if the war effort were not to bog down seriously for lack of steel, four things must be done:

(1) Make available to consuming industries a substantially larger volume of finished steel products, probably the equivalent of 90,000,000 tons of steel ingots in 1942 and still more in 1943.

(2) Increase the volume of plate for essential uses (direct military, defense construction, Lend-Lease, and such important war-supporting items as freight cars) 75 percent or more above its average rate in late 1941.

(3) Effect a huge expansion in the production and a marked change in the distribution of high quality alloy steels.

(4) Develop much more stringent methods of controlling the production and distribution of rolled and drawn steel products as a whole.

AUGMENTING SUPPLY

The job of increasing the over-all quantities of steel available for military and war-supporting needs broke down into three parts: (1) providing sufficient raw materials to permit relatively full utilization of steelmaking furnaces; (2) accelerating the expansion of basic iron-making and steelmaking capacities; and (3) mobilizing for war use inventories rendered idle and excess by shifts from peacetime production.

RAW MATERIALS

Of these tasks, expanding raw materials supply ranked as the most immediate. During the latter part of 1941 producers had run into shortages of metallics (pig iron, scrap, and charge ore). By early 1942, several open-hearth furnaces had been forced to shut down, and expectations were that the situation would worsen sufficiently to hold ingot production below its 1941 level of 82,400,000 tons, thus making impossible fulfillment of urgent demands.

To forestall such a development, the War Production Board had recourse to several drastic expedients. Orders were given to drive blast furnace stacks at the maximum rates possible. A strenuous and successful effort was made to open the Lake Superior ore shipping season earlier than ever before, and to keep carriers loaded to capacity. Producers were induced to use large quantities of scrap in the less desirable grades. A nation-wide collection drive was instituted to bring remote and ob-

solescent scrap to the melting furnaces. The War Production Board approved the use of experimental methods (for example, production of sponge iron) to add to the supply of high-grade melting stock. The inventory control provisions of the pig iron and scrap allocation orders were used to insure channeling of increased supplies to the tighter areas. And immediate steps were taken to enlarge the blast furnace expansion program and bring it into operation as speedily as possible.

The success of this campaign exceeded even the most optimistic expectations. By April, practically all open-hearths were back in operation. In July, pig iron ceased to be a problem, and it became clear that despite the heavy shift to alloy grades, steel ingot production for the year would reach at least 86,000,000 tons. And by the first part of 1943, scrap collections had improved enough to warrant a sharp cut in allocation activity.

FACILITIES EXPANSION

The outbreak of hostilities placed us in a very difficult position with respect to plans to increase basic iron and steel-making capacities. On the one hand, the extreme pressure of demand for ingots and metallics made it imperative not only to add to the expansion of blast furnace capacity, but to realize both this capacity and that planned for steel furnaces more rapidly than contemplated in the SPAB-approved report of September 1941. On the other hand, due to the huge quantities of steel and other materials required in their construction, there was serious doubt whether all the projects approved in this report should be kept in the picture. Both considerations pointed to the fact that only by a careful rescheduling of the whole program could we hope to adapt ourselves to the changed situation. WPB's Facilities Bureau worked intensively to push the program through. In the end, the amounts added came to 10,470,000 tons in the case of pig iron, and 9,275,000 tons in the case of steel ingots (chart, p. 46).

REDISTRIBUTION OF INVENTORIES

The job of redistributing steel inventories arose only after our rapid switch to a wartime basis. With this changeover, many large manufacturers (such as the automobile companies) found themselves unable to use much of the tonnage they had accumulated for peacetime production. Then, too, the flood of L-, P-, U-, and M-orders (including M-126, the famous steel conservation order) rendered idle and excess a large volume of material in fabricators' stocks. Finally, substantial amounts were frozen by changes in the scale and composition of war programs. The net effect was to create a huge mass of finished steel stocks potentially additive to mill supply, but requiring for this purpose to be transferred to other points in the economy.

Several steps were taken to effect such transference. One of the earliest (February 1942) was the formation of a Distressed Stock Unit within the Iron and Steel Branch of OPM to act as liaison between sellers and potential buyers. Following this, on July 7, 1942, WPB issued Priorities Regulation 13, permitting holders of idle and excess material to move it in accordance with established preference ratings. At the same time, the Steel Recovery Corporation was organized to absorb the Distressed Stock Unit and to formalize and systematize its functions. Various claimant agencies set up their own redistribution branches. By July 1943, most of the material available for reuse had been moved through these channels.

As a complement to the campaign to redistribute steel inventories held in mill forms, efforts were made throughout 1942 and 1943 to move excess stocks of fabricated steel parts. This phase of the work was handled by WPB's Redistribution Division.

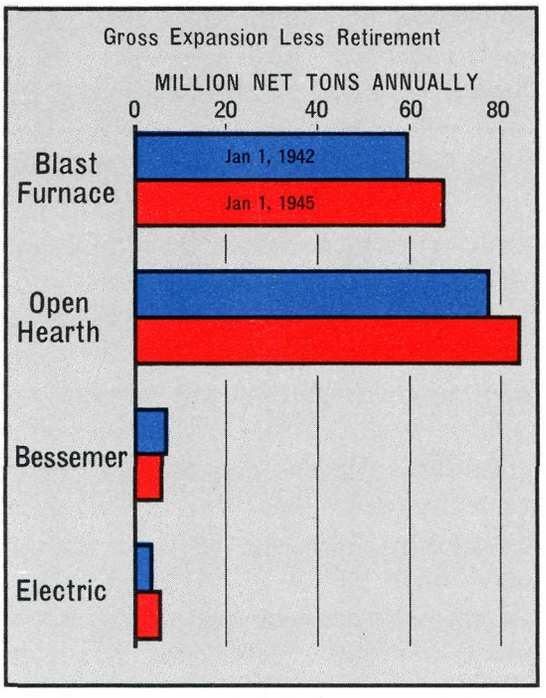
Records are inadequate to permit exact measurement of the aggregate volume of steel recovered by redistribution activities. It is known, however, that the Distressed Stock Unit and its successor handled more than 1,500,000 tons. Moreover, informed estimates place the movement under the terms of Priorities Regulation 13 in this neighborhood. And the Redistribution Division and various claimant agencies rerouted substantial amounts. It seems conservative, therefore, to assume that, in the aggregate, not less than 4,000,000 tons of finished shapes (the equivalent, in steel ingots, of 60 percent of the annual capacity added by the ingot expansion program) were pressed into service—the bulk of it during the period of our most urgent need.

RAISING PLATE PRODUCTION

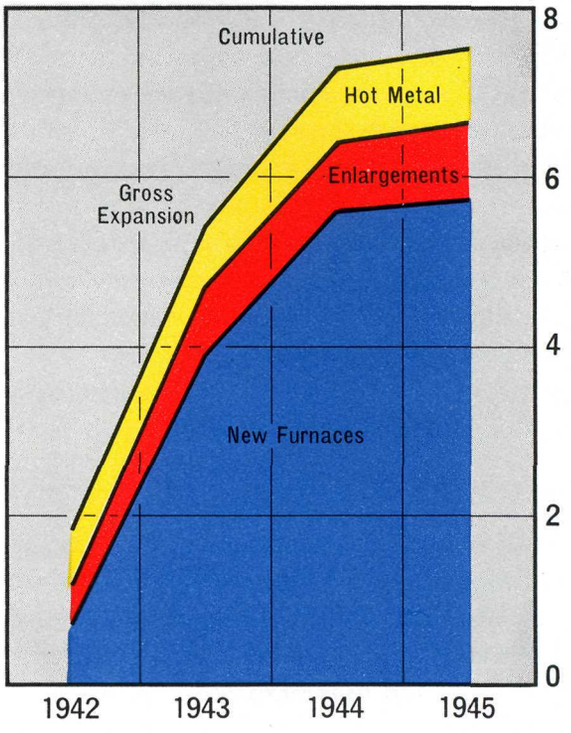
The methods employed to deal with the post-Pearl Harbor plate crisis—utilization of continuous strip mills, expansion of sheared plate mill capacity, and control over production and distribution—bore a surface resemblance to those used during 1941. In scope, char-

STEEL EXPANSION PROGRAM—1942-1945

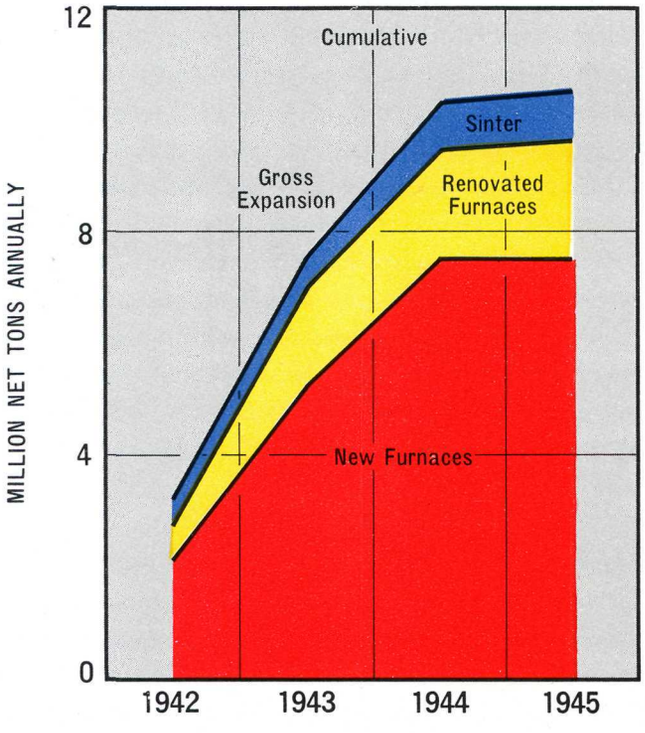
NET EXPANSION—JAN. 1, 1942–JAN. 1, 1945



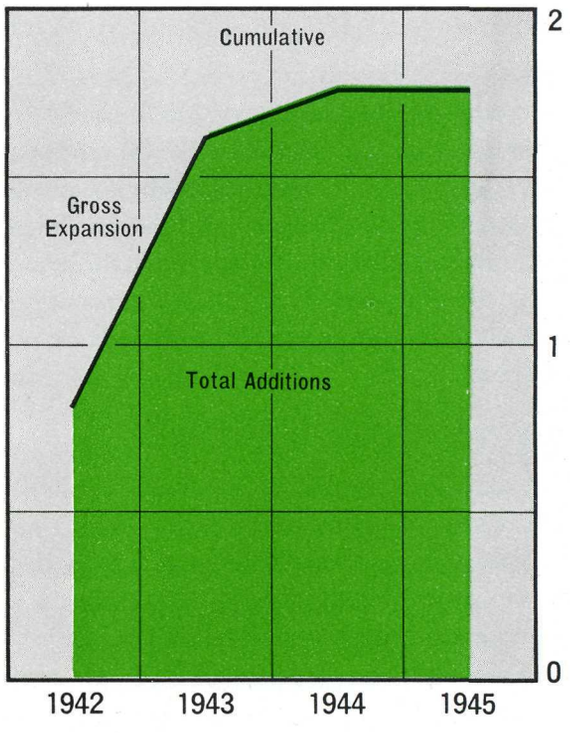
OPEN HEARTH ADDITIONS



BLAST FURNACE ADDITIONS



ELECTRIC FURNACE ADDITIONS



acter, and results, however, the differences were immense.

Strip mill utilization plans underwent perhaps the most startling change. Until Pearl Harbor, these had been confined largely to the few units which were equipped to produce some plate tonnage in any case. Thereafter, the aim became wholesale and speedy conversion. Surveys were made immediately to determine the potential plate capacity of each continuous mill. Records showing in detail the kinds and quantities of mill auxiliaries (shears, cooling beds, conveying machinery) needed to realize such capacities were assembled, and arrangements made to install this equipment at the earliest possible date. Bottlenecks at the slabbing mill and reheating furnace stages were broken with little regard for cost and convenience. And the Iron and Steel Branch engaged to load each mill with plate tonnage as rapidly as space developed. As a result, within seven months production of strip mill plates rose more than 300 percent, and by August 1942, had come to represent over half of a vastly increased over-all output (table below).

Changes in the control mechanism were almost as drastic. Plates had been placed under full priorities in August 1941. But with Maritime, Navy, and Defense Plant demands skyrocketing, this measure proved inadequate, and it became necessary to establish a system of full allocation. Under this scheme (put into effect in January 1942) each producer had to submit itemized order boards to the Iron and Steel Branch and to major claimant agencies. The latter were given the right to select, within the limits permitted by supply and other claimants' needs, the tonnage necessary to meet their programs each month. The lists of selected orders were then sent back to the mills and became their mandatory production schedules.

By the spring of 1942, it became apparent that, despite the rapidly rising production, even tighter supervision

PLATE SHIPMENTS, BY TYPE OF MILL, OCTOBER 1941 TO MARCH 1943

[Net tons]

	Universal	Sheared	Strip	Total
1941:				
October	94,311	346,401	152,440	593,152
November	99,828	350,868	169,311	620,007
December	113,467	358,273	182,604	654,344
1942:				
January	122,227	381,899	250,396	754,522
February	111,965	377,770	268,988	758,723
March	123,152	449,379	306,195	878,726
April	121,838	436,614	337,519	895,971
May	125,608	461,375	425,211	1,012,194
June	123,114	438,144	489,704	1,050,962
July	126,100	447,481	550,537	1,124,118
August	115,710	430,197	551,959	1,097,866
September	115,372	434,555	511,909	1,061,836
October	114,506	449,895	536,981	1,101,382
November	114,755	424,708	474,136	1,013,599
December	114,650	454,902	490,487	1,060,039
Total	1,428,997	5,186,919	5,194,022	11,809,938
1943:				
January	121,039	448,481	565,893	1,135,413
February	118,519	424,167	529,315	1,072,001
March	138,805	465,572	563,302	1,167,679

would be required over plates. Major changes, therefore, were made in the pattern of controls, notably: (1) establishment of a quota plan, under which both over-all plate output and its distribution among claimants were set by the Requirements Committee each month; (2) introduction of stringent inventory controls; and (3) institution of a procedure requiring each claimant to justify the individual orders composing its quota in the light of its contractors' inventories, prospective rates of consumption, and end-products. In this form, the system represented one of the strictest and most successful control systems ever established by WPB for a widely used material.

Largely as a consequence of these measures, essential plate requirements had been brought into balance with supply by the spring of 1943. This led to the abandonment of direct plate allocations in favor of the general CMP steel controls on July 1, 1943. Since that date, plates have presented fewer difficulties, though in the first quarter of 1944, demands for landing craft and cargo vessels made necessary the institution of a modified quota plan.

ALLOY STEEL

The huge growth in military programs after Pearl Harbor brought alloy steel into much the same general position as plates, confronting a level of demand well beyond regular melting and finishing capacity. But the prospective imbalance was somewhat more serious in this case, and there was one important complication: a critical shortage of basic alloying elements, such as chromium, nickel, and tungsten. The alloy steel industry thus had three formidable tasks set before it: (1) development of adequate manufacturing and processing facilities; (2) provision of the necessary supplies of ferroalloys; and (3) establishment of controls to insure the most effective distribution of supply until the latter should become sufficient to meet all essential demands.

With respect to increasing production, the same instruments (conversion and expansion) lay open to alloy producers as to steel plate producers; and, as in the case of plates, conversion came first in order of time and importance. The major action involved shifting basic open-hearth furnaces normally producing carbon steel ingots to the manufacture of alloy grades, wherever possible. In addition, steps were taken to eliminate bottlenecks in special processing and finishing departments and to divert labor and machinery to such operations. The conversion of melting facilities led to a substantial loss in over-all output, due to the longer refining cycle on alloyed material, but the gains were immediate and more than commensurate in terms of the relative importance of end products served.

Problems of expansion were tackled on three fronts. First, the Steel Division undertook immediately to speed the installation of electric furnaces already in the building program. Second, several new open-hearth projects (mainly for the production of armor castings) were brought into the steel foundry expansion program. And third, novel steel-making techniques (open-hearth-electric furnace, cupola-electric furnace, and cupola-bessemer-electric furnace combinations) were introduced at several plants to shorten the refining cycle on furnaces already operating, and thus give increased production at a much earlier date and much less expensively in terms of critical materials than was possible through construction of new units.

So successful in fact were these efforts that in the spring of 1943, with the help of some reduction in requirements, the supply of alloy steel ingots overhauled demand. It became possible to defer part of the projected expansion program and to begin switching back open-hearth capacity to carbon steel production.

FERROALLOYS

Measures to redress the balance in ferroalloys were pushed even more vigorously, and with equal success. First came a drive to increase production and imports to the maximum extent possible. As the second step, radical changes were effected in metallurgical practices and specifications—substitution of the famous NE steels for conventional SAE grades in so-called "constructional" uses, virtual elimination of nickel in ballistic test steels such as cast armor, and a major shift to molybdenum types in the field of tool steels—in order to reduce the average alloy content of steels serving given end uses, and to save nickel, chrome, and tungsten through increased use of manganese and molybdenum. The Steel Division also initiated a campaign (1) to increase the proportionate use of triple-alloy steels and (2) to compel segregation of wastage from such material into well-defined chemical combinations, thus rendering possible

maximum recovery of elements contained in scrap. By mid-1943, the last two actions had brought consumption of ferrochrome and virgin nickel some 25 percent below the average for 1941, and (with increased availability of chrome ore and nickel matte) the supply of these elements appeared adequate to meet all steelmaking demands.

To cope with the problems of distribution, the Iron and Steel Branch, after several attempts to improve priorities procedure, came finally (May 1942) to direct allocations. The plan put into effect had as its basis the major elements in the plate allocation scheme.

The major reason for alloy steel quotas and melt schedules vanished with the achievement of balance in this grade during the spring of 1943. However, a modified version of the schedules was maintained to assist in ferroalloy conservation efforts and as insurance against a revival of demand.

CONTROLLING FINISHED STEEL

The first major difficulties in the field of over-all steel controls arose on the side of production. Experience indicated that exclusive dependence upon the priorities system as a scheduling device would prove self-defeating. There were four major reasons for this:

(1) The system did not provide machinery for spreading orders among the several departments of a given mill, or among producers of a given product, in such a way as to permit establishment of efficient production patterns.

(2) Such difficulties were aggravated by constant inflation of ratings and rapid changes in the priorities pattern confronting each producer.

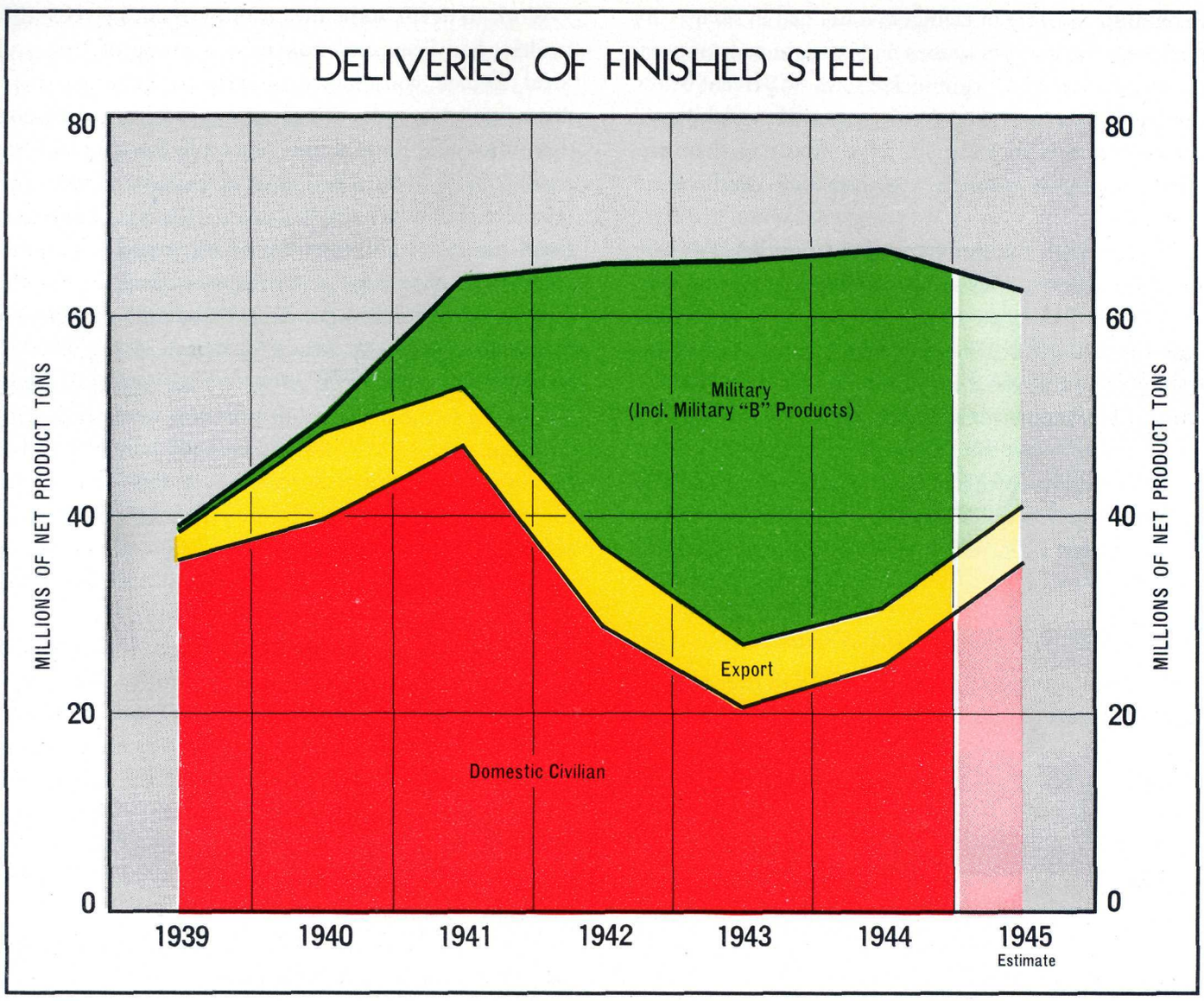
(3) Nonintegrated mills were penalized severely by the system. These units could obtain raw material only by extending priorities to integrated plants. With the time-lags involved, constant inflation of ratings led to sharp curtailment in the tonnage produced for their account.

(4) The Iron and Steel Branch could implement Requirements Committee allocations only by directing the necessary tonnage into mill schedules. This proved to be a disruptive factor even with the relatively small volume of allocations in early 1942, since the tonnage had to be imposed immediately and in most cases without detailed knowledge of product impact.

Work to devise some means of overcoming these difficulties had been undertaken by a group of Iron and Steel Branch consultants as early as February 1942. After intensive study, this group came to the conclusion that substantial relief could come only from a complete product-by-product scheduling of each steel mill, and offered a plan to achieve this goal. The plan envisaged establishment of a Committee which would be empowered (1) to meet regularly with each producer for the purpose of determining a proper and full distribution of the latter's capacity among various products, and (2) to direct the producer to adhere to the agreed pattern. According to the plan, this distribution would represent a combination of (1) allocations made pursuant to Requirements Committee decisions, and (2) the best possible compromise among priority ratings, character of production schedules and backlogs, potential manpower needs, and directives set or contemplated for other mills.

By August 31, the committee had issued directives to all large integrated producers. The smaller integrated producers and larger nonintegrated companies were covered within the next two months. And by the year-end, all steel mills had been brought within the system and were operating in accordance therewith. That it was possible to meet virtually all essential demands for steel in late 1942 and early 1943 was due in no small part to this speed of introduction.

Production directives were intended primarily to mend weaknesses in the system of production controls, not in the distributive machinery. In order to cope with the problems presented by such items as plates and alloy steel, it was necessary to modify drastically, or even to scrap completely, control by priorities. Within limits, this policy could be pursued without destroying the system. But when (by midsummer 1942) the process had been carried to a point at which more than half of total steel output (carbon steel plates, all alloy shapes, all material produced for warehouses, tin plate, all Lend-Lease steel, and such other tonnage as the mills were directed to produce) was being handled by devices other than preference ratings, it became clear that the only solution lay in an integrated allocation plan for all users. The problem in steel was of paramount importance in the development of the Controlled Materials Plan. (See p. 14.)



STEEL UNDER CMP

The heart of the steel problem: (1) balancing requirements against supply, (2) holding total authorized procurement within the limits of anticipated production, and (3) distributing allotments so as to maximize the total war effort—was attacked directly and largely resolved through CMP. During the two years of operation under the plan, therefore, the principal difficulties came from a series of technical operating problems. Among the more important of these problems were:

(1) The extent to which the anticipated supply should be overallotted to compensate for the failure of authorizations to reach the mills (which acquired the label "attrition"). For the first two quarters we felt our way along, so to speak, overallotting moderately and keeping a close watch on developments. Actual production fell considerably short of anticipations—largely because of slippages in the facilities expansion program. Attrition in those early quarters, on the other hand, proved to be considerably higher than anticipated. These early estimating mistakes almost exactly cancelled out; and by the beginning of 1944 techniques had been improved so much that for several quarters estimates of both supply and attrition proved remarkably accurate.

(2) The determination of whether over-all allotments in terms of carbon steel and alloy steel would be adequate or whether each steel shape should be separately allotted. The decision was to screen requirements submitted in terms of shapes, limit use of some shapes (rail, plates,

and others) by program control, and prune over-all allotments for programs drawing heavily on shapes in tight supply. Minor unbalances were handled by production directives on flexible mill facilities.

(3) Adjusting programming levels and allotment policies following rapid changes in the supply-demand balance in successive quarters. In the spring of 1944, substantial cutbacks in many military programs opened prospects of an easy supply situation. This was handled by selective relaxation of limitation and conservation orders. During the second quarter, production declined and the burden of allotments pushed the carry-over of unfilled orders slightly above 10 percent of the total order load. In the fourth quarter, 1944, Army requirements were sharply up and the supply forecasts were at low levels, reflecting the drain of labor away from the mills. Special controls over rails were tightened to cope with the shell steel problem. Strikes and bad weather in the first quarter, 1945, brought output to the lowest level since 1943. The Steel Division was forced increasingly to resort to special directives and mill overloads. The carry-over rose to 14 percent. Allotments for the next quarter were screened more rigidly than ever; allotments already issued for supplemental nonmilitary production were cancelled; a drive was launched, with WMP cooperation, to maximize ingot output and break bottlenecks in fabricating departments.

EASING AFTER V–E DAY

The military program reductions announced just before and just after V–E Day opened a prospect of an easier third quarter supply-requirements position, and a start was made toward lifting end-use restrictions. CMP authorizations were provided for essential programs only, the new nonmilitary consumption arising from relaxation of limitation and conservation orders to be supplied by whatever "open-end" steel might be available after taking care of CMP orders. There could, however, be no immediate marked increase in production of formerly prohibited civilian items, because the principal shapes required for their manufacture were sheets and strip—one area in which the steel situation showed only slight signs of easing.

The sheet and strip position grew progressively worse. The carry-over of past-due orders had risen to dangerous heights. The mills were plagued by manpower shortages. Such reductions of requirements as developed in some military programs were offset by mounting Pacific War requirements in others. Many of the large sheet-using component programs had been granted increases of third-quarter allotments to permit inventory replenishment, following drastic second-quarter cuts. The bulk of such increases as had been authorized for essential civilian product programs concentrated in items—farm machinery, trucks, freight cars, refrigerators, washing machines—which require a large proportion of sheet steel.

CLEARING MILL SPACE

To cope with the situation, intensive efforts were directed toward clearing space on sheet and strip mill schedules. Export orders were reviewed, and a substantial tonnage was cancelled. Prime contractors were pushed to pass cuts in schedules back to the steel mills. The permissible level of consumers' inventories was reduced from 60 to 45 days' supply. Sheet and strip producers' schedules were frozen against further acceptance of third quarter orders, except as specifically directed by WPB, and the rules were amended to make optional with producers the displacement of open-end tonnage by CMP orders offered less than thirty days before the specified month of delivery. This measure was designed to insure that space freed by the cancellation drive and inventory reduction would effect a reduction of the carry-over and increase acceptance of unrated orders, where this could be done without jeopardizing production of urgent CMP orders.

With the advent of V–J Day, military programs were so drastically cut back that the retention of end-use restrictions was obviously unnecessary, and limitation and conservation orders were revoked wholesale. CMP was terminated as of the end of the third quarter. Inventory restrictions were retained in order to forestall hoarding, and a few limitation orders were kept for special purposes. (For example, that governing the use of tin-plate was kept in order to help conserve our limited stocks of tin.) Finally, a simplified priorities system with two ratings was instituted, the first to protect military orders of high urgency and the second to break reconversion bottlenecks. Otherwise, steel has been completely freed of wartime control.

RECONVERSION AND THE 1946 OUTLOOK

For 1946 as a whole, finished steel demand is estimated to be in the neighborhood of 58,600,000 tons, or some 2,600,000 tons below estimated first-line production capacity (excluding high-cost capacity). The bulk of this indicated surplus, however, is expected to materialize in the first 6 months, with second-half demand pressing closely upon supply, or perhaps even slightly exceeding the latter. Some difficulties may be experienced, therefore, if the pace of reconversion should so differ from that forecast as to throw an even larger part of total demand into the second half. Present expectations are that, should such difficulties arise, they will be distributed among shapes, geographic areas, and customers in such a way that little, if any, real hardship will result.

Effective steel product capacity has been set at 15,200,000 tons per quarter in the first half of 1946, and about 15,400,000 tons per quarter in the last 6 months—respectively 15 and 14 percent below nominal capacity, assuming 100 percent utilization of all ingot making and foundry furnaces and a normal product "mix." The deductions reflect allowances for (1) the inability of some specialized war-built facilities quickly to adapt themselves to postwar product demands; (2) the expected dismantlement or retirement of high-cost obsolete furnaces, plus time lost for renovation of long-overworked, under-maintained facilities—expected to be more significant tonnagewise in the first half of 1946 than thereafter; and (3) probable decline in production of steel castings as a result of reduced demand for military use.

The quarterly estimates presume maintenance of current cost-price ratios. A rise in costs relative to prices, or a rise in prices relative to costs, might lead to some change in availability. It seems clear, however, that changes in the ratio would have to be very sharp to affect availability significantly.

The detail of the demand estimate, together with a statement of the general method employed in its derivation, is set forth in the table below. Certain qualifications should be noted:

(1) Total demand in the first half of the year is expected to run between 27,500,000 and 28,000,000 tons, and in the second half between 30,600,000 and 31,100,000 tons. These figures indicate a surplus in the first six

TENTATIVE ESTIMATES OF STEEL DEMAND IN 1946

[Thousands of product tons]

Product	1940 consumption	1946 demand
I. Producers' durable goods	14,918	22,476
1. Agricultural machinery and farm equipment	1,605	2,828
2. Industrial machinery and equipment	2,007	2,900
3. Machine tools and other metal working machinery	339	435
4. Industrial electrical equipment	721	870
5. Railroad equipment, rails and accessories	4,858	6,090
6. Engines and turbines	399	435
7. Business machinery and equipment	387	653
8. Subsidiary durable equipment	1,984	3,335
9. Commercial motor vehicles	2,618	4,930
II. Consumers' durable goods	7,850	9,896
1. Passenger cars	5,961	7,250
2. Radios and phonographs	17	36
3. Refrigerators	500	1,015
4. Other consumers' durables	1,372	1,595
III. Consumers' nondurables	300	363
IV. Services	70	73
V. Construction	7,892	6,743
VI. Petroleum and gas	2,248	2,538
VII. Containers	2,356	3,263
VIII. Barrels, kegs, and drums	684	870
IX. Exports	8,623	6,888
X. Direct military	985	798
XI. Increase in inventories	3,344	4,713
Total	49,270	58,621

Source: 1940 consumption based on division of Civilian Supply Report, "Allocation of Steel to Civilian End-Products", March 2, 1942. The 1946 demand was derived by translating forecasts of 1946 GNP made by General Economics and Planning Staff. The general method followed was to calculate 1940 ratios of tons of steel to dollar values of GNP categories shown in the table. The corresponding 1946 dollar values were then multiplied by these ratios with the price level in the two years assumed to be the same. Estimates for several important items, such as containers, which could not be distributed among GNP categories, represent rough GEPS estimates of the demand for these products. Export demand estimated by the Materials Division. Inventory demand is estimate made by the GEPS.

months of between 2,900,000 and 2,400,000 tons, and a range in the last 6 months from a surplus of 200,000 tons to a possible deficit of 300,000 tons.

(2) The figure of 7,250,000 tons shown for passenger cars represents production requirements for some 4,500,000 cars. Many forecasts have placed the output of cars at a substantially higher level, but the best evidence at hand suggests that performance will not exceed this level by any substantial amount.

(3) Export demand has been set at 6,888,000 tons, some 4,300,000 tons above 1939 deliveries but, on the other hand, roughly 1,700,000 tons below shipments in 1940, when the level of general activity ran somewhat below that forecast for 1946. (The reduction from the 1940 export level reflects allowance for (a) the huge British demands for defense purposes in that year, and (b) expected decline in Latin American demand as a result of recent increases in steelmaking capacity in that area.)

(4) The estimates provide for inventory rebuilding in the amount of 4,700,000 tons. It is quite possible that consumers will undertake to replenish stocks at a rate higher than this figure implies. If this proves to be the case, additional demand can be absorbed in the first half of the year, when inventory rebuilding is most likely to occur. On the other hand, if increases should be concentrated in the latter half of the year, additional pressure would be placed on scarce supplies.

The picture presented by most steel products resembles the over-all outlook, but with two or three notable exceptions. In light-gauge flat-rolled products, it seems probable that total demand (both for production and repipelining purposes) will exceed maximum supply during the next six months, with galvanized material showing a deficit of as much as 10 to 15 percent. Present expectations, however, are that the deficit will change to a surplus around April or May of 1946, despite a continued rise in demand and a tightening general position. The reason lies in a large-scale program to increase capacity in the sizes and grades most needed for durable consumers' goods production (although not over-all flatrolled product capacity) by some 2,800,000 tons per annum, which is expected to yield results by that time.

In the case of controlled-cooled rails, too, there is some evidence that the demand from domestic lines alone will exceed maximum mill capacity until the first part of 1947.

COPPER AND COPPER ALLOY PRODUCTS

Steeply rising military demands in the early stages of the war made copper one of the most critical metals in the war economy by the beginning of 1942. At first, during 1942 and early 1943, the shortage of refined copper was the major problem. Thereafter, the tightest spot was brass mill capacity. Brass cartridge cases for Army small arms ammunition and for Navy 20-mm. and 40-mm. antiaircraft ammunition made up the great bulk of the demand at that time.

After the cut-back in the Army small arms ammunition program in December 1943, the only problem which remained was in obtaining specialized facilities for the production of certain shapes, forms, and sizes of copper products. For example, an acute shortage developed in large-size tubing for rotating bands to meet the stepped-up Army artillery ammunition program in 1944. Also, certain sizes of alloy rod and fine wire were tight, although over-all supply and demand for copper products were about in balance.

METAL SUPPLY

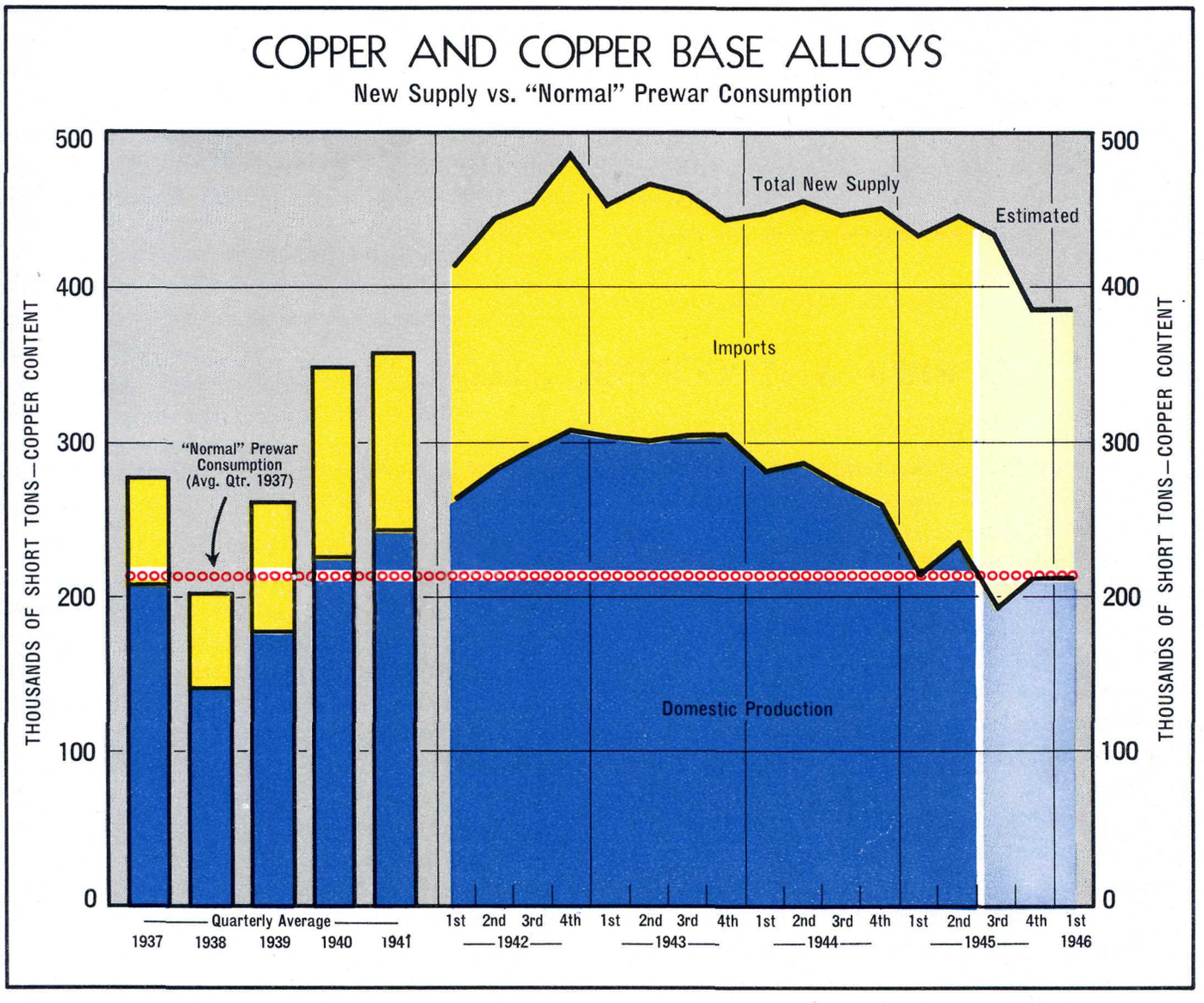
Domestic production of refined copper in 1939 was 70,000 short tons, which was wholly inadequate to meet war demands. Strenuous efforts were made to increase domestic production at the mines as well as to expand smelting and refining facilities.

The increase in domestic production was achieved largely through a series of plans for subsidizing marginal, high-cost production. The Premium Price Plan was formalized early in 1942 and was administered jointly by the War Production Board and the Office of Price Administration. The Premium Price Quota Committee established quotas for each producer, determining what part of his total output could be sold

at the base price of 12 cents per pound. Additional production above this quota could be sold at a premium price as high as 17 cents per pound, with the Metals Reserve Company paying the subsidy. Largely as a result of this move, domestic production in 1942 increased by 185,000 tons or 19 percent over the preceeding year (chart, below).

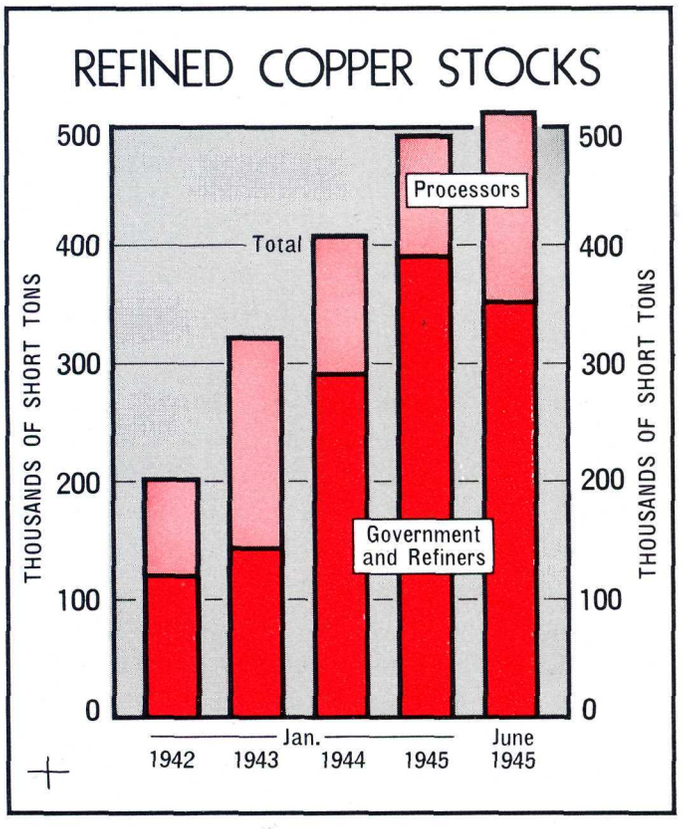
To cope with manpower problems which threatened copper production, a number of steps were taken. Gold mining was virtually suspended to induce workers to transfer to copper mines. Wages at the mines were increased. Local draft boards were requested to give special consideration to miners, and the Army released 2,800 copper miners by the end of 1942. In addition to these steps, the Government offered the copper industry many aids, such as exploratory work and drilling operations, liberalization of loans to mining companies by RFC, plant construction by DPC, and WPB priority assistance in obtaining mining equipment.

Domestic production of copper was supplemented by greatly increased imports, which about doubled between 1939 and 1942 (see chart). Late in 1940, the Metals Reserve Company was authorized to buy as much foreign copper as could be made available with U. S. Government help in furnishing necessary equipment and supplies. Chile alone supplied about two-thirds of total U. S. copper imports from 1941 on; the second largest supplier was the Belgian Congo. The four-cent copper tariff was remitted and some subsidies were given to stimulate imports further.



The Combined Raw Materials Board took an active role in allocating the international supply of copper. In general, the United States was permitted to purchase the entire output of Latin-American countries, with the United Kingdom obtaining its supplies largely from the Belgian Congo, Northern Rhodesia, and Australia. To maximize world production, the United States provided equipment and supplies for expansion of mine capacity abroad, not only in Latin America but also in sources assigned to the British. These moves yielded results in that we obtained substantial copper from the Belgian Congo in 1943 and 1944 from production there in excess of United Kingdom needs.

In June 1941, the Office of Production Management recommended the establishment of a copper stock pile of 500,000 tons to be accumulated over three years, and by September the recommendation had been increased to 600,000 tons to be built up as soon as possible. On December 7, 1941, the government stock pile amounted to a little over 50,000 tons. At the end of 1942 the stock pile was still less than 100,000 tons (see chart below) but it was more than doubled during 1943, and by the end of 1944 reached a peak of 350,000 tons. In November 1944, the limit for the quantity to be held in government account by the Metals Reserve Co. was reduced from 600,000 tons to 450,000 tons, to be held subject to WPB instructions.



EXPANSION OF PROCESSORS

Following the step-up in domestic and foreign production of refined copper, expansion of the copper processing industries became necessary in order to provide the armed services with the specific shapes and forms required. The heaviest demand fell upon the brass mills for such ammunition components as cartridge cases, fuzes, and rotating bands. Net facility expansions at brass mills amounted to $84,000,000, of which $73,000,000 was government-financed. The expanded facilities have enabled brass mills to hit a wartime peak of production equal to more than five times the average monthly prewar rate. The greatest expansion occurred in brass strip mills and made possible wartime production more than ten times the peacetime rate, while alloy rod and tubing each reached peaks of about four times the prewar level.

It is estimated that the postwar rate of production at brass mills will drop from the peak of 550,000,000 pounds to between 150,000,000 and 200,000,000 pounds per month—still far above the prewar average of 100,000,000 pounds per month. While most of the war-developed facilities can probably be utilized in the postwar period, some of the alloy strip capacity may have to be dismantled.

Expansion in the wire mill industry was necessitated by the Army communications program and the Navy and Maritime shipbuilding programs. As late as January 1944, requirements for communication wire were running at less than 90,000 miles a month. With the approach of the Normandy invasion, requirements jumped sharply and reached a peak of 270,000 miles by May 1945. This program required erection of a $5,000,000 plant at St. Louis and the installation of several hundred seven-wire stranding machines which will be of little value in postwar civilian production. Special facilities also had to be acquired for the production of Navy shipboard cable, which has practically no commercial use. However, a number of other expansions, principally those required for the use of synthetic rubber and plastics to replace natural rubber in cable coverings, will be useful in the anticipated heavy demand for wire over the next few years.

During the war years, foundry capacity as a whole was sufficient to meet the demands placed upon it, although production had to be increased from a prewar average of 250,000 tons to 786,000 tons last year. New facilities costing nearly $10,000,000 were built, largely to cope with specialized orders and to meet transportation and manpower problems. There is reason to believe that the present capacity of the industry is in excess of the probable postwar requirements for foundry products.

CONTROLS

Copper was placed under Government control on May 29, 1941, by the issuance of General Preference Order M–9. Supplementary orders were issued subsequently which placed refined copper under allocation, extended preference ratings to copper products, regulated the flow of copper scrap, and prohibited the use of copper in specified civilian products. Frozen fabricated stocks were recovered through the Copper Recovery Corporation.

Conservation Order M–9–c, issued October 21, 1941, and supplementary amendments brought about a drastic reduction in the use of copper for civilians. The order at first restricted the use of copper, in more than 100 civilian products, to 60 percent of the 1940 base period for the balance of 1941, and it prohibited such use after January 1, 1942. Included in the list were jewelry, plumbing and heating supplies and other specified building supplies and hardware, certain automotive equipment, various household appliances such as fans and heaters, and a long list of miscellaneous products.

In addition to civilian conservation measures, every effort was made to induce the military agencies to eliminate or cut down on the use of copper wherever possible by the use of substitute materials. The Army and Navy experimented with steel cartridge cases—the Navy actually preferred steel to brass after manufacturing techniques were perfected. Aluminum fuzes saved brass rod, and at one stage experiments were conducted to substitute cast iron propellers for bronze propellers on some merchant ships. Tight shapes and forms of copper were conserved by substituting other easier forms; for example, cast rotating bands were used to conserve the limited quantities of large brass tubing.

DISTRIBUTION CONTROLS

Order M–9–a, controlling the distribution of copper, was amended in August 1941, to insure that no delivery of copper might be made by any refiner without a WPB allocation certificate and that no brass mill or wire mill should deliver any of its products except as expressly authorized by WPB. The Copper Division reviewed processors' order boards and specifically approved shipments. Most important was the scheduling of ammunition by the Copper Division with the cooperation of the armed services. PRP assisted the process by helping to cut down the volume of orders on brass and wire mills which it was necessary to schedule.

In April 1943, the allocation of copper as one of the three controlled materials under CMP was begun. Since there would not have been sufficient copper to meet desired ammunition schedules in full even if all other competing uses, military and civilian, were eliminated, the allocation technique developed was to reduce essential civilian and nonammunition military requirements to an absolute minimum and then allocate the remainder of the supply of copper products to ammunition programs, making the division between Army and Navy on a previously agreed-upon formula.

As the copper supply became easier, controls were gradually relaxed until May 1945, when the order prohibiting its use in nonessential civilian items was revoked. After July 1, 1945, CMP was "open-ended" and copper became available for unrated orders. All restrictions on the use of copper and its alloys have now been removed.

POSTWAR PROSPECTS

Although copper will have to compete with the lighter metals, aluminum and magnesium, in the future, it is probable that consumption of copper will remain high throughout the period of reconversion and for several years thereafter. Electrical equipment of all kinds took about 400,000 tons of refined copper in 1939, or approximately half of total consumption in that year. Building and automobiles, excluding electrical work, each took a little over 10 percent of total 1939 consumption. It has been estimated that the automobile industry alone will take 150 percent of its prewar rate of use.

ALUMINUM

The war history of aluminum is the record of a successful race to expand facilities fast enough to meet the multiple increases in military requirements, principally for aircraft. From the beginning of the defense program in 1940 through 1942, requirements estimates were repeatedly lifted to new high levels, and plans for increasing capacity had to be constantly revised. In 1943, basic metal supply caught up with and exceeded requirements, and by 1944, the surplus of primary production was large enough to force cut-backs in output and the closing of several plants.

In the past two years, ingot capacity has been ample, though periodic critical shortages have been experienced for a few fabricated shapes as a result of sudden shifts in demand. And now with all controls lifted we are faced with surplus capacity, surplus stocks, and surplus scrap.

In 1938 there was only one United States producer of primary aluminum (which was also the major fabricator), operating four reduction plants with an annual capacity of 300 million pounds. Secondary recovery was less than 100 million pounds, and the total fabricating facilities in the country were barely adequate to process the available metal. When the wartime expansion program was completed, installed ingot capacity was 2.3 billion pounds per year (see table, p. 58); secondary recovery had increased sixfold; and the fabricating system had an annual machine capacity of approximately 2.6 billion pounds.

As a result of this huge expansion—both private and Government financed—approximately 42 percent of the world's total installed primary capacity is now concentrated in the United States, and the domestic fabricating system is by far the largest in the world. By even the most optimistic estimates of postwar demand, 50 percent of our capacity is surplus for commercial operations, and the potential effects on the world industry resulting from the ultimate disposition of Government-owned facilities are far reaching.

SUPPLY AND REQUIREMENTS—PHASE ONE

The impact of military requirements broke suddenly on the industry. As a result of its over-all expansion program in 1937–39, Alcoa was judged at the time in a position to meet all foreseen demands, including normal increases in domestic civilian consumption, the British and French plane procurement programs as then determined, and our own 1939 military plane schedule of 2,100 aircraft.

Even in May 1940, when the President's message to Congress called for a production goal of 50,000 planes per year, there was no indication of an immediate aluminum shortage. After the announcement of the plane objective, the War Department estimated requirements for the next two years at 513 million pounds for the Services (including material for 31,336 planes) and 530 million pounds for civilian usage, a total of 1,043 million pounds. Alcoa estimated new supply for the same period at 878 million pounds of primary and 140 million of secondary. Adding in stocks of 90 million pounds brought total supply to more than 1,100 million pounds.

By drawing on stocks, therefore, demand could be met. But with further demand increases in prospect, a drive for facilities expansion was begun. It was argued that military requirements were underestimated, that achievement of the 50,000-plane objective could not be met from Alcoa's planned expansion, and that both ingot and fabricating facilities soon would be in critically short supply. Throughout the remainder of 1940, aircraft requirements were constantly revised—always upward—and the successive balance sheets began to show substantial cuts in the amount available for civilian consumption.

At this point, the race started between expanding facilities and expanding requirements. In August 1940, Reynolds Metals Co. received an RFC loan to construct an alumina and aluminum plant of 60 million pounds annual capacity, to begin operations in 1941. From a capacity of 450 million pounds as of October 1940, Alcoa announced planned expansions to a peak of 690 million pounds by July 1942. By the end of 1940, however, it was evident that these contemplated expansions would not be in operation in time to meet visible military demands and a mounting uncontrolled civilian demand.

Military requirements had been underestimated for a number of reasons, including: (1) use of the finished weight of the end items, e. g., aircraft, as base rather than bills of material including necessary scrap losses; (2) failure to include allowances for filling pipelines in the expanding aluminum fabricating and consuming plants; (3) failure to allow for spoilage resulting from operations of inexperienced labor and management.

ALUMINUM PRIMARY INGOT FACILITIES 1940–45

[Million pounds per year]

Plant	Installed capacity June 1940	Additions to capacity				Total installed capacity	Peak production (Oct. 1943)	Production in July 1945
		Private [1]		Government				
		July 1940 to Dec. 1941	1942	First experiment program authorized 6–27–41	Second experiment program authorized 2–26–42			
TOTAL	400	373	234	617	720	2,344	2,257	1,149
Private plants, total	400	373	234	.....	.....	1,007	1,006	745
Aluminum Co. of America, total	400	299	144	.....	.....	843	843	587
Alcoa, Tenn	175	65	108	.....	.....	348	347	252
Badin, N. C	53	40	17	.....	.....	110	114	56
Massena, N. Y	134	14	16	.....	.....	164	171	139
Niagara, N. Y	38	0	3	.....	.....	41	42	38
Vancouver, Wash	0	180	0	.....	.....	180	169	102
Reynolds Metals Co., total	0	[2] 74	[2] 90	.....	.....	164	163	158
Listerhill, Ala	0	40	61	.....	.....	101	100	100
Longview, Wash	0	34	29	.....	.....	63	63	58
Government (DPC) plants, total	0	.....	.....	617	720	1,337	1,251	404
Alcoa-operated, total	0	.....	.....	[3] 576	[3] 720	1,296	1,212	372
Burlington, N. J	0	.....	.....	0	108	108	114	0
Jones Mills, Ark	0	.....	.....	144	0	144	156	109
Los Angeles, Calif	0	.....	.....	144	36	180	108	0
Queens, N. Y	0	.....	.....	0	288	288	303	0
Riverbank, Calif	0	.....	.....	0	108	108	67	0
St. Lawrence, N. Y	0	.....	.....	108	0	108	109	0
Spokane, Wash	0	.....	.....	72	144	216	216	160
Troutdale, Oreg	0	.....	.....	108	36	144	139	103
Olin-operated: Tacoma, Wash	0	.....	.....	41	0	41	39	32

[1] Based on actual production attained.

[2] Government financed through RFC loans.

[3] Based on capacity of 36 million pounds yearly per potline, rather than original estimate of 32 million pounds yearly.

THE FIRST EXPANSION PROGRAM

By April 1941, recast requirements based on the aircraft program as then projected showed an annual deficit of 310 million pounds at peak demand level, assuming the completion on time of the scheduled expansion of production. To meet this deficit, OPM first planned an expansion program of 200 million pounds in Alcoa facilities, supported by 200 million pounds of imports from Canada. Before anything could be accomplished on this program, requirements again were lifted to a new peak of 1,640 million pounds per year, including aircraft at 900 million (4,000 planes monthly), other military demand at 300 million, and civilian at 440 million. Annual supply, actual and in sight, was estimated at 1,040 million pounds. Thus, the peak annual indicated deficit at the end of April 1941 was 600 million pounds.

To carry this load, the decision was made to add another 400 million pounds to the government-financed expansion program, bringing total planned production to 1,400 million pounds. This, with Canadian shipments, would balance the demand load, on paper. Alumina capacity of 1,200 million pounds was provided for—400 million to be operated by Reynolds and 800 million by Alcoa; carbon electrode capacity was to be expanded, bauxite production and imports increased, cryolite imports stepped up, and a synthetic cryolite plant constructed.

As a stop-gap measure, since facility expansion was still on paper while requirements were current and urgent, a contract for 375 million pounds was negotiated with Canada in May and an additional contract for a like amount was signed in July. At the same time, plans were made for the parallel expansion of fabricating facilities. It was anticipated (before Pearl Harbor) that by the middle of 1942 aluminum would be in balance across-the-board.

THE SECOND EXPANSION PROGRAM

The President's war program of January 1942, calling for 60,000 planes that year and 125,000 in 1943, again raised future requirements above the supply anticipated from both facilities in being and those under construction. Estimates of requirements, based on the President's program, indicated peak military demand of 2,600 million pounds annually, far out ahead of the total output to be realized after the completion of the first expansion program.

In February, an additional government-financed ingot expansion of 600 million pounds, with balanced alumina capacity, was approved. Simultaneously, the Canadian contracts were increased by 250 million pounds, bringing the total under contract to 1 billion pounds. By the end of February, the Joint Aluminum Committee's report (including the 8–I Aircraft Program) anticipated total requirements of 1,600 million pounds (including 1,400 million pounds for aircraft) for 1942, and 2,700 million pounds (including 2,400 million pounds for aircraft) in 1943.

By the middle of 1942, the facilities in the first expansion program had started operations, and construction of the second program, including fabricating plants to balance the ingot expansion, was well under way. Although during 1942 and even in 1943 additional fabricating capacity was added as military demand fluctuated or specifications shifted (for example, forged instead of cast cylinder heads), the expansions approved by February 1942, were the base for the aluminum system as it is today. In March 1942, the two Canadian contracts were superseded by a new contract for 1 billion pounds (to be delivered by December 1944), supplemented in April by an additional contract for 370 million pounds (to be delivered by December 1945). By means of the expansion programs and the Canadian contracts, it was believed that the aluminum shortage would be licked.

FABRICATED SHAPES

By early 1943, the outcome of the facility-requirements race was clear. We were in balance or better over-all, and the problems ahead were all associated with the shifting impacts of requirements for fabricated shapes. The nature of the problem is illustrated by the 1943 situation in extrusions. The B–29 program scheduled for fall production called for a large increase in extruded shapes. The resultant shortage in capacity affected tubing (through the cut-back in tube bloom production), extruded rod and bar, and forgings (because of the shortage of rod and bar forge stock, necessitating a scheduling procedure for forgings). An expansion in extrusion facilities was immediately started to meet this squeeze. By the middle of the year, the B–29 program had been

669713 O - 45 - 5

rescheduled because, regardless of the aluminum extrusion supply, the original schedule could not be met. It also became evident that peak requirements had been overstated, and a substantial portion of the expansion program in extrusions was cancelled.

A sheet shortage was indicated for the second quarter and it was proposed to utilize steel sheet capacity to roll aluminum as temporary relief. Sheet demand, however, did not reach the projected high levels until the end of the year, when adequate aluminum rolling facilities were available.

The conversion of cylinder head specifications from castings to forgings necessitated a rapid increase in facilities, and the larger castings required by the superbombers and giant transport planes called for an increase in sand casting capacity.

By the end of 1943, however, the only major problem left in the industry was a manpower shortage. It was anticipated that in 1944 it would be possible to balance supplies and requirements for all fabricated products. The 1944 metal supply, as then estimated, was well in excess of anticipated fabricating needs, the industry was in an excess working inventory position, and Government stocks approximated 168 million pounds.

1944: CUT-BACKS IN PRODUCTION

Therefore, the first step was taken in the curtailment program (which was to continue throughout the year), and four of the 35 DPC lines in operation were closed as of the first of the year. Alcoa also closed 88.5 million pounds of privately owned capacity in its first cut-back.

Operations in 1944 were characterized by the continuing cut-backs in ingot and alumina production, the depipelining of the aluminum system, and actual demands on fabricating plants well below the anticipated levels upon which the aluminum expansion program had been based. This was due primarily to three factors: (1) lowered and more realistic requirements, based on greatly improved bills of material; (2) inventory absorption in consuming plants; and (3) lower schedules for aircraft, reflecting a lower than expected plane mortality rate.

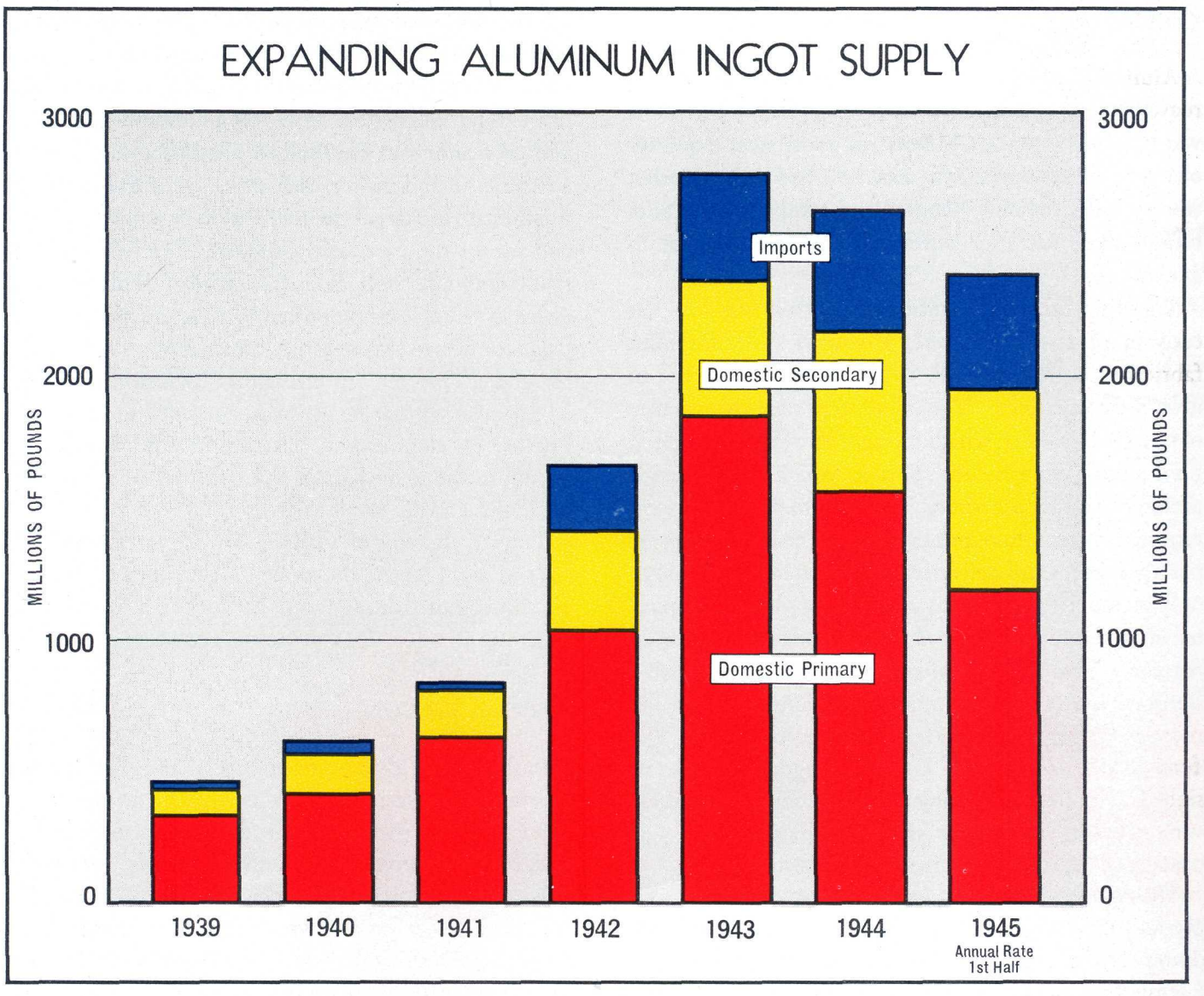
In the summer after the European invasion, the indicated surplus position of aluminum induced relaxation of controls, as a part of the "Nelson program" to give reconversion a start. Despite the curtailment in production, which by November had closed slightly more than half of the installed ingot capacity and had reduced output to 1.1 billion pounds a year (the rate reached in July 1942), Government stocks had increased rapidly. Therefore, it was agreed to postpone for an indefinite period the remainder of 250 million pounds due on the Canadian contracts in 1945. By the end of 1944, reserve stocks had reached 565 million pounds. (Following up the curtailment program, three plants with a total capacity of 504 million pounds were declared surplus, one of which, Queens, has been dismantled.)

Aircraft requirements and shipments of aluminum declined throughout 1944. Ground Army and Navy requirements and shipments, however, showed an uptrend. The increased take was due largely to stepped-up ammunition programs, the partial substitution of aluminum for steel in landing mats, and the rapid acceleration in the use of atomized powder for explosives and of foil for packaging and antiradar use. Deliveries to Russia and the United Kingdom also showed large increases. As a result of the relaxation of controls, civilian deliveries on both a firm and deferred basis were more than 50 percent higher than in 1943.

SUPPLY AND REQUIREMENTS—LAST PHASE

The final descent-and-climb on the roller-coaster in requirements began in the last quarter of 1944. Aircraft shipments fell off to the level of the fourth quarter of 1942 (260 million pounds). This was due not only to lower aircraft schedules, but also to the very heavy year-end inventory absorption. As a result, the labor force in the aluminum mills was cut down and the entire industry was operating at a low level.

In December 1944, aircraft schedules for 1945 were revised sharply upward and, in view of the depleted inventory position in consuming plants, the full requirements for the first quarter of 1945 were carried through to the mill order books. Shortages again developed in the early months of 1945 in all products except tubing—particularly in sheet, foil, and extrusions. These shortages were due solely to lack of manpower, which had been lost in the previous quarter. Powder requirements continued the uptrend initiated in 1944; foil demand for both radar and packaging use was increased well beyond the available facilities; and the Army bridge program



was initiated, which competed with the accelerated aircraft requirements for extrusion capacity. It was apparent that civilian orders on an unrated basis would be frozen out of mill schedules.

Every effort was made to obtain manpower, including the furloughing of soldiers to sheet mills; extrusion capacity was increased; and United Kingdom demands for foil and powder were diverted to capacity in Canada. The industry was forced to repipeline to meet the accelerating demand, and Government stocks were reduced to 337 million pounds by the end of the first quarter. The postponed balance of 250 million pounds from Canada was adjusted to 169 million pounds and rescheduled, and efforts were made to reopen domestic potlines to avert the impending ingot shortage. Since these efforts were largely unsuccessful because of the over-all manpower situation, a new Canadian contract for 250 million pounds was signed in March.

First quarter shipments of fabricated products, despite the difficulties encountered, reached an all-time peak of 627 million pounds, and second quarter operations were scheduled at the same level. Aside from attempts to increase ingot supply, the only shortage expected in the second quarter was in foil and extrusion capacity, resulting from the acceleration of the packaging and bridge programs. By May, ARCO again cut back its programs, thus releasing capacity, and the March contract with Canada was reduced to 75 million pounds. Prior to V–J Day, further cuts in ARCO programs removed pressure from all shapes.

CONTROLS

Aluminum was the first basic production material to require over-all distribution controls. Before the metal was absorbed into the CMP system in the second quarter of 1943, its distribution was accomplished through what was probably the most detailed and comprehensive allocation procedure ever developed for any material in general use.

The need for the institution of controls was first felt early in 1941, when aircraft producers and aluminum fabricators were unable to obtain adequate supplies to meet their schedules. The initial steps were the issuance of two Orders: M–1, which brought all aluminum operations under control; and M–1–a, which established a preference rating schedule. Aluminum producers were required to maintain records and furnish monthly reports on orders and deliveries, as requested. (Although only incomplete data are available through the last quarter of 1941, aluminum producers, beginning with 1942, regularly have filed detailed reports, and the available statistical series on aluminum operations are probably more comprehensive than for any other material.) Defense orders (including United Kingdom) were assigned A preference ratings, while nondefense orders were rated in the B series and were restricted to a percentage of 1940 use, scaled in order of essentiality.

The rapidly developing imbalance of aluminum supply and demand forced successive revisions in and additions to the controls. The M–1 orders, first issued as a temporary measure, were extended to the end of 1941. Beginning in July, all nondefense orders were submitted for review by the joint WPB-Military Aluminum and Magnesium Priority Committee and were filled only after approval. The pyramiding of new requirements was making it clear, however, that control through a preference rating sequence was inadequate.

Two major steps were taken to resolve the difficulty. First, early in 1942, M–1–e was issued, representing the most drastic measure of its type attempted to that date. The order listed only 15 permitted uses for aluminum; all uses not listed were forbidden. The problem of inadequate supply even for permitted uses remained, however, and called for a second step, taken in the issuance of M–1–f. Under this order, each aluminum producer and fabricator was required to file a monthly shipping schedule, including for each order information on the manufacturing use of the material to be shipped and the end use of the fabricated product. Delivery could be made only after specific authorization. This order-by-order screening was supported by a supply-requirements balance effected through the Joint Aluminum Committee and a "pie cut" to claimants. Screening of order boards insured that no claimant exceeded its allocation. Further development of this comprehensive allocation system in the latter part of 1942 was halted by the projection of CMP.

Toward the end of 1943 and in the early months of 1944, as supply eased, the controlling orders were relaxed, and in August 1944, as part of the four-part reconversion program, all restrictions on use were removed.

RECONVERSION

In the case of aluminum, the problem is not one of a shortage for reconversion; it is a problem of surplus. As of V–J Day, primary plants were operating at an annual rate of approximately 1 billion pounds, or less than half of capacity (400 million pounds from DPC lines, the balance from privately owned capacity); secondary recovery was at an annual rate of 650 million pounds; and the deliveries on the Canadian contract had been completed. The estimated Government stock pile approximated 400 million pounds, and over-all metal stocks within the industry, as a result of the repipelining in the first half of this year, was in the neighborhood of 700 million pounds. When consideration is given also to the huge stocks of scrap held by dealers, the scrap and potential scrap in generating plants, and the potential scrap in the form of obsolete or surplus war material, particularly aircraft, the prospect for considerable idle capacity in the industry is obvious.

MAGNESIUM EXPANSION

The history of magnesium during the past five years in many ways parallels that of aluminum. Like aluminum, magnesium before the war was being made by only one producer, and in very small volume in relation

to wartime needs. As in the case of aluminum, requirements were constantly being revised—and mostly upward in the early war period—with changes in the aircraft program, though the magnesium picture was complicated by the demand for incendiary bombs. As with aluminum, the race to expand facilities as fast as requirements grew was won by 1943, and production was cut back in 1944 to far below capacity.

There were, however, also striking differences in the records of the two metals. Not only was the percentage expansion in magnesium production far greater than that in aluminum, but the technical problems involved were more complex. All of the new aluminum capacity used the basic aluminum reduction process which Alcoa had successfully used commercially for many years before the war. But magnesium was produced by half a dozen different processes, some of which were entirely new on a commercial scale; fabricating facilities and equipment for the most part represented a departure from previous methods; and a whole new body of labor and supervisory personnel had to learn the new techniques.

SUPPLY AND REQUIREMENTS

Although there were five magnesium producers who started operation in this country after the last World War, by 1927 Dow Chemical was the only primary producer in the field. Despite the years of research and education in magnesium fabrication and the efforts spent to promote its use, the primary production level in 1937 was still only 4½ million pounds a year, about 11 percent of world production. Germany at that time was producing 60 percent of the world's total.

In 1939, as a result of the increasing demands of our defense program and the French and British aircraft programs, Dow Chemical initiated an expansion partly financed by advance payments on British orders. When the 50,000-plane objective was set by the President in 1940, it became apparent that the aircraft program, plus British needs, would consume all available magnesium. Therefore, Dow again expanded both primary and fabricating facilities.

To supplement these expansions, early in 1941 RFC approved a loan to Todd-California Shipbuilding (later taken over by Permanente Metals) to construct a primary magnesium plant with a capacity of 24 million pounds at Permanente, Calif., which was to use a process developed by Dr. Hansgirg, an Austrian scientist.

In an effort to meet military demand, if at all possible, in the first months of 1941, when demand was exceeding available supply, magnesium was placed under conservation and priority control. As 1941 wore on, the controls were tightened. And late in the year ingot output was made subject to complete allocation. Shipments of fabricated products were made subject to WPB approval and continued so until the relaxation of restrictions in the summer of 1944.

The astronomical advance in calculated requirements and the struggle to achieve a supply balance are indicated by the following data:

Date	Period	Calculated requirements (000 lbs.)	Calculated supply (000 lbs.)
April 1941	Year 1942	92,000	76,000
June 1941	At peak annual	411,000	165,000
September 1941	do	293,000	278,000
January 1942	At peak, 1943	670,000	[1]

[1] 70 million pounds in operation, 501 million scheduled, 154 million under negotiation.

After February 1942, successive reductions brought calculated annual requirements down to less than 400 million pounds.

CARRYING OUT THE EXPANSIONS

The expansions came in two waves. The first was programmed in June 1941; the second in February 1942. Capacity eventually reached 586 million pounds annually (see table, p. 64). Peak production was reached in January 1944 (annual rate, 491 million pounds), while shipments of fabricated shapes reached a high in April of the same year at a 432-million-pound annual rate.

On balance, 1940–42 was a period of continued shortage. For example, in the last nine months of 1942 actual shipments were only 90 million pounds compared with the June estimate of 121 million pounds. All primary facilities under construction experienced delays in obtaining structural steel, electrical equipment, and the complicated components necessary for the completion

of the plants. The magnesium expansion construction was in competition indirectly with other construction programs, and particularly for electrical equipment with the tremendous aluminum expansion. In the initial phases of operations most plants using the new processes encountered production problems. The ferro-silicon plants experienced difficulties in maintaining retorts in operation; the carbo-thermic reduction plant had fires and explosions; and Basic, the largest primary plant in the world, was delayed because of difficulty in the concentration treatment of magnesite. Throughout the field there was a dearth of skilled technicians and labor.

Fabricating facilities were also slow in coming into production. (Unlike the aluminum fabrication expansion, which was under War Production Board sponsorship, magnesium general purpose fabricating plants were

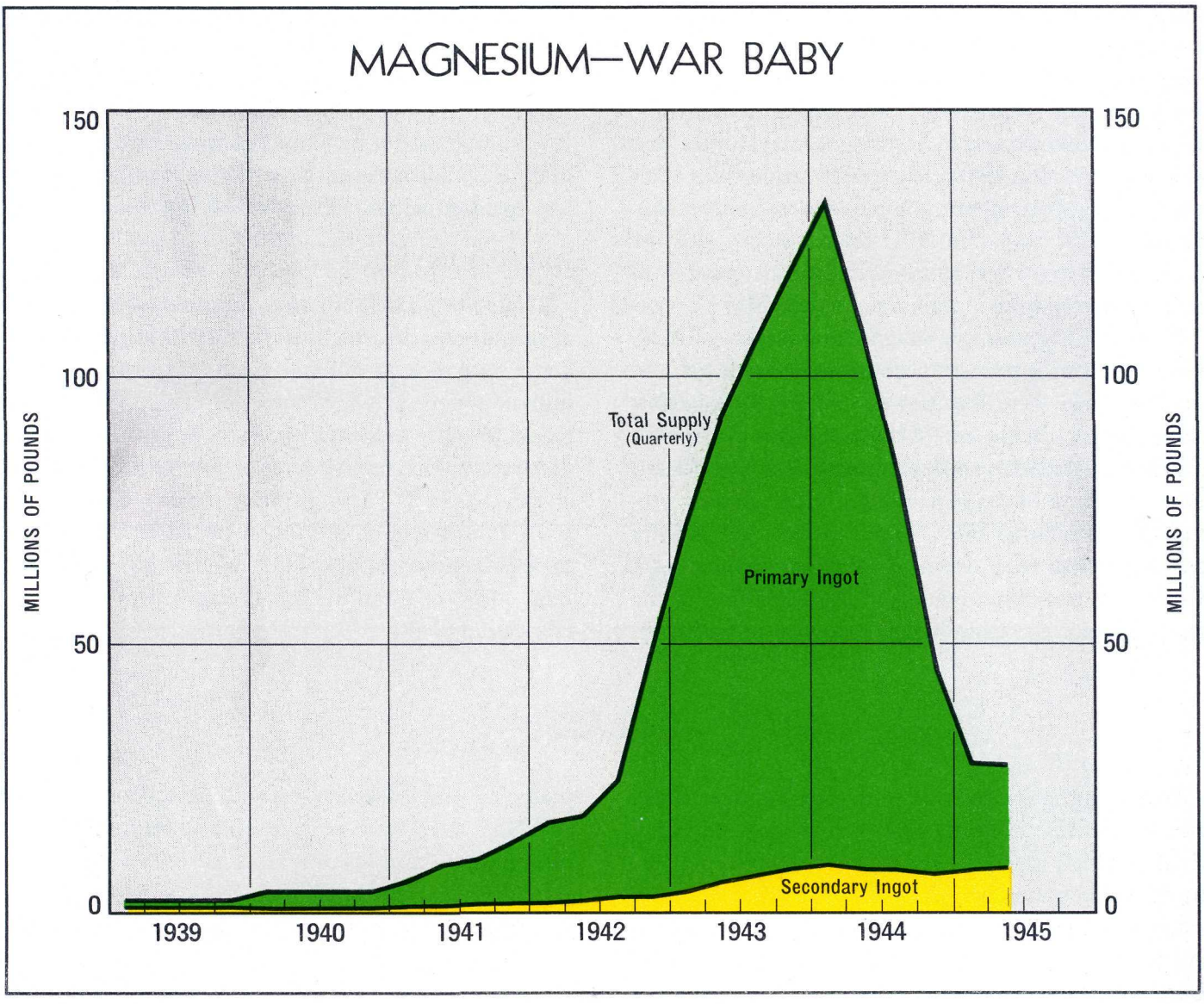
MAGNESIUM PRIMARY INGOT FACILITIES

[Thousand pounds annual rate]

Plant	Process	Raw material	1939 capacity	Total installed capacity	Peak production (Jan. 1944)	Production in July 1945
Total			6,000	586,000	491,136	110,832
Private:						
Dow Chemical:						
Midland, Mich	Dow Cell	Brine	6,000	18,000	16,008	6,024
Freeport, Tex	do	Sea water		[1] 36,000	43,632	42,324
Permanente Metals:						
Permanente, Calif	Carbo-thermic Reduction	do	do	[2] 24,000	6,456	
DPC:						
Dow Magnesium:						
Marysville, Mich	Dow Cell	Brine		72,000	71,820	
Velasco, Tex	do	Sea water		72,000	80,400	27,312
Diamond Magnesium:						
Painesville, Ohio	do	Dolomite		36,000	39,000	25,104
International Minerals and Chemicals:						
Carlsbad, N. Mex	do	Langbeinite and dolomite.		24,000	23,628	
Basic Magnesium:						
Las Vegas, Nev	M. E. L	Magnesite		112,000	120,012	
Mathieson Alkali:						
Lake Charles, La	Math. Cell	Dolomite		54,000	11,460	
Amco Magnesium:						
Wingdale, N. Y	Ferro-silicon	do		10,000	5,100	
Electro-Metallurgical:						
Spokane, Wash	do	do		48,000	18,528	
Ford Motor:						
Dearborn, Mich	do	do		40,000	11,028	
Magnesium Reduction:						
Luckey, Ohio	do	do		10,000	12,384	7,296
New England Lime:						
Canaan, Conn	do	do		10,000	9,120	2,772
Permanente Metals:						
Manteca, Calif	do	do		20,000	22,560	

[1] Half privately financed, half DPC financed.

[2] RFC financed.



under the jurisdiction of the Aircraft Scheduling Unit until mid-1943, when they were transferred to WPB; bomb casters were under Chemical Warfare Service; and powder grinders under the Army and the Navy.) Although facilities were being expanded, the uncertainty of the programs, the need for new types of equipment, and the lack of trained labor caused considerable delay. There was, however, adequate capacity to absorb the available metal, and at that period magnesium metal was the bottleneck.

Throughout the entire year 1942, the use of magnesium had to be curtailed, urgent export demands were not fully met, and powder was not available in the requested amounts for flares and ammunition. However, it was the incendiary bomb program which bore the brunt of the shortage, receiving only 11.4 million pounds of magnesium for the year compared with the greatly reduced calculated requirements of 62 million pounds. Although a substitute thermite bomb had been developed, it could not replace entirely the urgent need for incendiaries in the European theater.

OVER THE HUMP ON SUPPLY

In January 1943, success was in sight. The Magnesium Supply-Requirements Committee issued a report which indicated a shortage in the first half but a surplus of 15 million pounds for the full year, based on supply of 400 million pounds and requirements of 385 million.

As a result of production and priorities difficulties, out-

put of both primary and secondary magnesium in the first quarter of 1943 was substantially lower than the estimates. In April, however, production began to accelerate sharply (chart, p. 65) and a surplus position over the coming months was indicated. In May, for the first time, supply was adequate to cover all requests for allotments, and in June all primary plants were in operation. By the end of 1943, the DPC reserve stocks plus the Chemical Warfare Service stockpile had increased to 48 million pounds, from 2 million pounds on May 1.

The following year saw magnesium output cut back. Throughout 1944, primary production was reduced, and pipeline stocks were absorbed in military owned fabricating plants. By the end of the year, eight plants with 464 million pounds primary capacity had been closed down, and those plants remaining in operation were producing at a reduced rate. Bomb casters' and powder grinders' stocks were down to 3 million pounds, compared with 30 million pounds at the beginning of the year. Despite the curtailment program, however, reserve stocks had increased from 48 million pounds to 115 million pounds during the year.

A sharp increase in the incendiary bomb program in 1945 resulted in reducing stocks to 61 million pounds on July 1 and caused reopening of primary facilities to meet indicated high demand later in the year. Production was again expanding when the V–J Day cutbacks came.

RECONVERSION

Magnesium, like aluminum, must resolve the problem of surplus capacity, stocks and scrap. The prewar market in 1939 took 11 million pounds of primary metal, 4 million pounds of which were for export. Today, potential primary capacity is 50 times as great, and secondary recovery has been at a rate of over 35 million pounds a year. As of V–J Day, primary plants were operating at an annual rate of 28 million pounds. DPC reserve stocks amounted to 63 million pounds and there were large stocks of metal in various stages of production in fabricating plants.

LEAD

After being in comfortable supply during most of the war, lead became critically short late in 1944 and is one of the materials expected to continue in short supply during the reconversion period.

The shortages forecast for the remainder of this year and for 1946 are traceable in part to the false sense of security fostered by the existence of a large stockpile which the Government was able to acquire in the early years of the war. This accumulation—largely foreign lead purchased during the disruption of the world market in 1942 and 1943—made it difficult to take precautionary measures to conserve lead and to impose restrictions on consumption. The steady reduction in the stockpile from 1943 on was almost universally ignored. Consumers were firmly imbued with the idea that lead was in easy supply.

Lead was no problem in the period preceding the United States entry into the war. It was omitted from the first list of critical materials drawn up by the Army and Navy Munitions Board under the Strategic Materials Act of 1939. Although prices rose moderately in the fall of 1939, they were stabilized by the inflow of foreign lead which was not absorbed as normally by European countries. Imports were still adequate going into 1941 and there were no price difficulties, even though consumption continued to increase. Export controls were instituted in March 1941, but this was to prevent United States lead from getting into enemy hands rather than to conserve the supply.

In normal times United States requirements had been met almost wholly from domestic sources. In May 1941, when it was realized how heavily the country had become dependent upon imports, lead was placed on the critical list and steps taken for stockpiling. Although there was still no allocation problem, consumption was rising rapidly and it was decided to put lead under a control order. Conservation Order M–38, issued October 4, 1941, provided mainly for the equitable distribution of lead either purchased by the Government or held back in monthly pools for Government allocation. These pools were made up of 15 percent of each producer's monthly output.

PREMIUM PRICE PLAN

Prices of lead had advanced at times in 1939 and 1940, but until late 1940, price gains did not hold, because of

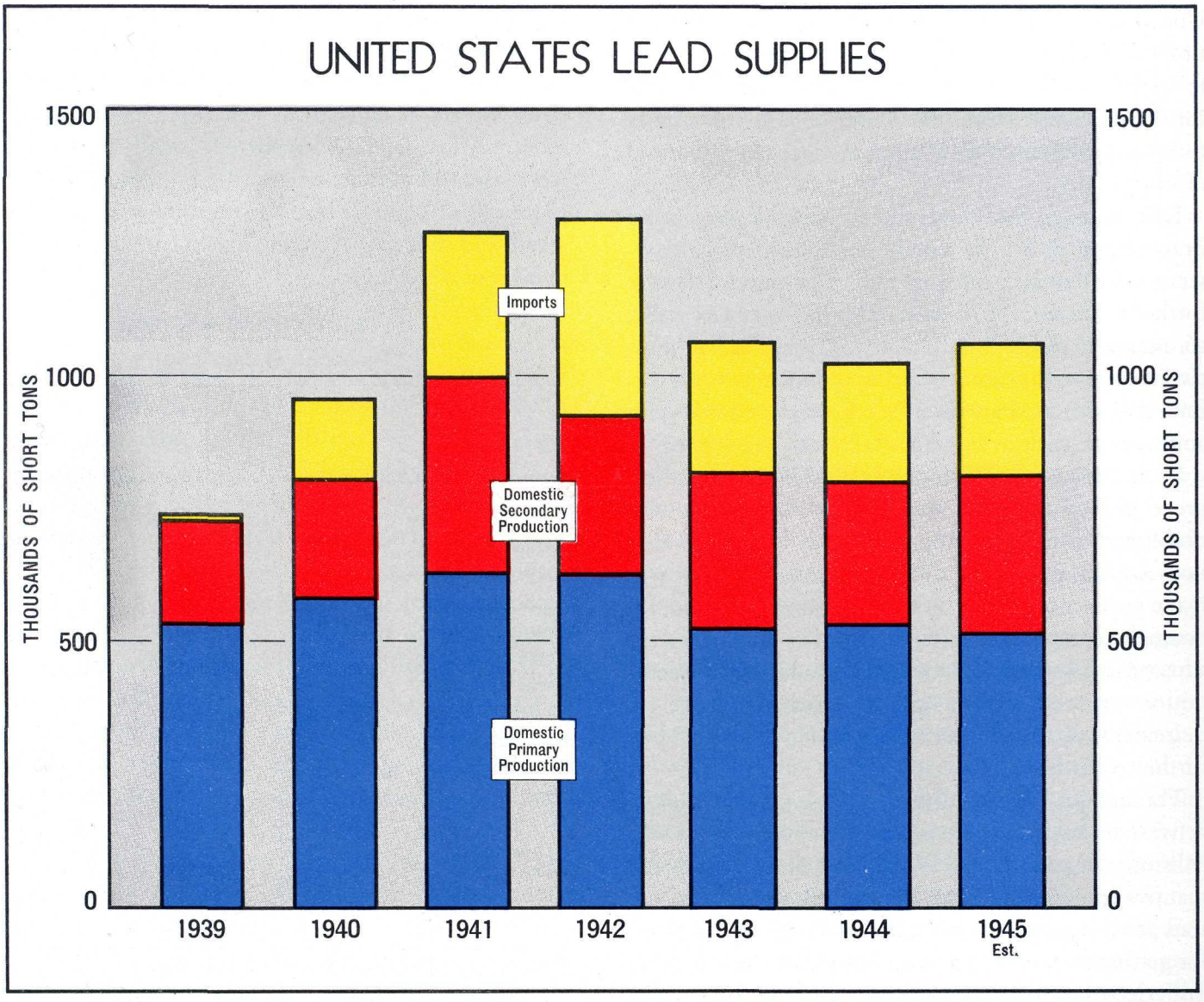
large foreign surpluses. In 1941, however, prices were up to 5.85 cents a pound at New York, compared with quotations as low as 4.75 cents in 1939. The Office of Price Administration and Civilian Supply asked the producers to hold that price to avoid unnecessary inflation. In 1942, a ceiling of 6.5 cents was agreed upon, and at that time a Premium Price Plan was introduced to subsidize marginal production. The ceiling has been maintained at the 6.5-cent level up to the present, but by 1945 subsidies of up to 5.5 cents a pound were being paid on about half of the domestic-mine production.

EARLY RESTRICTIONS ON USE

The use of lead was first curtailed in January 1942, when nonessential users were deprived of supplies and other users were obliged to restrict consumption to 90 percent of the base period (third and fourth quarters of 1941). Exceptions were made for military orders and those carrying certain types of priorities. The most important forbidden uses were automobile body solder and foil for wrapping candy, gum, cigarettes, etc.

International controls were instituted by the Combined Raw Materials Board in August 1942. The United States was given exclusive access to the exportable surpluses of pig lead in all Western Hemisphere countries except Canada and to all available supplies of concentrates, but was forbidden to purchase lead from any other source without permission of CRMB.

As a result of heavy purchases in 1942 and 1943 from Australia, Canada, Peru, and Mexico, the Government



was able to build up its stockpile from 18,000 tons at the beginning of 1942 to 265,000 tons by April 1943. Lead was taken off the critical list when a cut-back in ammunition reduced 1944 requirements by 108,000 tons, and it appeared that the lead problem had been solved for the duration.

NEW SHORTAGES

But domestic production slumped sharply in 1943 (chart, p. 67). Labor shortages in mines contributed to a reduction in primary output from 625,000 tons in 1941 to 528,000 tons. Lack of manpower also hampered secondary production, which declined from 370,000 tons in 1941 to 291,000 in 1943 and on down to 267,000 tons in 1944. Australia and Canada were cut off as sources because all of their available surpluses were needed by the United Kingdom. As a result, United States imports dropped from the all-time high of 370,000 tons in 1942 to 245,000 tons in 1943. At the same time, wartime consumption was more than 1,000,000 tons annually as compared to 800,000 tons in 1939, and was running ahead of new supply.

Late in 1944, the Government stockpile was being drawn upon so heavily that it was evident that the reserves would soon be dissipated unless consumption were further restricted. A revision of M–38, issued December 26, 1944, and clarified on January 15, 1945, limited most civilian uses to 60 percent of the 1944 annual rate but permitted unrestricted use for military orders and in certain applications, such as terne plating, heat treating, etc.

In the meantime, WPB had taken other steps to improve the situation. A special Lead Committee was established, comprising representatives of various divisions within the Board. The committee was asked to make recommendations on conservation, restriction, rationing of end products, etc. Many of its proposals were adopted in subsequent allocations. In addition, the committee reviewed appeals and investigated relative requirements, so that the permissive lists in M–38 could be further revised.

Throughout the early months of 1945, WPB worked actively to help the lead industry increase production, enlisting the assistance of WMC in obtaining additional manpower, particularly in the secondary smelters. A lead-production task committee investigated methods for getting men into lead production, aided in obtaining draft deferments, helped expedite ratings for both mines and smelters, and supported attempts to recruit war prisoners and foreign laborers. In addition, a salvage drive was instituted in order to channel lead scrap to secondary smelters.

On March 31, 1945, a sweeping revision of M–38 had been issued, the most important feature being the permissive list. This permitted the use of lead in the manufacture only of those end items specifically mentioned in the order. Few appeals were granted, since a thorough airing of the relative importance of end uses—accompanied by a heated discussion of the true level of need for civilian batteries, collapsible tubes, and some other lead-using items—had preceded the preparation of the order.

By the time third-quarter allotments were made late in June, a few military cutbacks resulting from the end of the war in Europe could be translated into lower lead requirements, notably in batteries and ammunition. Increased tonnages were made available for civilian batteries, chemicals other than white lead, and collapsible tubes. After Japan surrendered, small adjustments were made to permit some civilian ammunition to be produced in plants where military cutbacks had been severe and sudden. A small adjustment was also made in favor of white lead.

U. S. LEAD CONSUMPTION

[Thousands of short tons]

	1939 [1]	1942	1943	1944	Estimated 1945
Storage batteries	200	220	264	307	315
Cable covering	72	183	145	130	118
Chemicals, including paint	140	181	159	167	138
Ammunition	40	91	178	63	51
Tetra ethyl lead	32	51	63	81	79
Sheet and pipe [2]	48	78	63	87	76
Solder	24	34	41	41	46
Bearing metal	24	20	35	41	37
Brass and bronze	24	25	25	41	38
Foil	20	6	13	20	21
All other	96	154	127	140	161
Exports	74	6	13	16	1
Total	794	1,049	1,126	1,134	1,081
Total supply	736	1,291	1,061	1,026	1,060

[1] Estimates from incomplete prewar data.

[2] Caulking is included in "all other" in 1945.

THE OUTLOOK

The allocations for the fourth quarter were designed to provide substantial increases for civilian use, but no attempt was made to refill pipe lines completely or to raise total civilian consumption to a prewar level.

Despite the big reduction in military demands, requirements for lead continue to exceed supply. Removal of restrictions would dissipate within a few months the Government stock pile, which will be down by the end of the year to 65,000 tons.

The outlook for 1946 is far from reassuring. Even if United States lead usage ran to no more than the proposed rate for the fourth quarter of this year, consumption for 1946 would be about 1,060,000 tons. The most optimistic estimate of new supplies from domestic primary and secondary smelters is 750,000 tons. Add to this the 65,000 tons expected to remain in the Government stocks at the close of 1945 and the total of 815,000 tons would fall short of demand by 250,000, which would have to be made up from imports.

Unfortunately, it is unlikely that the United States can procure anything like that amount abroad in 1946. Imports for 1945 are estimated at about 250,000 tons, but this has been possible largely because the United Kingdom cut down wartime emergency reserves during the year and reduced its new purchases to one-third the prewar level. Furthermore, the European nations under wartime controls were allowed by CRMB to procure lead at less than half their prewar rate. In 1946, the demands of the United States will have no more validity than those of any other country on an essentiality basis. In some cases, the relative needs of other countries are more urgent (for example, the Netherlands was stripped of lead by the Germans). The CRMB has decided to retain lead under international control, but the method of allocation, which must allow for participation in the negotiations by most of the interested countries, has not been settled.

In spite of the indicated shortage, the basic economy of the United States should not be seriously disturbed by a moderate stringency in lead, providing available supplies are carefully distributed and some conservation controls are maintained.

TIN

Although no tin is produced in the United States (with the exception of small amounts of secondary material) and despite the fact that the Japanese invaded the world's major tin producing areas in the Far East very soon after the war broke out, tin was available in the United States throughout the war in sufficient quantities to fill all military and essential civilian requirements.

This achievement was made possible largely because of accumulation by the United States of a sizable tin stock pile prior to the outbreak of the war with Japan, strict conservation in the use of tin during the war and elimination of nonessential uses, and international allocation of new supplies of tin by the Combined Raw Materials Board. This allocation ensured to the United States an amount commensurate with the magnitude of its industrial effort.

Strangely enough, the Japanese surrender aggravated, rather than eased, the tin position of this country. There are four major reasons:

(1) The tin stock pile was drawn down sharply during the war.

(2) The end of the war has not increased the amount of tin immediately available to consuming nations, and it will be some time before sizable amounts will be forthcoming from the Far East.

(3) The end of the war has increased the number of claimants for the already meager world supplies.

(4) The amounts needed for the civilian reconversion program in this country are greater than supplies made available by military cut-backs.

Little is known yet—though information has begun to come in—about the extent of destruction of tin properties in the Far East, or the stocks of metal or concentrates which may be immediately available in these areas. It should be remembered in this connection that the amount of tin which may be available to the United States from these British and Dutch areas will be determined in international negotiations in which the needs of other nations will have to be considered.

There are no grounds, therefore, for optimism about the amount of new tin this country may count upon in the near future. It is possible that destruction will be

UNITED STATES STOCKS OF TIN

[Long tons metal and content]

	Stocks as of—					
	Jan. 1 1941	Jan. 1 1942	Jan. 1 1943	Jan. 1 1944	Jan. 1 1945	July 1 1945
Government:						
Metal	20,804	50,039	63,981	52,815	41,177	32,199
Concentrates	0	23,245	36,725	40,303	41,097	36,586
Total	20,804	73,284	100,706	93,118	82,274	68,785
Industry total	57,204	58,470	32,852	23,766	17,414	18,483
Total all stocks	78,008	131,754	133,558	116,884	99,688	87,268

less than is feared, and that sizable stocks may be discovered. But prudence dictates a policy of continued careful husbanding of our stock pile so as to serve the essential needs of industry, on the assumption that additional new supplies will not be available in significant amounts for a minimum period of 1½ to 2 years.

STOCKPILE POLICY DURING THE WAR

The accumulation of a stock pile of tin was initiated by the National Defense Advisory Committee in June 1940, at which time the construction of a domestic smelter for tin concentrates also was planned. By January 1, 1941, the Government-owned stocks of tin, acquired by arrangement with the International Tin Committee, totaled 20,804 tons of metal. No concentrates had been acquired.

Shortly after Pearl Harbor, total American stocks of pig tin and concentrates attained a peak of 150,000 tons. Since that time there has been a steady decrease to the present total of about 87,000 tons. The record of United States stocks of tin during the war is shown in the table above.

The comparative trends of Government and industry stocks of metal reflect WPB's allocation policy, under which industry was granted allocations from tin already in its hands, and remaining requirements were met from Government stocks.

AVAILABLE STOCKS

The size of United States stocks on July 1, 1945, is somewhat misleading, because total tin supplies cannot be made available for consumption without a complete liquidation of working and strategic reserves—which would bring industry to a standstill—and without smelting the ores in the stock pile, which takes time. Total stocks compared with stocks available for allocation (or available as input for smelting, in the case of concentrates) as of July 1, 1945, follow:

	Available for allocation	Strategic reserve and working stock	Total
Government:			
Metal	20,059	12,140	32,199
Concentrates	26,586	10,000	36,586
Total	46,645	22,140	68,785
Industry; total	483	18,000	18,483
Total all stocks	47,128	40,140	87,268

At the present rate of restricted consumption, stocks available for allocation July 1 were equivalent to about 8 months' supply.

CONSERVATION

With the exception of its use as tinplating on steel (as in the case of tin cans) virtually all tin uses are as an alloy with other metals, and the amount of such alloys used in the ultimate product is relatively small. It was not found practical to control the amount of tin alloys used in finished products. All efforts at conservation of tin during the war were directed towards decreasing to the maximum possible extent the tin content of alloys and tin products used in the production of finished articles. WPB allocations have covered only pig tin and have limited the amounts made available to manufacturers of tinplate, solders, babbitts, brasses and bronzes, and other tin products.

The use of tin in luxury products was prohibited, as were many nonessential uses, such as in hardware and household and kitchen utensils. Tinplate coatings were eliminated in many cases, and were reduced in others. Electrolytic tinplating was required in place of the hot dip method, reducing the tin coating of steel to about one-half pound of tin per base box of tinplate, from the normal 1¼ to 1½ pounds of tin. Solders containing as little as 2 to 4 percent tin were found to do the job adequately, where 30 to 40 percent tin solders had been in use. Similar reductions were effected in bronzes, babbitts, and other tin products.

Through such measures, and despite the overall increased use of tin for direct and indirect military purposes in such products as bronzes for the Navy and food cans, consumption of pig tin was decreased by almost 50 percent from 113,000 tons of 1941 to about 58,000 tons in 1943. The record of tin consumption during the war is presented in the table below.

TIN CONSUMPTION

[Long tons]

Product	1941	1942	1943	1944	1st half 1945 annual rate
Tinplate and terneplate	46,900	29,404	22,643	26,337	28,120
Brass and bronze	23,170	27,655	28,889	33,625	31,378
Solder	28,225	13,924	13,098	13,868	16,966
Babbitt	10,599	6,099	7,381	8,503	8,924
Tinning	4,132	3,015	2,517	3,242	3,394
Collapsible tubes	4,445	1,099	602	502	486
Foil	4,292	576	371	382	384
Type metal	1,815	1,153	550	861	1,004
Chemicals	970	246	133	81	132
Pipe and tubing	1,32	161	117	250	258
Other	9,919	2,764	5,589	2,683	3,146
Total all tin	135,789	86,096	81,840	90,352	94,192
Breakdown of total:					
New pig tin	107,551	56,862	53,137	61,926	68,086
Secondary pig tin	5,635	4,945	4,898	3,335	2,428
Total pig tin	113,186	61,807	58,035	65,262	70,514
Secondary in alloys	22,603	24,289	23,805	25,090	23,678

INTERNATIONAL ALLOCATION

Tin was among the first materials to come under the jurisdiction of the Combined Raw Materials Board. Two major problems confronted the Board immediately following Pearl Harbor: Loss of the Far Eastern tin producing areas which accounted for 75 percent of the world's tin, and loss of the great tin smelters in Malaya and the Netherlands East Indies, which forced the United Nations to place their reliance solely on smelters in Great Britain and the Belgian Congo. (Smelting establishments in Europe were, of course, already under German occupation.)

The major sources of new tin available to the United Nations after Pearl Harbor were Bolivia, the Belgian Congo, and Nigeria. Some tin was available in China, but its availability to the United States and the United Kingdom depended on air transport "over the hump" into India. Small amounts of tin were also available to the United States and the United Kingdom from various African sources. Australia's production was consumed locally. Canada, Russia, and India, with domestic production insufficient for their needs, were also claimants on supplies available for allocation by the Board.

Altogether, at the outbreak of the Japanese war, there were in sight for the Allies the equivalent of some 70,000–80,000 tons of new tin annually, compared with requirements of 90,000–100,000 tons annually. Smelting capacity was even lower (40,000–50,000 tons annually), pointing to the immediate need for a new smelter. The United States was the only allied nation with sizable stocks of tin, and the deficit fell almost entirely on this country. This was reflected in the decline in United States stocks of tin metal; smelting of tin concentrates in this country did not really get under way until the latter part of 1942.

In accordance with allocations by the Combined Raw Materials Board, tin was allocated to the United States (in the form of metal and in concentrates) from Bolivia, Belgian Congo, French Cameroons, China, and Mexico. Bolivian tin was shared with the British on about a 50–50 basis until January 1944, after which about three-fourths of Bolivia's production was allocated to the United States.

At first, after loss of the Far Eastern tin smelters, United Nations supplies of tin metal depended on the output of smelters in the United Kingdom, which had an annual capacity of about 40,000 tons of metal, and small smelters in the Belgian Congo with an annual capacity of some 10,000 tons of metal. The loss of the Far Eastern smelters also promoted smelters in the United Kingdom to the first rank among probable objectives of enemy bombers.

A proposal for the construction of a tin smelter in the United States was considered at a meeting called by the N. D. A. C. in June 1940. A formal proposal to this effect was made toward the end of the year and a contract for the construction of a smelter was awarded to the Billiton Co. in the early part of February 1941. The smelter was constructed and equipped by the Tin Processing Corporation and financed by the Defense Plant Corporation.

The smelter commenced operations in April 1942, and has since shown the following production of tin metal:

	Tons
1942	15,695
1943	20,727
1944	30,619
1945 (7 months)	23,494

POSTWAR OUTLOOK

Current demands for tin by civilian industries manufacturing such products as automobiles, refrigerators, washing machines, electrical appliances, tin cans, radios, etc., are well in excess of supplies of tin freed by cutbacks in military programs. At the same time, the tin stock pile has been drawn down sharply, and no new supply sources are immediately available as a result of the termination of the war.

To add to the problem, the reconstruction needs of Europe must be met out of wartime supply sources. As a result, it is likely that United States imports of tin during the immediate postwar period will not be so great as they have been in war years. This condition is likely to continue until the tin properties in the Far East are rehabilitated and supplies are once again flowing from those areas to consuming countries.

The difficult problem of procuring mining machinery and equipment to be installed in the Far East is complicated by the temporary lack of knowledge of the extent of destruction of the equipment which was in place at the outbreak of the war. It is possible that stocks of tin metal and concentrates may be found above ground in producing areas as well as in Japan, but it would be hazardous to plan reconversion policies on the basis of such

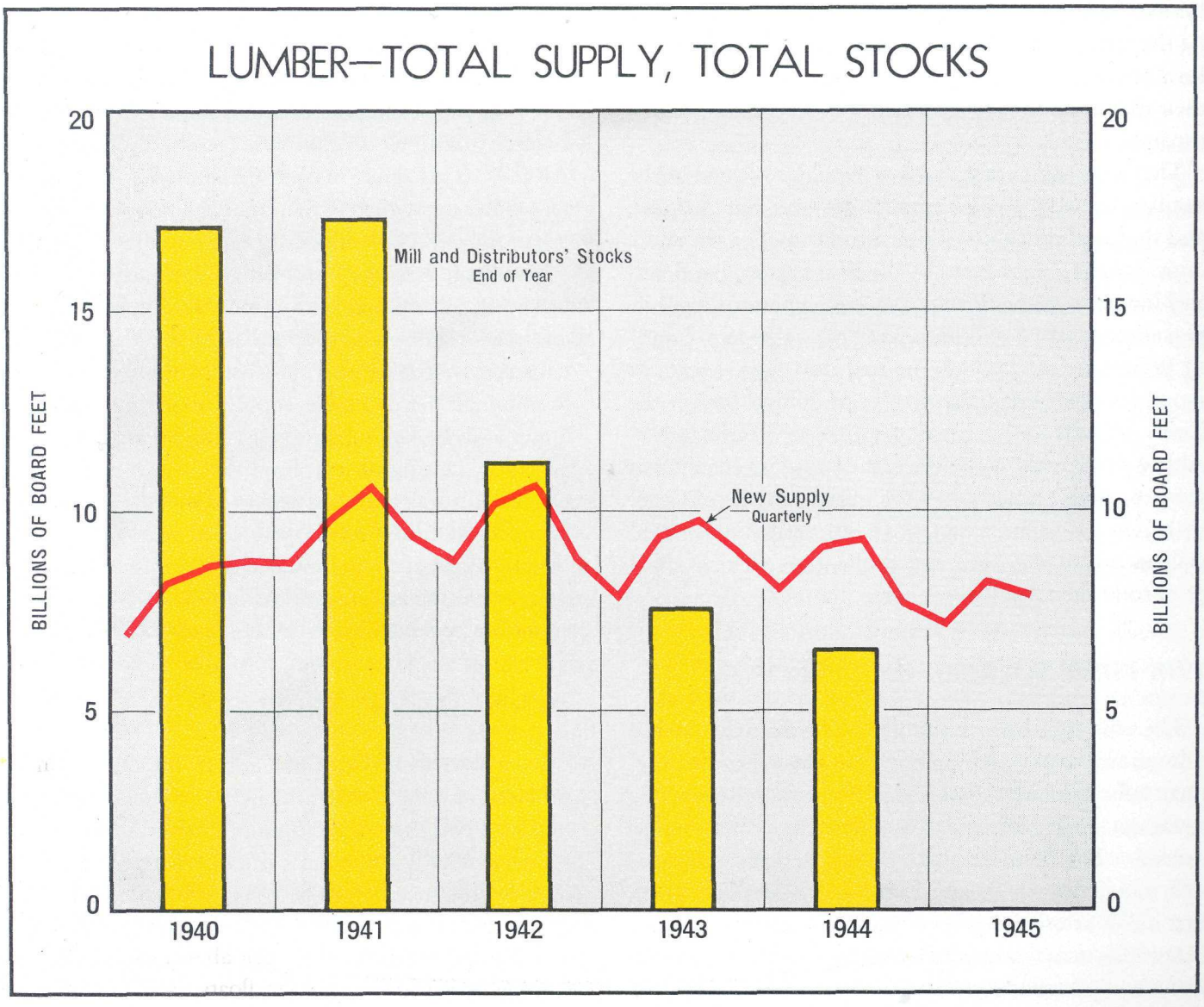
a guess. The War Production Board is assisting in the procurement of mining machinery, both from existing equipment and from new machine production.

At the same time, controls over the use of tin must be further tightened. And, since no substantial increase in tin imports can be expected from areas under the control of other nations, the United States is taking an active part in international discussions toward an agreement on distribution of supplies of tin and metal concentrates from the Netherlands East Indies and Malaya.

LUMBER

The history of lumber during the war is the record of a transition from surplus to scarcity (chart, below). At the start of the defense program we dealt prodigally with lumber. By 1944, WPB had to devise a lumber budget and the necessary procedures to force the industrial economy to live within its lumber means.

From the start of the defense program through 1942, forest products were commonly regarded as a great reservoir which could be drawn upon almost at will and in any quantity to meet expanding requirements. When critical shortages developed in other materials—notably the metals—wood, in one form or another, was seized



as a substitute. Wood boxes and paper were enlisted for agricultural packaging when the burlap supply from India was cut off; tight cooperage took the place of metal drums in many special uses; timber replaced steel in small, fast marine craft such as subchasers and torpedo boats; construction designs were changed to specify timbers rather than steel for the long beams and arches over plant floors, for bridge members, and for river barges and radio towers; experiments were made looking to the use of veneer and plywood in large quantities in place of the then-scarcer light metals in gliders and in trainers and transport planes.

The huge military construction program which began directly after Pearl Harbor was handled with comparative ease, feeding generously from the fat inventories (well over 6 months based on 1941 usage) held by the lumber industry when the deluge of orders descended. At the same time, many lines of civilian activity, such as furniture manufacture, which depended upon wood as their major fabricating material, were even permitted to expand.

The impression that lumber would continue to be available in any needed amount for any war purpose, and that it also could serve as a substitute for the more critical metals, was shared by the War Production Board and industry alike. Production had expanded from its peacetime level of 26 billion feet (the 1935–39 average) to 36 billion feet annually in 1941 and 1942, a gain of around 40 percent. There were 17 billion feet in the hands of mills and yards at the time of Pearl Harbor. Although roughly 6 billion feet of this inventory was worked off in 1942 to carry the initial cantonment construction program, along with virtually unrestricted civilian use of the same softwoods, few persons inside or outside the Government were alarmed.

THE FIRST SQUEEZE ON SUPPLY

The year 1942 was well under way before the surface calm in the lumber situation was broken when procurement officers of the Army and Navy found that they could no longer depend upon delivery of lumber as needed. The War Production Board dealt with this difficulty in May by issuing Limitation Order L–121, the first major restriction placed directly on the use of lumber. This order gave blanket priority to the Army and Navy on the nation's production of softwood lumber of construction grade (normally three-fourths of total lumber production). The absence of any statement from the military or other agencies of their over-all requirements made it impossible at that time to design a more comprehensive order or one less arbitrary in character.

With production staying at the peak of 36 billion feet annually reached in 1941, and mill capacity known to be above 40 billion, realization that the basic lumber structure was weak and was soon to undergo rapid deterioration came slowly. The issuance in August of General Conservation Order M–208 to supersede L–121 did not reflect wide acceptance of the seriousness of the lumber problem so much as it recognized the inequities in the original limitation order. The new order set up a rating system for construction lumber by end uses and also embodied some conservation features.

Another source of difficulty—competitive bidding within the Services—was resolved by the creation of the Central Procurement Agency, charged with responsibility for purchasing construction lumber for the Army, Navy, Maritime Commission, and (subsequently) ARCO. This resort to centralized buying by the military was a step which at that time had no precedent, and it had the effect of eliminating many artificial shortages.

The tough operating problems of the early war period were not general, but within individual species, grades, and sizes. The most spectacular of these special problems occurred in aircraft dimensional lumber. Full allocation of the available supply between the United States and the United Kingdom aircraft programs, supported by cutting directives on the mills, was instituted October 1, 1942. In the year that followed, United States production of these select grades had more than tripled. When requirements were scaled down at the time allocations were made for the fall and winter quarters of 1943–44, it was possible to balance supply and demand.

OTHER SPECIAL PROBLEMS

Even older than West Coast aircraft lumber as a special problem, and the first lumber item to come under allocation, was balsa wood, the lightest known wood and one which is wholly imported (almost entirely from Ecuador). This species had been in heavy demand by the British for aircraft purposes before we entered the war. The United States needed balsa almost exclusively as a flotation material for life rafts, floats, and life preservers.

The British use was concentrated in the lightest grades—preferably under 8 pounds per cubic foot—whereas our need was found to be met satisfactorily with the medium-weight grades. The greatest urgency was attached to maximizing production in Ecuador, and the Combined Chiefs of Staff ruled that the United Kingdom was to have first priority on the lighter weight pieces, used as the core of the plywood fuselage of the Mosquito fighter-bomber.

In the final half of 1942, the Combined Raw Materials Board introduced allocations between the United States and the United Kingdom, and the FEA (then the Board of Economic Warfare) commenced the centralized buying of all balsa of aero and flotation grades produced in Ecuador. Production increased from its prewar level of only 6 million feet annually, when the chief outlet was toys and model planes for the United States market, to nearly 40 million feet in 1943.

Other problem woods which required special treatment in the first two years included mahogany (for torpedo boats and aircraft), birch and hard maple aircraft veneer and plywood (for which the British had a large use for propellers as well as air frames), and Douglas fir clears and structural stress timbers required for aircraft, pontoons, ship decking and planking. As in the case of balsa and of Sitka spruce aero lumber, the shortages which developed in these items were for the most part overcome by the end of 1943.

THE CRISIS IN SHIPPING LUMBER

In 1943 a radical change took place in the character of the demand for softwoods as a consequence of the shift in our military position. Boxes, crates, and dunnage emerged as the dominant users of softwood, and later of all lumber. As the United States grew in its role of world arsenal and then moved from the defensive to the offensive, an almost insatiable appetite developed for any kind of wood that could be used to package and protect shipments of cargoes in transit. In normal times, boxes, crates, and dunnage accounted for only 15 percent of total lumber consumption, or around 4 billion feet per year. This demand doubled in 1942, and in 1943 continued up almost on a straight line to a point where it claimed 40 percent of the new mill cuttings. In 1943, also, came several other developments which had an immediate and lasting influence on the lumber situation. The military accelerated their purchases of lumber to be shipped overseas for construction of air and naval bases, harbors, barracks, and railroads. Pressure on the metals was unrelenting, and substitution of lumber for production and construction, as well as for shipping purposes, continued. By that time, lumber had itself become critical, and orders could be filled only by drawing down stocks another 4 billion feet.

General scarcities of quite another kind—manpower and equipment—began to limit the output of lumber. The equipment and labor shortages resulted in a 5 percent decline in lumber production during 1943 and caused a further reduction of 6 percent in 1944 when only 32.5 billion feet were produced.

FRAMING AN OVER-ALL CONTROL

By the early spring of 1944 it was clear that comprehensive controls over lumber production, distribution, and consumption must be instituted.

A decline in supply of at least 5 percent from 1943 was forecast for 1944. There was every indication that demand, unless checked, would run a good 20 percent beyond supply. No early relief could be expected on the manpower front—the draft and higher-paying war industries would continue taking men out of the woods and sawmills. Inventories—already well below 50 percent of prewar levels—could no longer be depended upon to make any significant contribution. The equipment problems faced by the industry were certain to get worse rather than better. Finally, the existing patchwork of orders in the lumber field had not only failed to bring demand into line with supply, but also had proved ineffective in channeling the limited output to the most essential uses.

Earlier controls, applied piecemeal by species, had obvious weaknesses. No quantitative limit was placed on procurement by the Services. Artificial deficits were created throughout the lumber system by the common practice of multiple placement of orders. Above all, no machinery was provided for balancing total supply against total demand and distributing the available lumber equitably to the more important war-connected uses.

The lumber control program set up under Order L–335 attempted to resolve all these difficulties. Large industrial consumers were placed under a quarterly application-authorization procedure for all their lumber

669713 O - 45 - 6

requirements. Military and export claimants filed consolidated quarterly applications for their direct requirements. A special quarterly application-authorization procedure was also set up by WFA and NHA, the principal claimants for construction lumber. Other rated construction and small industrial users (under 50,000 board feet per quarter) were allowed to procure by self-certification. The whole plan operated through a quarterly balancing of supply and demand, a Requirements Committee "pie cut," quantitative control over authorizations, cutting directives, and mill set-asides for the military.

The system was effective in channeling lumber to direct and indirect military and essential civilian uses, and was sufficiently flexible in operation to deal equally well with the rapid decline in requirements during the fourth quarter of 1944 and the abrupt upswing in the first quarter of 1945. Mill and yard stocks, which had been drained to dangerously low levels, were stabilized. Inventories of industrial consumers were reduced (from over 60 days' supply to 54 days') without disrupting their operations. Duplication and pyramiding of orders were eliminated. The services effected improvements in procurement, inventory control, and lumber utilization.

AFTER V-J DAY

It is estimated that direct military procurement will drop in the next few months about 75 percent below pre-V-J Day levels, freeing slightly over a billion feet per quarter. In addition, it is believed that the indirect military use of lumber—mainly for the boxes, crates, and dunnage used by war contractors and shipping agents—will fall at least 50 percent, resulting in an immediate release of about 1½ billion feet more per quarter.

The only significant limiting factor is the drying time necessary to make seasoned lumber of standard specifications available where and when needed. This is a pipelining job which should progress far enough in the next 60 to 90 days to take care of all foreseeable demands for consumption by the first quarter of next year.

Throughout the war export has been held to a minimum. In 1944, for example, it amounted to only 400 million board feet, against the 1935–39 average of more than a billion. Without restrictions, export demand would probably take double the recent (250 million feet quarterly) rate of shipments, beginning in the current quarter. Shipments of this volume—twice those of the late 1930's—would provide not only for all requests for United States lumber filed by Liberated Areas, but for peacetime inquiries from normal export destinations as well.

In view of the estimated surplus above requirements for consumption, no controls of any description other than the general WPB inventory regulations are being retained over domestic distribution of lumber. FEA will continue individual license control over the export of lumber and over most of the major lumber items, and quantitative limits have been arranged between WPB and FEA for the fourth quarter.

It is doubtful if lumber supplies available to civilians

HOW LUMBER CONTROL WORKED

Supply, requirements, authorizations, and allotments during the control period

	1944		1945	
	Third quarter	Fourth quarter	First quarter	Second quarter
	Million board feet			
Net allocable supply	8,732	7,299	7,449	7,740
Requirements submitted	11,021	9,934	9,746	9,807
Authorizations granted	9,729	8,919	8,231	8,108
Allotments issued	8,138	7,327	7,775	7,956
Allotments issued, total	8,813	7,327	7,775	7,956
By industry divisions	5,264	4,710	4,804	4,622
By military agencies	1,750	1,152	1,332	1,346
By export agencies	145	95	118	192
By WFA county boards	451	245	228	324
By NHA	282	165	222	388
Self-certified reserves	692	749	743	780
Uncertified reserves	229	211	328	304
	Percent of allocable supply			
Net allocable supply	100	100	100	100
Requirements submitted	126	136	131	127
Authorizations granted	111	122	100	105
Allotments issued	101	100	104	103

will at any time, except in the next 90 days, exert a retarding influence on national reconversion, unless production losses from the current labor troubles reach large proportions. For a few more weeks dry lumber of standard grades and sizes will not be available for every call. But the season of the year operates to minimize the impact on new construction and on other lines of activity which have been restrained in their lumber purchases during the war, such as farm, railroad, and urban residential repair.

COTTON BROAD WOVEN GOODS

In the early stages of the war, it was difficult to foresee any shortage of cotton broad woven goods—or, indeed, of soft goods generally. Resources, in terms of both raw cotton and mill capacity, seemed ample to meet all probable military and civilian demands.

Up through the first quarter of 1943, production did keep pace with demand. Total supply expanded rapidly from about 8.3 billion linear yards in 1939 to a peak of 11.2 billion yards in 1942. In the first quarter of 1943, production edged still higher to reach an annual rate of 11.4 billion yards, 37 percent above the 1939 rate. This great increase was accomplished both by more intensive use of facilities and by a steady increase in the working force, from an average of 396,000 in 1939 to a peak of 510,000 in December 1942.

Starting in April 1943, however, labor began to drift away from the cotton mills—as a result of the draft and of the higher wages offered by war industries—faster than it could be replaced by new workers. By May 1945, employment had declined to 411,000, 20 percent below the wartime peak. As a result, production started a steady decline. By the second half of 1943, output had dropped almost 13 percent to an annual rate of about 10 billion yards. In 1944, production was only slightly in excess of 9.5 billion yards and in the current year, despite intensive efforts to increase the labor supply, production has continued to drop (chart, p. 78).

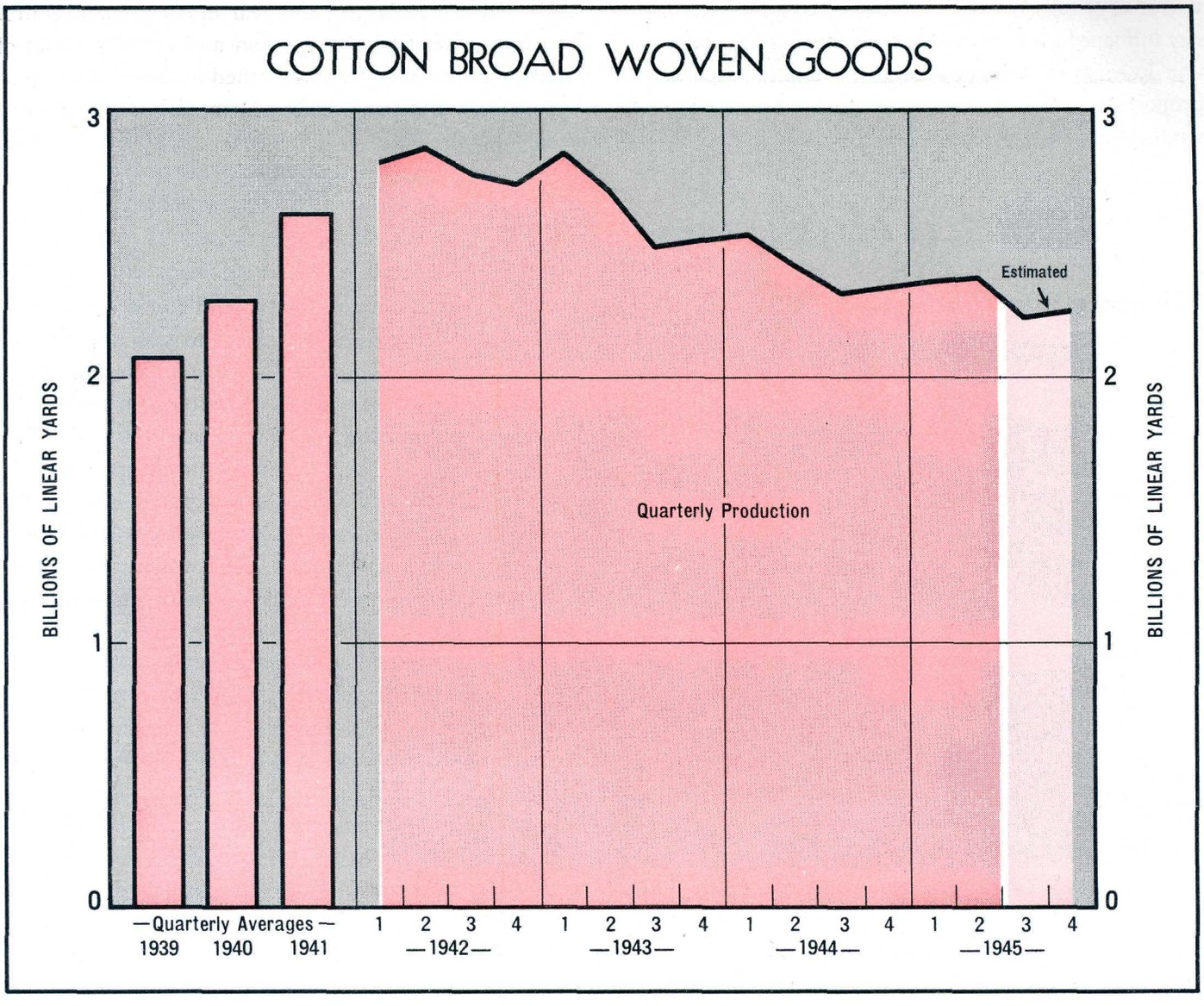
COTTON DUCK

While supplies were generally adequate throughout 1942, shortages of specific fabrics had already begun to make themselves felt, and the War Production Board was forced to undertake its initial steps at control. The first such shortage was occasioned by heavy military demands for cotton duck, which proved far beyond the capacity of looms normally engaged in the production of duck. Accordingly, on March 2, 1942, Conservation Order M-91 was issued, freezing all cotton duck stocks and cotton duck facilities subject to sale or operation only on authorization of the War Production Board. In addition, 100 million pounds of cotton yarn suitable for duck production were diverted from cotton tire cord mills (which had been forced to curtail operations because of the rubber shortage) to integrated duck producers and to carpet and rug mills converted to duck production. As a result, duck output was increased from 108 million yards in the first quarter of 1942 to a peak of 169 million yards in the first quarter of 1943—almost four times the 43-million-yard quarterly average of 1939.

After early 1943, military demands dropped sharply, and many looms were reconverted. But in the second quarter of 1944, Army requirements again increased suddenly. The entire conversion process had to be repeated and supplemented by conversion of denim and similar looms to tent twills. Production of duck and duck substitutes went up to 225 million yards in the second quarter of 1945, just before V-E Day. Multiple changes of this sort involved inevitable losses in the industry's production efficiency.

BAGGING

The second major problem confronting the industry was occasioned by the early Japanese successes in the Far East and the consequent curtailment of burlap shipments from Calcutta. Large quantities of cotton bagging material were needed to make up the deficit. This resulted in issuance, on April 20, 1942, of the first general order controlling the production of cotton textiles—L-99. Under this order, mills were directed to convert some 45,000 looms previously engaged in the manufacture of denims, towels, tickings and draperies to the manufacture of about 15 specified constructions of bag osnaburgs and bag sheetings, and to operate these looms 120 hours per week. The goal of this conversion was to produce



1.5 billion yards annually of heavy bagging materials, or about double the previous rate. The goal was surpassed.

At about the same time, the initial step toward extending preference ratings to nonmilitary users of cotton cloth was taken under Order M–107, which established an A–2 rating (then a high rating) for manufacturers of agricultural bags. This was coupled with a 60-day inventory limitation.

CONTROLS EXTENDED

By March 1943, it became apparent that, despite the sharp increase in production, supplies would not be adequate to meet all civilian demands, which had risen with the increase in purchasing power. Therefore, to insure the production of a broad classification of serviceable fabrics, L–99 was broadened in March 1943, to include lighter weight sheetings and plain print cloths. This amendment limited the range of constructions which could be manufactured in these two categories and ordered the construction of many of the standard fabrics changed in order to obtain greater productivity per machine-hour. In May 1943, the order was further broadened to bring all types of carded gray goods within its scope.

Gradually, Order L–99 was further extended until virtually all cotton looms, except those on combed goods,

were brought under control. Primary emphasis was on the satisfaction of military needs for specific fabrics, but maximum production of staple serviceable fabrics for civilians was also a major objective.

As new shortages continued to develop, controls over the distribution of cloth were also expanded. In December 1943, General Conservation Order M–317 was issued, which established a new rating structure for many classes of essential users. These ratings were on a self-assigned basis and carried no quantitative limitations. This order was gradually modified and extended with no change in its basic rating structure until the third quarter of 1945, when all self-assigned ratings were revoked and replaced by a detailed application-authorization system.

LOW-PRICED GARMENTS

Meanwhile, the Office of Civilian Requirements had requested, early in 1944, that steps be taken to insure the production of a minimum quantity of essential cotton garments of specific types and within reasonable price ranges. Particular stress was placed upon the need for low-priced infants' and children's apparel. Accordingly, on May 9, 1944, Order M–328B was issued, granting preference ratings for cloth to garment manufacturers who were willing to abide by the quality and price specifications prescribed by WPB. This order has operated effectively within the limits of its scope and is continuing for the fourth quarter of 1945 as the principal instrument for providing priority assistance for the manufacture of low-cost apparel.

In the winter of 1944–45, as the supply situation deteriorated progressively, the War Production Board, in cooperation with the Office of Price Administration, began to seek methods of channeling into reasonably priced essential civilian items a larger proportion of the limited supplies of cloth available. The two agencies took concurrent steps. OPA issued its Maximum Average Price Regulation, which prohibited any clothing manufacturer from selling garments at an average price greater than his average price for the same class of garments in a 1943 base period. The War Production Board issued Order M–388A which granted preference ratings to manufacturers of stipulated articles of clothing selling within designated price ranges; the quantity of cloth granted each manufacturer was based upon his 1943 production of the articles in question. The assigned AA–4 rating was to be served upon the converter who, in turn was required to set aside a stipulated percentage of his otherwise nonrated supplies for these orders. M–388A was in full effect for only one quarter—the third quarter of 1945. With the defeat of Japan, it became evident that cloth supplies would improve sufficiently to eliminate the need for an order of this type, and it was revoked as of September 30, 1945.

ALLOCATION CONTROLS

Until the end of 1943 the supply situation had not warranted the establishment of any general plan of allocation. During the latter part of that year, however, allotments were set up for the export claimants—Foreign Economic Administration and Canada. But no allotments were made to domestic claimants and no effort was made to control military procurement.

When requirements for the first quarter of 1944 were reviewed it was evident that demands upon United States production far exceeded available supply. In an effort to make at least minimum provision for essential export claims without impinging too seriously upon the domestic civilian economy, the War Production Board initiated its first general review of the basis upon which military requirements were calculated. As a result, agreements were reached for a readjustment of Army inventory policy on a more conservative basis.

During the first half of 1944, it was not, however, believed feasible to impose direct budgetary controls upon the military, and consequently, the Program Determination (No. 551), issued on February 21, 1944, established firm allocations only for export claimants. In order to insure that the amounts allotted were actually provided for export, the "set-aside" principle was introduced into Order M–317A.

At that time, supplies were only slightly below the level of stated requirements, but in the third quarter of 1944 the situation rapidly became worse. Production declined and military demands went up. It was then determined to establish budgetary controls over military claimants in the third quarter. Allotments finally granted to all claimants were substantially below stated requirements (table, p. 80).

COTTON BROAD WOVEN FABRICS

Supply, requirements, and distribution of allotments

[Millions of linear yards]

	1944		1945			
	Third quarter	Fourth quarter	First quarter	Second quarter	Third quarter	Fourth quarter
Estimated total supply	2,304	2,326	2,370	2,375	2,231	2,343
Stated requirements	3,084	3,272	3,221	3,316	3,589	.....
Final allotments	2,446	2,446	2,471	2,375	2,231	.....
Distribution of final allotments: [1]						
Army	420	414	458	494	429	.....
Navy	211	207	164	162	121	.....
Other military	17	29	23	26	26	.....
Total military	648	650	645	682	576	51
Export (FEA, Canada)	189	201	210	188	170	275
OCR	1,208	1,166	1,210	1,015	893	1,467
Other domestic	401	429	406	490	470	550
Reserve	.....	.....	.....	.....	122	.....

[1] Third quarter, 1945, figures are initial allotments; fourth quarter, 1945, figures are estimated distribution of supply.

NOTE: The distribution of allotments is not necessarily an accurate picture of the consumption by claimants since (1) no accounting was required of OCR or the industry divisions until the third quarter of 1945, (2) not all of the allotment authority granted to claimants under budgetary control was used, and (3) there were several shifts in classification of claims during the control quarters, particularly with respect to indirect military uses.

It was hoped, at that time, that military requirements for cotton duck could be met through conversion of looms engaged in producing less essential fabrics, such as rugs and carpets, draperies, and upholsteries. Expected results did not materialize and in September 1944, some 4,000 denim looms had to be converted to tent twill—a duck substitute. This was the first of a series of steps which seriously reduced the production of work clothing fabric for civilian use.

Another major conversion job became necessary early in 1945 when Army requirements for fine combed goods increased from 67,000,000 yards in the first quarter to 107,000,000 yards in the second. By bringing all the combed looms under control and scheduling production of military fabrics on them, it was possible to allot the Army 99,000,000 yards. However, because of the heavier weight of military fabrics and the production loss in conversion, the last 20,000,000 yards of combed goods provided for the military was at the expense of almost 60,000,000 yards of civilian fabrics.

The basic framework of the allocation procedure did not change substantially between the third quarter of 1944 and the second quarter of 1945. But during this period the supply situation continued to deteriorate steadily. Export allotments had to be reduced progressively, despite increasing demand from all parts of the world. Domestic civilian supplies likewise were cut. Whereas in the first half of 1944 it had been possible to provide allotments up to 87 percent of total requests, only 72 percent of requests could be met in the second quarter.

By the second quarter of 1945 the situation had become so serious that much tighter controls appeared essential. Accordingly, for the third quarter all self-assigned ratings under Order M-317A were cancelled and future ratings for industrial and civilian uses were issued only

by the War Production Board upon application. Allocations were provided for each of the WPB industry divisions, thus establishing for the first time virtually complete control over the entire distribution of cotton broad woven fabrics.

The extreme complexity of the textile industry contributed importantly to the delay in establishment of this comprehensive control program. A tremendous amount of detailed work was involved in setting up controls extending from the initial processing of raw cotton through the production and distribution of end items by tens of thousands of individual establishments. As regulations were gradually extended, each step involved numerous unforeseen problems which could be resolved only upon the basis of accumulated experience. Moreover, each new regulation encountered considerable opposition from the several segments of the industry affected and compliance with WPB regulations often proved difficult and was never perfect.

Throughout the period of allocation controls the WPB staff worked closely with the military services, and in the last two quarters of the program the presentation of military requirements was virtually a joint effort. And although stated requirements could not be met, there is no evidence that any military program suffered from lack of textiles.

Export demand kept rising throughout the allocation period. Reduced United Kingdom production and the cutting off of Japanese exports forced the United States to supply normal British and Japanese markets in Latin America, Canada and other Empire countries, and elsewhere. And the steady advance of the United Nations armed forces meant large requirements to fill the needs of the liberated areas.

Among the steps taken to cope with the world textile shortage was the organization of the Textile Committee of the Combined Production and Resources Board. This committee established procedures to coordinate the export programs of the United States, the United Kingdom, India, and Canada, and later sent a mission to Brazil and Mexico to insure the most effective utilization of the export potentials of those countries. These steps did result in a more effective utilization of the supplies that were available but could not appreciably affect the major problem occasioned by the constantly increasing gap between available supply and total requirements.

TEXTILES IN THE TRANSITION PERIOD

With the defeat of Japan, military needs dropped from about 31 percent of supply at the start of the third quarter to an estimated 2½ percent for the fourth quarter. Some types of cloth, such as duck, became in extremely easy supply; the duck conservation order (M–91) was revoked and export quotas suspended. In addition, other orders were amended to permit as much as possible of the newly released cloth to flow free of ratings, on the open market. Both FEA and Canada received supplemental export allocations.

While the picture for the fourth quarter is not yet fully clear, it seems evident that there will be some continuing domestic shortages, despite the cancellation of the great bulk of military procurement. It is probable that the amount of cloth available for consumer end-products, such as clothing and house furnishings, will be about 10 percent less than was available in 1939, and about 10 percent below the requirements estimated by OCR. Bag fabrics will remain in relatively short supply until the shortage of burlap from Calcutta has been remedied.

Moreover, the world shortage of cotton goods seems certain to continue well into 1946. There is no immediate replacement in sight for the 2.5 billion yards exported annually by Japan before the war. The deficit accumulated throughout the world during the war years must be made up at least in part. The restoration of textile production on the European Continent has been disappointing, largely because of the shortage of coal.

Even on the domestic front, it seems likely that supplies of cotton cloth for clothing, house furnishings, and similar uses will be insufficient to meet full unrestricted demand. Quantities available for distribution now are still slightly less than before the war. The backlog of two years of inadequate production hangs over the market. Moreover, returning soldiers will be finding it necessary to replenish their civilian wardrobes. All these factors point to the probability of a strong seller's market until at least the middle of 1945.

Nevertheless, most of the controls under which the textile industries operate can be removed. Thus, in the fourth quarter of 1945 preference rating assistance will not be necessary except for military uses, exports, and the low-end civilian program. Set-asides are being retained to insure satisfaction of export allocations and of the low-

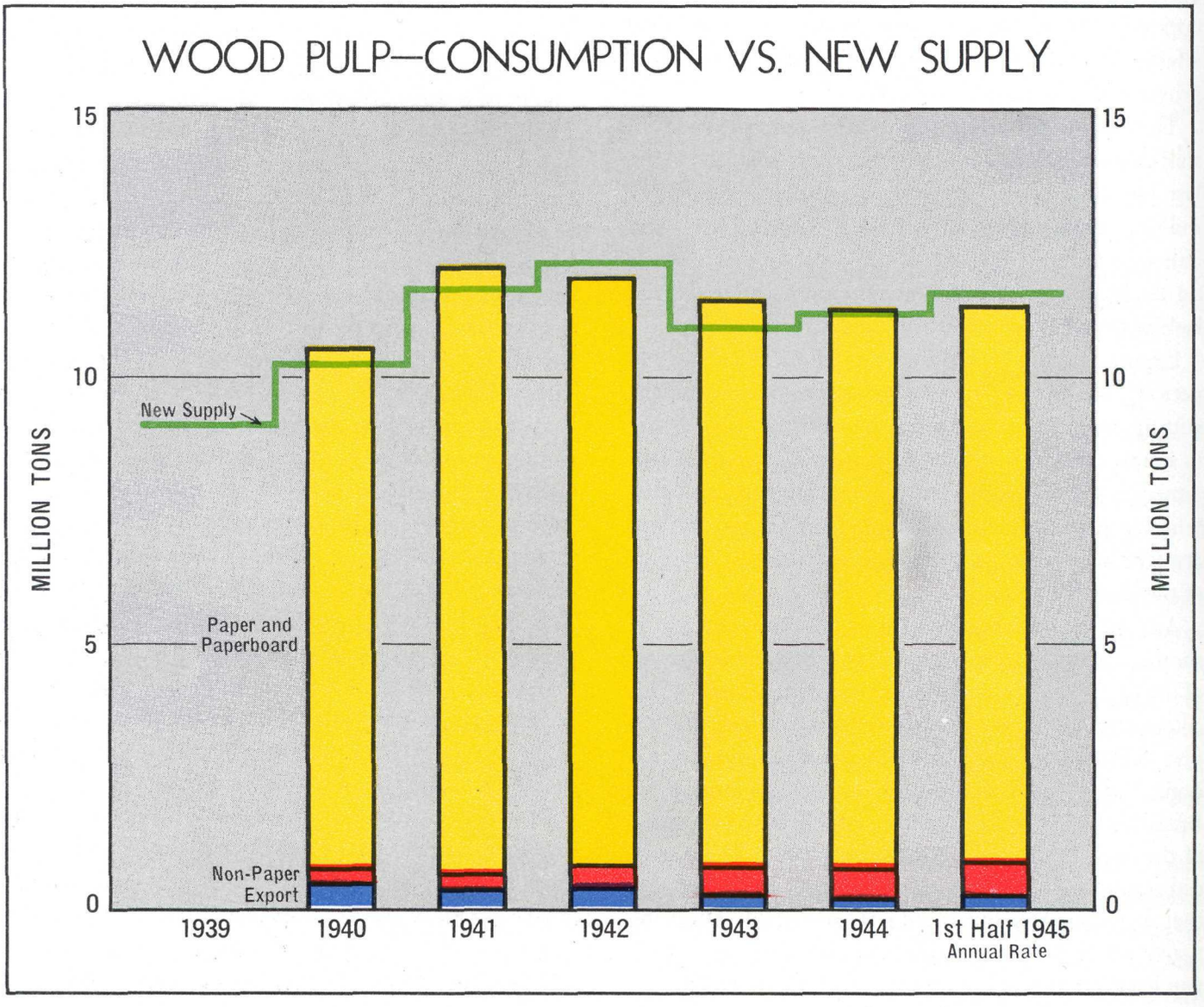
end civilian program. A special set-aside has been established for bagging fabrics. The regulation of loom assignments is being reduced to a minimum.

As long as the world shortage persists, it may be desirable to maintain at least the framework of international planning heretofore handled through the Textile Committee of the Combined Production and Resources Board. There is no other means at present for judging the relative urgency of the essential needs of importing areas.

PULP AND PAPER

Outbreak of the war in Europe brought an unparalleled expansion in the United States pulp and paper industry. Newspaper, book, and magazine circulations increased. Demand soared for wrapping, bag, and special industrial papers, multiwall shipping sacks, paperboard shipping and inner containers, and many other items. The rise was accelerated after Pearl Harbor, and paper, normally one of the cheapest and commonest of materials, eventually became one of the tightest.

Although the war caused wood pulp imports from Scandinavia to drop sharply, then dwindle to a trickle, and finally disappear, increased domestic production and



importations from Canada raised total wood-pulp supply from 9 million tons in 1939 to 12 million tons in 1942 (chart, p. 82). At the same time, paper and paperboard production rose from 13½ million tons to more than 17 million, with the aid of wastepaper collection drives which brought in 6 million tons annually in 1941 and 1942.

Because stocks were large and new wood-pulp supply increased almost in proportion to consumption, the situation continued easy during this early period. However, the structure of the industry required that certain controls be introduced. Cessation of woodpulp imports from Scandinavia cut off many nonintegrated and semiintegrated paper and paperboard mills from their normal sources of supply. Increased imports from Canada and expanded domestic production did not increase the supply of market wood pulp enough to maintain these mills in operation. In addition, nitration pulp requirements of the military forces were absorbing increasing quantities of market pulp.

In January 1942, OPM Order M–52 attempted to distribute the burden of nitration pulp requirements among the producers of sulphite wood pulp (the grade used in nitration) so that the customers of these producers would not be disproportionately affected. This was only a temporary measure. Order M–93, effective May 1, 1942, authorized WPB to direct woodpulp deliveries. Control was exercised on a month-to-month basis during the remainder of 1942. Fortunately, average inventories of mills dependent upon market supplies were sizeable, and it was possible to maintain all such mills in operation by diverting deliveries from those with large inventories to those which lacked such a cushion. M–93 was supplemented by L–120, which conserved pulp by reducing the basic weights of many types of papers, and by M–241a, which limited the quantities of paper that converters could use in the manufacture of many items.

DEVELOPING SHORTAGE

The situation took a sharp turn for the worse in 1943. The difficulty was primarily in the woods, where a growing labor shortage in both the United States and Canada resulted in a 10 percent drop in wood supplies. This was reflected in wood pulp supply, which fell from more than 12 million tons in 1942 to less than 11 million in 1943. Pulp consumption was running ahead of new supply. The deficit came out of stocks, which declined to dangerous levels.

Additional difficulties were encountered on the consumption side. Increasing requirements for explosives and for rayon production had boosted wood pulp use for nonpaper purposes from 262,000 tons in 1940 to 514,000 tons in 1943. Exports were reduced sharply, but they were still 140,000 tons greater than in 1939. Paper and paperboard mills cut their pulp consumption from 11,000,000 tons in 1942 to 10,600,000 tons in 1943. However, by using more waste paper and other waste materials, producers stretched their pulp supply and were thus able to sustain paper and paperboard production at approximately the 1942 level.

It became plain, early in 1943, that freely offered market supplies, and inventories of mills dependent on such supplies, were no longer adequate to keep such mills in operation, especially since lend-lease requirements for unbleached Kraft pulp had substantially increased. The control was therefore broadened to require pulp producers to set aside a percentage of their output for direction by WPB. Up to 20 percent of the unbleached Kraft production of integrated mills was diverted for market purposes.

Further controls were introduced by the middle of the year, as the shortage of pulp extended to all grades. Beginning in August 1943, mills dependent on market supplies were restricted as to the total quantities of pulp they could consume. Curbs were placed on consumption of paper by newspaper, book, and magazine publishers and commercial printers. Limitations were set on the production of grocery and variety bags. Conservation orders were introduced in the field of specialty and other papers. Producers were required by Order M–241 to reserve stated percentages of their production time and facilities to provide for needs of military and other Government agencies. But even these measures were not adequate by the end of 1943 to meet the crisis which was rapidly developing.

TIGHTER CONTROL

The period of tight control began late in 1943 and lasted through the first half of 1945. Up till then, controls had been exercised only on wood pulp deliveries and to the total quantities that might be used. It was now necessary to extend control over end products for which pulp might be used. Accordingly, M–93 was

amended, and a complete reorganization of WPB operating divisions was effected for a more efficient handling of the situation. Paper and Paperboard Division Requirements Committees were set up to prepare quarterly requirements programs and to submit their requirements to the new Pulp and Paper Production Committee (actually a wood pulp allocation committee).

Not only were specific quantities of wood pulp allocated by formal program for paper and paperboard, rayon, nitration, plastics, exports, etc., but paper and paperboard mill authorizations to consume wood pulp were tied to specific quantities of the various grades to be manufactured. Minimum quantities of the various grades to be produced were stipulated. Authorization of wood pulp use for relatively less essential papers and paperboards was curtailed.

Consumption of printing papers by newspaper, book, and magazine publishers and commercial printers was curtailed by as much as 25 percent. Containerboard was placed under separate allocation procedure to manufacturers of shipping cartons (M–290), and essential users of cartons were given special priority ratings (P–146) to assist them in procurement. (This was the sole wartime instance of the use of priority ratings in the paper and paperboard field.)

MORE WASTEPAPER USED

Meanwhile, drives were carried on to increase pulpwood production and waste-paper salvage, and negotiations were initiated with Canada to boost imports of pulpwood, wood pulp, and newsprint. Quantities of wood pulp which might be used by paper and paperboard mills were rigidly limited, but no ceiling was placed on the quantities of waste paper and other waste materials that might be used nor on total production. In consequence, the volume of waste materials used increased to 48 percent in 1944, and production of paper and paperboard in 1944, with less pulp than in 1943, exceeded both programmed production goals and the 1943 output.

Although total paper and paperboard production was maintained throughout 1944 and the first half of 1945 at a level only slightly below that of the record-breaking year 1941, serious stresses and strains developed in certain fields. Perhaps the most serious was in containerboard. With containerboard production averaging a little more than a million tons a quarter, the military and WFA take of V-board (a high test containerboard used for the manufacture of containers for overseas shipment) increased from a quarterly average of 122,000 tons in 1943 to 355,000 tons in the second quarter of 1945. This sharply reduced the residual available for domestic fiber shipping containers and other uses and threatened to disrupt the economy.

The effects of the strain on containerboard were indirectly reflected in a growing shortage of Kraft wrapping paper and grocery and variety bag papers. Containerboard, multiwall shipping sacks, and waterproof papers required by the military were dipping heavily into the limited supplies of unbleached Kraft pulp. Less and less of this could be allocated for wrapping and bag papers. By the second quarter of 1945, the program called for the production of Kraft wrapping paper at only 53 percent of the 1942 rate and bag papers at only 36 percent.

Increased military and export requirements, together with the shortage of textiles, inadequate laundry service, and increasing industrial usage created a shortage in the sanitary paper field, especially facial and toilet tissue.

In the case of multiwall shipping sacks, in which large quantities of chemicals, fertilizers, potatoes, cement, etc., are packaged, the wartime expansion of production was unable to keep pace with requirements, and a concurrent shortage in textile bags aggravated the problem.

Added to these and other difficulties were the requirements of liberated areas, beginning in the first quarter of 1945. While the quantities involved were not large in relation to total supply, they did have the effect of reducing the residual supplies available for consumers.

It became apparent in the second quarter of 1945 that continuation of the two-front war would bring new and more drastic controls. Prisoners of war were being utilized to increase pulpwood and therefore wood pulp production. Waste paper had been used to the fullest possible extent to augment scarce wood pulp supplies. Canada was producing and shipping to the United States all the pulpwood and wood pulp of which she was capable. Production of pulpwood, Kraft pulp, containerboard, and fiber shipping containers had been placed on the National Production Urgency List. Despite all of these measures, inventories of both pulpwood and wood pulp were below the danger point. Military requirements for nitration pulp and V-board, already huge,

were on the verge of further increases. Steps were being taken to convert two additional paper pulp mills to the production of nitration pulp, and Army Ordnance plants, after long experimentation, had begun to dip into the precious Kraft pulp as a nitration raw material.

RELAXATION OF CONTROLS

Victory in Europe came in the nick of time. It brought an immediate and sizeable reduction in nitration-pulp requirements. More important, it promised the early resumption of wood-pulp shipments from northern Europe.

The decline in nitration-pulp requirements following V–E Day brought a noticeable easement in the white paper situation by the end of the second quarter of 1945. In the third quarter, imports of wood pulp from Sweden began to arrive. By September 21, some 164,000 tons (a large part of it Kraft) had already arrived from northern Europe.

With additional supplies in prospect, preparation of the third-quarter 1945 program had become considerably less difficult. Although wood-pulp allocation was retained, the programming of paper and paperboard production was abandoned, with the exception of waterproof and shipping sack papers and containerboard.

Between V–E and V–J Days a number of the less important pulp and paper controls were revoked and others, notably the printing and publishing orders, were relaxed. Withholding of pulp from integrated mills was sharply reduced during the third quarter, and inventories in mills dependent on market supplies were increased in order to build up stocks to a 45-day level by the end of the quarter and thus permit revocation of M–93.

With the arrival of Swedish pulp, the pulp and paper industry's difficulties, born during the war, virtually vanished. All remaining controls with the exception of M–241, the reserve-production order, and L–240, the newsprint consumption control order, were revoked by October 1, and it was certain that these would be short-lived.

Since the war did not require the physical conversion of the pulp and paper industry, reconversion poses no serious problems. Although the capacity of some paper mills to produce papers of special grades (condenser tissue, moisture vapor barrier materials, etc.) was expanded beyond probable peacetime requirements for these grades, this capacity represents only a small portion of the industry's output.

INCREASED POSTWAR MARKET

During the war, inventories of pulpwood, wood pulp, paper, and paperboard have been depleted all along the pipeline, and these will have to be built up. The widespread substitution of paper and paperboard products for steel, tin, lumber, and other scarce materials in the early stage of the war opened new markets for these products which may be retained. Striking advances were made in paper use during the war, particularly in waterproof packaging materials. There is reason to anticipate postwar consumption of printed materials at or close to the record-breaking levels established during the first years of the war. The promise of a high-production economy indicates continued high levels of consumption for paper and paperboard wrapping and packaging materials.

The outlook for pulp and paper exports is similarly favorable. It will be some time before countries like France, Belgium, and the Netherlands, which normally produced a sizeable part of their own requirements, achieve normal paper production. Similarly, it will take a long time for Northern Europe (Sweden, Norway, and Finland), which normally supply the import requirements of Western Europe, to reach normal export levels and costs. United States pulp and paper producers, therefore, should be able to find willing markets in both Europe and Latin America for whatever part of their total production can be spared by domestic consumers.

Various forecasts have been made of the levels of paper and paperboard production which may be attained in the postwar period. There seems little doubt, however, that the domestic market could absorb close to 20,000,000 tons of domestic paper and paperboard production annually, in addition to almost 3,000,000 tons of imported newsprint. This level of production would be about 50 percent larger than that of 1939.

It is not quite clear just how soon such a level of production could be reached. Output of pulp and paper mill machinery has been limited during the war, and some replacement will be necessary. The same is true of printing and publishing equipment. On the raw material side, it is undetermined to what extent the imminent withdrawal of prisoners of war from pulpwood cutting will affect the industry, or how soon workers

released from military service and war production will find their way back to the woods. A sharp decline in waste paper collections may also be anticipated, at least temporarily, although vigorous efforts will be made to maintain them at recent levels. In spite of these uncertainties, the near and longer-term outlooks for the pulp and paper industry appear bright for both production and employment.

CHEMICALS, DRUGS AND ALLIED PRODUCTS

The chemicals field is a broad one. Basic chemicals were used in virtually every field of war production, including conspicuously synthetic rubber, aviation gasoline, plastics, rayon, nylon, explosives and propellants, protective coatings, dyes, fertilizers, insecticides, and medical supplies.

A RECORD OF ACHIEVEMENT

The rearmament program undertaken in 1940 soon gave rise to large problems of rapid expansion in the domestic chemical industry. Two chemicals of fundamental importance, chemical nitrogen and industrial alcohol, reported specially below, serve to highlight the over-all development. The significance of these and other chemicals to national defense was recognized as early as June 1940, when a Division of Chemical and Allied Products was set up in the National Defense Advisory Commission. The officials of this Division, which eventually became the Chemicals Bureau of WPB, worked closely with the Army and Navy Munitions Board's Chemical Advisory Committee to develop military requirements and maintain contact with industry.

At the time of Pearl Harbor, the Chemicals Branch had under its supervision 276 chemicals (not including rubber chemicals), of which the most critical to the war effort were deemed to be chlorine, oxygen toluene, phthalic anhydride, ethyl alcohol, phenol, and synthetic ammonia. As the explosives and synthetic rubber programs increased, production goals had to be set higher and higher. By the middle of 1942, it was evident that for these as well as many other materials, all but the most essential civilian requirements would have to be eliminated. Controls were tightened, permitted end uses carefully screened, public purchase programs instituted for materials obtainable abroad, subsidies were recommended where necessary to stimulate production, and above all, a large program of publicly and privately financed new production facilities was begun. As the result of these efforts, and of encouragement to the use of substitutes wherever possible, major production bottlenecks in chemicals were few.

PRODUCTION

Despite fluctuations in military requirements during 1943 and 1944, production increased steadily, until by the beginning of 1945, the industry had reached the highest level of output and employed the largest number of workers in its history. The increase in value of output of chemicals and allied products has kept pace with the rise in the gross national product, amounting to about 4 percent of the latter in each year.

At the end of 1944, the expanding war program was not being held up seriously for lack of chemicals, but early in 1945, when the explosives and tire production goals were raised again, shortages developed in such items as benzene, phthalic anhydride, nitrogen, and particularly in carbon black. The latter was overcome by authorization of new plants to reach a total capacity of 1,538,000,000 pounds per year, reduced after V–E Day to 1,400,000,000 pounds. When the defeat of Japan was at hand, only a few chemicals, such as sodium bichromate, hydrogen peroxide, and rosin, were in seriously short supply.

MANPOWER

Employment in the chemicals and allied products industries rose from 280,000 in 1939 to 715,000 by 1943, keeping pace with production needs. Thereafter, manpower became a vexing problem, with the labor force drained by Selective Service requirements and the higher paying aircraft and shipbuilding industries. Although there were about 628,000 workers employed as of the beginning of 1945, it was estimated that about 50,000 more were then needed.

OTHER DIFFICULTIES

At various times, and particularly early in 1945, difficult situations were brought about by a lack of repair parts for chemical equipment, shortages of containers, transportation difficulties and breakdowns, and an insufficient number of special types of tank cars.

FACILITIES EXPANSION

Although its policy has been to limit wartime construction to projects essential to the war effort, the Chemicals Bureau has estimated that the total value of chemical plant expansion completed since 1939 was $1,500,000,000. The entire approved expansion program of $1,700,000,000 was about 88 percent completed at the end of 1944, with new facilities being authorized at a rate of about $12,000,000 per month for 1945. The total program as of January 1, 1945, stood as follows:

Program	Cost—millions of dollars	Percent complete end of 1944	Percent Government financed
Synthetic rubber	[1] 500	95	96
Military explosives	350	95	85
Chemical warfare	50	100	100
Chemicals [2]	800	80	40
Total	1,700	88	67

[1] Includes Government financed butadiene, neoprene, catalyst, etc., and estimate of privately financed butadiene and styrene plants. Does not include copolymer plants.
[2] Includes allied products except rayon.

EXPORTS AND LEND-LEASE

In addition to meeting augmented domestic requirements, this country shipped substantial quantities of chemicals and drugs to our allies under lend-lease, and maintained commercial exports to other countries. Shortages of shipping and materials reduced the totals in 1944:

CHEMICAL EXPORTS

Lend-lease and total exports of chemicals and allied products

[Millions of Dollars]

Year	Lend-lease [1]	Total exports
1941	15	333
1942	150	387
1943	282	409
1944	240	517
6 mos. 1945	90	.....
Total	778	.....

[1] Includes explosives.

INTERNATIONAL ALLOCATIONS

Included in the chemicals allocated among the United States, the British Empire, and the United Nations by the Combined Raw Materials Board were pyrethrum, rotenone, shellac, copper sulfate, gum copal, bones, hide glue-stock, casein, cotton linters, cinchona bark, and rosin. These allocations were often accompanied by public purchase and coordinated buying arrangements and price understandings. In some cases materials were obtained under reverse lend-lease. WPB was represented on the Combined Committee on Fertilizers of CRMB and the Combined Food Board which made world allocations of fertilizers, and on the Medical Supplies Committee of CPRB which allocated scarce drugs.

Chemicals made available from abroad through public purchase programs included benzene, cresol, and naphthalene from the United Kingdom; pyrethrum, rotenone and cinchona bark from South America; shellac from India; and nitrates from Chile.

CONTROLS

Chemical control orders go back to the early days of OPM, and the types of control have ranged from complete allocation for the most critical chemicals to general restrictions on production and use of less critical items, i. e., limitation to levels of a base year period.

The difficulty of determining precisely the end products into which most chemicals eventually found their way led to the adoption, in the majority of cases, of full allocation to specified end uses, with monthly reports by the producers and consumers stating their stocks, production, and the end use to which the material was to be put. In this way it was possible for the Chemicals Bureau to ascertain the first use and at least one step beyond, an invaluable aid to programming. At first most orders were of an individual character, drawn to fit the needs of a particular chemical. In February 1944, after sufficient experience had been acquired, a general allocations order, M-300, was issued in order to promote uniformity. Thereafter, most individual orders were incorporated into this order as separate schedules. As of April 1945, there were in force 131 separate control orders and schedules of M-300, all of which have now been revoked. For a number of miscellaneous and special chemicals, Order M-340 provided military preference where necessary. General Imports Order M-63 con-

tained many chemicals in its schedules, providing a means for licensing and transfer of imports, and of implementing CRMB decisions.

RECONVERSION

Very few orders affecting chemicals now remain in force. Special cases which might be mentioned are rosin and cinchona bark, the latter to insure supplies of quinoidine, a drug still in short supply. Where it becomes necessary to insure military needs, materials can be moved from allocation control to the preferential restrictions of Order M-340, although this will result in shifting the burden from the buyer to the seller. Further protection exists in the application of the CC rating band of Priorities Regulations 28 and 29.

With the advent of military cut-backs, materials have become available for manufacture of new products and for research and development. There is a large reservoir of new developments which has been held back during the war, and which may be expected to absorb part of the existing facilities and labor force in the industry. Until the end of the year shortages in special fields, such as chemicals for protective coatings and certain insecticides, including nicotine and rotenone, may be expected to continue.

In general, the reconversion problem in the chemical industry is largely one of the disposition of surplus capacity and of finding new markets. Most chemical products are utilized in the same form for either war or peace. Producing plants do not have to be redesigned or shut down for changes in assembly lines or appearance of new models. Most products, except such things as explosives and war gases, will find ready use in the postwar period, although the volume of demand may be reduced.

It has been estimated that in the first full postwar year the expected production in the chemicals and allied products industries may be $5,900,000,000, as contrasted with $3,700,000,000 in 1939, and $8,300,000,000 in 1944.

CHEMICAL NITROGEN

Chemical nitrogen is a basic element of warfare and agriculture. Nitric acid is indispensable in the manufacture of practically all military and industrial explosives, nitrocellulose lacquers and films, and many organic chemicals. Ammonia going into fertilizer is needed to maintain the nitrogen requirements of cotton and food crops, and it is also important as a refrigerant.

Prior to Pearl Harbor, the OPM had recognized that in the light of defense needs, the long term outlook for increasing synthetic ammonia production was unfavorable. There was a scarcity of power-generating equipment and of high-temperature, high-pressure apparatus and compressors necessary to build new ammonia plants. Moreover, smokeless powder and TNT plants could be erected in 12 months or less, while it took from 15 to 20 months to complete an ammonia plant. Hence, recommendations were made to increase production (if necessary with Government funds) in order to meet indicated military needs, to limit exports, to import more Chile nitrate, and to install a system of priorities.

By October 1942, the huge expansion in synthetic ammonia production to meet the demands of the explosives program was under way. With nine commercial plants and one Ordnance unit already in operation, the Government had contracted for nine additional facilities, expected to come into operation in late 1942 and 1943. The rise in production is strikingly shown in the following table:

CHEMICAL NITROGEN

[Thousands of short tons of nitrogen content]

	1941	1943–44 crop year	1944–45 (estimated) crop year
Production:			
Government plants		536	606
Private plants	640	668	704
Total	640	1,204	1,310
Imports:			
Chile	98	96	160
Canada	72	92	101
Total	170	188	261
Exports	53	25	23
Consumption:			
Military	59	400	596
Agriculture	454	631	660
Industry	243	305	290
Total	756	1,336	1,546

Increased domestic production and imports from Canada and Chile made it possible to keep pace with fluctuating military demands and larger food production goals until 1945, when the needs of liberated countries for fertilizer were superimposed. This situation was relieved by the ending of the war.

The problem in the reconversion period is one of disposal of surplus capacity, some of which could be utilized for fertilizer, some converted to production of synthetic methanol, and some possibly kept in standby condition for future military use, or sold abroad. A wartime development was the application of excess ammonium nitrate for fertilizer use, a field where it has won acceptance.

INDUSTRIAL ALCOHOL

Even in normal times, alcohol was one of the most important industrial chemicals, with a long list of essential uses, such as anti-freeze, drugs, foods, paints, dyes, explosives, plastics, tetraethyl lead, and photographic film. The impact of war increased the demand for these products and still further accelerated the consumption of alcohol, which was used in enormous quantities in the manufacture of smokeless powder, chemical warfare gas, and synthetic rubber. Its extensive use in the war-born synthetic rubber industry eventually gave alcohol an importance far beyond expectations of the pre-Pearl Harbor period.

Because it can be made from either molasses or grain, alcohol was involved in heated controversies revolving around the surplus wheat and corn of the Middle West, the maintenance of a healthy economy in Cuba, and the provision of adequate sugar supplies for rationing to the population of the United States. Later, as supplies of raw materials became short, questions of subsidy to producers and of public purchase of molasses arose. The efforts to meet the demands for synthetic rubber after September 1942, when the Baruch report pointed out the urgency of providing butadiene for rubber from alcohol, as well as from petroleum, caused WPB to order all whiskey distillers to devote their entire output to war production. The ensuing liquor shortage subsequently resulted in the declaration of periodic "whisky holidays" to enable stocks to be restored.

The following table illustrates the tremendous expansion in production and the change in the consumption pattern from 1941 to June 30, 1945, together with Government stocks:

INDUSTRIAL ALCOHOL
Supply, consumption, and stocks, 1941–45

[Millions of Gallons]

	1941	1942	1943	1944	First half 1945
Supply:					
Industrial alcohol plants	217	177	203	284	111
Synthetic	43	50	56	60	29
From molasses and grain	(1)	127	147	224	.....
Beverage plants	.....	120	228	225	80
Foreign	.....	1	12	33	15
Total	217	298	449	601	235
Consumption:					
Direct military	18	46	40	27	15
Lend-lease	9	25	63	60	23
Synthetic rubber	.....	.....	126	330	155
Antifreeze	23	30	51	32	9
Indirect military and civilian	165	128	148	160	81
Total	215	229	428	609	283
Government stocks:					
End of year	.....	64	[2]87	81	84

[1] Not available.

[2] Stocks reached 138 million gallons in July, 1943.

Order M–30, adopted in August 1941, limited alcohol usage in order to conserve supply and build up a stockpile. The control was less rigid than an allocation system and required only that deliveries and acceptance be made under certain general regulations. There were no limitations on certain military agencies and specified uses. For other uses, quantities were permitted on the basis of a percentage of use in the fiscal year 1940–41.

Reconversion problems revolve about the disposition of the D. S. C. stockpile of about 84 million gallons, and disposal of surplus plants in projects having an aggregate capacity of some 80 million gallons per year.

NATURAL AND SYNTHETIC RUBBER

The natural rubber problem had assumed critical proportions even before the War Production Board was established. With the attack on Pearl Harbor, the United States was faced with loss of access to 90 percent of our normal rubber supplies. V–J Day still leaves us with a time lag of possibly several months before the flow of rubber from the Far East will be resumed. During the intervening 4-year period, the Board has participated with other national and international agencies in the spectacular development of a synthetic rubber industry the output of which in 1945 will exceed pre-1939 annual exports of natural rubber from all producing areas. This new synthetic industry has not only supported our own manufacturing industries at unprecedented levels of consumption but has contributed substantially to supplies for the rest of the world as well.

PREWAR STOCKPILING EFFORTS

First steps toward the accumulation of a stock pile of natural rubber in the United States were taken in June 1939, when a barter agreement was made with the United Kingdom for the exchange of surplus cotton for 90,505 long tons of natural rubber. In 1940, the Rubber Reserve Co. was created as a subsidiary of RFC, and on July 1 of that year, it announced an agreement with the International Rubber Regulation Committee (then in control of some 98 percent of the world production of natural rubber) under which the United States could acquire an additional 150,000 long tons for the emergency stockpile. Agreements negotiated over the next 18 months raised our potential purchases to a total of 800,000 long tons by the close of 1941.

Imports increased rapidly under the impetus of public plus private purchases, but the over-all stock position improved relatively slowly in the face of a strong upward trend in domestic consumption. Imports rose from 500,000 long tons in 1939 to 819,000 long tons in 1940, and to the peak annual figure of 1,029,000 long tons in 1941. Consumption climbed from the 592,000 long ton level of 1939 to 648,500 long tons in 1940 and to the prewar peak of 775,000 long tons in 1941. As a result, our net stocks, which had been down to 106,000 long tons in November 1939, had risen only to 533,000 tons by December 1941, the month of the attack on Pearl Harbor.

Additional heavy shipments before the fall of Singapore carried our national stocks to their peak level of 634,000 long tons as of April 30, 1942. From that point forward we were faced with a gradually dwindling stock of natural rubber, which had to be budgeted to last until synthetic production could be brought in to augment and gradually replace it. Hoarding was obviously not the solution, for curtailed production of needed military products at that time would simply have advanced the date at which we suffered the effects of this raw material shortage.

The problem was attacked simultaneously along at least five main fronts:

(1) Creation and expediting of a synthetic industry.

(2) Maximizing output and procurement from rubber-producing areas still accessible to us.

(3) Elimination of rubber consumption to nonessential items and curtailed consumption in permitted items.

(4) Conservation, through gasoline rationing, mileage limitations, and other devices, of the rubber "on the road" and otherwise in consumer hands.

(5) Expansion of reclaimed rubber production and its use as an extender to natural rubber.

THE SYNTHETIC RUBBER PROGRAM

The most dramatic aspect of the problem was the creation of a new synthetic industry. Without this eventual accomplishment, all other remedies could serve

merely to delay the final exhaustion of rubber supplies. With synthetic in sight, the other measures became invaluable aids in maintaining an unbroken flow of rubber products for the maximum war effort.

The original program called for the construction of plants to produce 40,000 tons of synthetic annually. The Pearl Harbor disaster quickly dispelled the idea of minimum commitments, and the original program was increased early in January 1942 to one of 400,000 long tons. The fall of Singapore and other considerations led to successive additions to the projected synthetic capacity during the first half of 1942 until the program goal stood at 877,000 long tons, comprised of 40,000 tons of neoprene rubber (including 9,000 tons of private capacity already in operation); 132,000 tons of butyl rubber, and an over-all production of 705,000 tons of Buna-S rubber. Of this total capacity of 877,000 long tons, 37,000 was to be located in Canada. This enlarged program had the sanction of the War Production Board and its full support as regards priority and allocation assistance necessary to expedite the facilities to assure production of a minimum of 350,000 long tons during the calendar year 1943.

An inter-agency committee representing the various government interests was set up to explore and resolve the issues involved in selection of processes, determination of relative costs and availability of alternative raw materials (alcohol vs. petroleum), selection of plant locations and sponsoring companies, scheduling of plant completions, estimates of requirements, and requests for allocation of essential construction materials.

Most controversial and troubling of the issues were those concerning the processes and the choice of raw material for butadiene production. These issues, highly technical in many aspects, would have been complicated enough in a leisurely peacetime economy with fully documented data on laboratory techniques, availability of basic raw materials, plant designs, and construction costs. To settle them in the face of erratic changes stemming from other phases of the war effort was even more burdensome and risky.

THE BARUCH REPORT

In a decisive move to cut through the involved tangle of opinion and divided counsel from experts and laymen and to emerge with a clear-cut action program, the President on August 6, 1942, appointed the Baruch Committee, with instruction to survey the whole rubber problem and to recommend such action as would "best produce the synthetic rubber necessary for our total war effort, including essential civilian use, with the minimum interference with the production of other weapons of war."

The recommendations contained in the committee's report extended to numerous aspects of the rubber problem. As regards the synthetic program, they called specifically for (1) carrying through without further alterations or substitutions the currently-approved plant construction program, (2) immediate authorization of 140,000 long tons additional of Buna-S (GR–S) capacity per annum, (3) immediate institution of a refinery conversion program to yield 100,000 long tons of quick butadiene in addition to quantities then planned, (4) immediate adjustment in the rates of construction of approved styrene and polymerization plants in order to obtain the maximum output of Buna-S in 1943, (5) expansion of the scheduled polymerization and styrene output by January 1944, to balance and increase the entire Buna-S program, (6) erection of additional alcohol capacity, (7) construction of additional neoprene plant capacity of 20,000 long tons per year, and (8) expansion of thiokol capacity by 36,000 tons to provide recapping material for civilian tires. Some other recommendations, including increased Buna-S capacity based on butadiene made from grain alcohol, were made contingent on the judgment of the Rubber Administrator in the light of developments during the ensuing 6-month period.

RUBBER DIRECTOR

To carry out the Baruch Committee recommendations, the President issued an Executive order on September 17, 1942, under which the full responsibility for the rubber program was lodged with the Chairman of the War Production Board, who was called upon to appoint a Rubber Director to whom he would delegate the task of administering the program, and all the powers necessary to carry through that task. Mr. William Jeffers was named promptly as the new Rubber Director.

The building and bringing into operation of a tremendous synthetic industry entailed difficult problems of scheduling and priority assistance. The primary construction program alone involved more than 50 plants to be designed, constructed, and placed in operation. A total of 49 rubber, chemical, petroleum, and industrial

669713 O - 45 - 7

companies now participate in their operation, under the supervisory direction of the Rubber Reserve Co. The estimated plant investment cost exceeds $700,000,000.

Upon the War Production Board fell the direct burden of providing priority assistance for vital construction materials, components, and the necessary chemicals, alcohol, and petroleum feed stocks. This burden involved the resolving of major conflicts with other high-priority war programs, especially the aviation gasoline program.

Upon this priority assistance hinged the rate of completion of the synthetic capacity and the early availability of synthetic rubber to supplement the declining stocks of crude. The Baruch report had set a minimum figure of 100,000 long tons of natural rubber as the danger level below which our stocks must not be allowed to fall. Long before that point was reached, synthetic had to be available for mixing with natural rubber. Without some natural rubber, synthetic could not be utilized for vitally needed heavy duty tires. The success of our synthetic program depended, therefore, not on the ultimate productive capacity to be attained, but on the early increments to output, the tonnage that could be produced in 1943.

RISING PRODUCTION

Actual 1943 output from both public and private facilities reached 231,599 long tons, well below the 350,000 tons for which priority help was solicited early in 1942, but above the minimum of 211,000 tons set by the Baruch Committee as essential to avoid a deficit in our natural rubber position. The end of 1943 found our stocks of natural rubber at 139,594 long tons, almost 40 percent above the danger line of 100,000 set by the committee.

By February 1944, production from synthetic plants exceeded the rate of natural rubber consumption in the United States in any year prior to 1941. During 1944, production totalled 762,630 long tons, and by the end of that year production was at the rate of approximately 900,000 long tons annually. The 1945 output is expected to approach 945,000 long tons. The scoreboard on synthetic production and natural rubber imports is shown in the adjoining table.

By mid-1944, the synthetic program was sufficiently in hand so that the Rubber Director felt it possible to recommend the abolition of the Office of Rubber Director. Its major operating functions were transferred to a Rubber Bureau established in the War Production Board on September 1, 1944, while responsibility for the production of synthetic rubber and related research and development was transferred to Rubber Reserve Co.

UNITED STATES RUBBER SUPPLY
Imports and Synthetic Production

Period	Natural imports	Domestic synthetic production
	Long tons	*Long tons*
1939:		
First quarter	113,844	(1)
Second quarter	112,280	(1)
Third quarter	113,646	(1)
Fourth quarter	159,846	(1)
1940:		
First quarter	174,885	(1)
Second quarter	176,160	(1)
Third quarter	221,596	(1)
Fourth quarter	245,983	(1)
1941:		
First quarter	247,929	1,466
Second quarter	229,286	2,151
Third quarter	206,772	2,445
Fourth quarter	265,020	2,321
1942:		
First quarter	207,631	3,459
Second quarter	45,735	5,221
Third quarter	11,472	5,722
Fourth quarter	17,815	8,032
1943:		
First quarter	19,962	10,486
Second quarter	13,746	28,373
Third quarter	9,035	71,217
Fourth quarter	12,109	121,523
1944:		
First quarter	18,302	159,603
Second quarter	29,516	198,905
Third quarter	27,772	193,602
Fourth quarter	32,114	210,520
1945:		
First quarter	45,267	227,865
Second quarter	29,886	237,857
Third quarter (estimate)	27,416	222,966
Fourth quarter (estimate)	31,612	256,051

[1] Not available.

NATURAL RUBBER

The spectacular achievement of creating a new synthetic industry should not dwarf the equally great

achievement of maximizing and conserving our natural rubber supplies and guiding the conversion of a war-mobilized, expanding rubber industry from a 100 percent natural rubber fare to one composed of more than 85 percent synthetic rubber.

With the fall of Singapore a reality, and further access to Far Eastern supplies impossible, the United States faced the necessity of exploiting to the limit such sources of supply as still remained accessible. These were limited, so far as plantation rubber was concerned, to Ceylon and India (both British-controlled areas), and the Firestone Plantations in Liberia. Together, these areas had a potential capacity at that time of about 125,000 long tons per year. The guayule production of Mexico and wild-rubber production in African and Latin American areas comprised the other possibilities of development.

An international division of responsibility for exploiting these possible sources was clearly needed, and the Combined Raw Materials Board provided such a cooperative set-up early in 1942. The United Kingdom was assigned primary responsibility for development and procurement in Ceylon, India, all Africa except Liberia, and certain minor Pacific Islands. The United States assumed responsibility for Liberia and all Western Hemisphere sources.

Within its sphere of development and procurement responsibility, the United States began early in 1942 the active stimulation of increased rubber production. Domestic guayule and cryptostegia projects were initiated. During the period March 1942, to October 1943, informal rubber agreements were negotiated with 16 rubber-producing countries of Latin America and with the Firestone Plantation Co. of Liberia. Responsibility for these agreements was shared by the Department of State and several of the agencies that have at various stages been vested with procurement and development responsibility, including the Rubber Reserve Company, Board of Economic Warfare, Rubber Development Corporation, and FEA.

The rubber agreements negotiated with Latin-American countries differed in detail, but provided generally that these countries would sell their exportable surpluses of natural rubber and rubber manufactured goods to the United States, for a fixed term of years at a fixed incentive price (far above normal prewar prices). They also set ceilings on the domestic use of rubber in the agreement countries. In return, the United States undertook to purchase all rubber made available and to aid and stimulate increased production through technical and financial help for development projects, involving transportation, health facilities, etc.

These agreements have been extended and modified at intervals, with many of them now in force extending as late as the middle of 1947. Output from the areas included was desperately needed to augment our natural rubber imports during the lean war years and must still be purchased at subsidized levels for some time to come.

DISTRIBUTION AND USE CONTROL

Basic controls over synthetic and natural rubber were instituted in the spring of 1941. Eventually these controls were superseded by WPB Rubber Order R–1, which is still in existence. This order extended detailed control over virtually all aspects of the distribution and use of both natural and synthetic rubber, reclaim rubber, scrap rubber, and even finished rubber products. The technical manufacturing regulations of the order provided a detailed blueprint for the mandatory conversions from natural to synthetic on an orderly industry-wide basis, with a minimum sacrifice of quantity and quality of end products.

The domestic distribution problem has always had to be attacked in terms of over-all long-range planning rather than a quarterly dividing up of available supplies among claimant agencies or uses. Because accumulated stocks have from the beginning of the war represented our major supply of natural rubber, there has never been a short-run physical shortage of raw material. Supplies have always been on hand to meet approved consumption needs. This fact, plus the integrated structure of the rubber and rubber products industry and the absence of any sharp cleavage between military and civilian type end products—notably tires—have all influenced the pattern of rubber controls.

In the early months of 1942, an inter-agency Rubber Allocation Committee was formed for the purpose of collating supply and requirements estimates and for cooperative budgeting of current consumption in the light of the long-range prospect. On the recommendation of this committee, a number of steps were taken to conserve and augment the supply of rubber, notably the establishment of a scrap rubber purchasing program under Rubber Reserve Co. in June 1942. It remained for the

Baruch Committee, however, to dramatize many of the issues and consolidate public opinion on them.

Prominent among the recommendations of that committee which were carried into effect were: (1) a program of civilian automobile tire conservation based on supervised recapping and replacement of tires to maintain cars in operating condition; (2) universal enforcement of a 35-mile-per-hour speed limit, compulsory tire inspections, and reduction in mileage to a national annual average of not over 5,000 miles per car; (3) Nationwide gasoline rationing to conserve tires; (4) immediate steps to increase by 20 percent the country's capacity to reclaim rubber from rubber scrap, and (5) continuation of the scrap collection drives and further protective measures for existing scrap stock piles.

In addition to these specific measures, the Rubber Director took steps to centralize within his office the functions of assembling and screening requirements for rubber, programming production of various end products, and controlling the release of both natural and synthetic rubber to meet the authorized production goals.

Allocation to claimant agencies was abandoned at an early date. Authorizations for monthly consumption in permitted uses were issued to rubber manufacturers, and releases from stocks were made in accordance with such authorizations and fixed inventory limits. Master production plans to meet estimated end products requirements were prepared and translated into rubber raw-material requirements on the basis of established specifications and conversion schedules. These served as a guide for approving consumption applications of manufacturers.

To facilitate the acceptance of synthetic rubber in place of natural and to avoid confusion and disruption of OPA price ceilings on rubber products, fixed selling prices of synthetic rubber were established at subsidized level of 18½ cents a pound, well under prevailing costs of production and below the 22½-cent price for natural rubber at that time.

One other major task that had to be accomplished during the latter half of 1943 and early 1944 was a general expansion of rubber processing facilities to take account not only of the increasing end product requirements but the greater time required for milling, mixing, and fabricating the new synthetic rubber. This facility expansion program called for extensive priority assistance from the WPB.

COMBINED RUBBER COMMITTEE

In order to maintain the close link between international and domestic controls necessary to maintain a going rubber economy for all the Allied Nations, there was created at this time, under the auspices of the Combined Raw Materials Board, a Combined Rubber Committee, consisting of representatives of the British and the United States sides of the Board and the Deputy Rubber Director who served as chairman. This committee has made recommendations to the Board with respect to all international allocations of natural, synthetic, and reclaim rubber since its establishment in January 1943.

By the beginning of 1945, the United States had achieved an over-all supply position in rubber which permitted consumption rates far in excess of any prewar year. Total domestic consumption of new rubber, which had dropped during 1941 and 1942 from a quarterly rate of about 200,000 long tons to a low of 92,000 tons in the last quarter of 1942, had not only been restored to prewar levels, but had risen some 10 percent above them. In addition, the quarterly export rate had risen from the trickle of 3,281 tons in 1939 to total exports of 23,653 tons in the first quarter of 1945.

This new abundance in rubber supply was predominantly in terms of the new synthetic output. Natural rubber usage had been sharply curtailed to less than 10,000 long tons per month. Our domestic consumption had by this date been converted to a basis of 85 percent synthetic to 15 percent natural rubber (table, p. 95).

The extent of conversion varied widely among end products; our passenger tires were 98 percent synthetic, while the heaviest truck and largest airplane tires still required up to 60 percent or more of natural. This residual technological dependence on natural rubber meant that our precarious supply outlook for that raw material persisted to the very end of the Japanese war. Forward demand estimates for 1945 and 1946 under the stepped-up military tire schedules for those years had indicated exhaustion of our reserve stocks during the first half of 1946.

V–E Day brought no easing of this situation; in fact, it increased United Nations capacity for tire-making and placed added demands on the world's natural rubber resources. V–J Day brought relief to the long-run balance sheet but did little to ease the position in the immediate postwar period.

UNITED STATES RUBBER CONSUMPTION

Period	Natural	Synthetic	Total
1939:	*Long tons*	*Long tons*	*Long tons*
First quarter	142,225	(1)	(1)
Second quarter	139,190	(1)	(1)
Third quarter	148,117	(1)	(1)
Fourth quarter	162,468	(1)	(1)
1940:			
First quarter	162,593	(1)	(1)
Second quarter	154,708	(1)	(1)
Third quarter	154,130	(1)	(1)
Fourth quarter	177,069	(1)	(1)
1941:			
First quarter	197,705	1,372	199,077
Second quarter	228,601	1,484	230,085
Third quarter	180,522	1,682	169,893
Fourth quarter	168,172	1,721	169,893
1942:			
First quarter	106,673	2,544	109,217
Second quarter	90,691	4,102	94,793
Third quarter	93,515	4,933	98,448
Fourth quarter	85,912	6,072	91,984
1943:			
First quarter	93,548	7,696	101,244
Second quarter	90,776	17,526	108,302
Third quarter	74,519	50,421	124,940
Fourth quarter	58,791	95,248	154,039
1944:			
First quarter	45,638	116,887	162,525
Second quarter	38,361	130,080	168,441
Third quarter	31,373	150,092	181,465
Fourth quarter	28,741	169,611	198,353
1945:			
First quarter	32,622	189,184	221,806
Second quarter	28,953	180,403	209,356
Third quarter (estimate)	23,894	167,469	191,363
Fourth quarter (estimate)	26,921	207,018	233,939

[1] Not available.

POST V-J DAY PROBLEMS

Military tire cut-backs have been very extensive since V–J Day, with future needs to be met from pipeline and stocks. However, the capacity released by such cut-backs will be largely absorbed by expanded output of civilian truck, bus, and passenger tires, with the result that there will probably be no significant reduction of natural rubber consumption in the fourth quarter of 1945. Indeed, total rubber consumption is expected to rise in 1946 well above any previous levels. This increase will, of necessity, be largely in synthetic rubber. GR–S, Neoprene, and N-type synthetics were freed after V–J Day for use in items long banned from the permitted list of rubber manufacturers. Butyl rubber, in demand for tubes, is still in limited supply. Natural rubber supplies will be adequate only under existing tight controls and usage limitations.

The progress of reoccupation and rehabilitation of Far Eastern rubber areas will be the determining factor as regards availability of increased supplies of natural rubber. Until such supplies are in sight, consumption must of necessity be held to the approximate level of new supplies from existing accessible areas. This means approximately the level of consumption that has been maintained during 1945. It is likely that there will be some shrinkage of our imports from Latin American areas as restrictions on their domestic consumption are lifted. The proposed maintenance of the manufacturing regulations and allocation controls of Order R–1 may serve to delay briefly the upward trend in consumption of natural rubber by preventing immediate depletion of stocks and by relaxing controls only when sufficient supplies are on hand to permit industry-wide reconversion in specified uses.

Present intentions are to retain the R–1 controls over natural rubber substantially unchanged during the immediate post V–J Day period. That means monthly allocations to manufacturers for specified end products; retention of manufacturing regulations governing the allowable percentage content of natural rubber in various end products; limits on inventory, etc. It means exclusive Government importation and maintenance of central distribution control through the Rubber Reserve Co. Price controls will be retained, but price levels may have to undergo revision.

So far as the national reconversion program is concerned, there seems no reason to suppose that shortages of natural rubber will interfere. The abundant supplies of synthetic rubber of various types will permit greater than prewar volume of all types of rubber products. Those projects may not, in every instance, be of prewar quality in the immediate post V–J Day period, but the proposed selective program of reconversion to natural rubber will soon repair any significant quality shortcomings. It is perhaps significant to note that potential temporary deficiencies of certain items like spare tires for new passenger cars stem from limiting factors other than the natural rubber shortage.

TRUCK AND BUS TIRES

Up to late 1943, there was no serious deficiency in truck and bus tire production. Facilities were more than adequate to process all the natural and synthetic rubber the industry could obtain, and the amounts provided were sufficient to prevent any acute shortage. Civilian vehicles had entered the war well shod, and with the help of rationing, all essential vehicles—and a good percentage of the less essential—were kept in service. Priorities took care of military needs.

Primary attention throughout the first two years the United States was at war was focussed on expansion of the synthetic rubber supply and development of the techniques for processing synthetic. The tire industry, for the most part, was left to solve its own problems as they arose. In mid-1943, when the progress of the synthetic rubber program promised to make adequate rubber supplies available, the industry on its own initiative, and without Government financing assistance, embarked on a $100,000,000 within-walls facilities expansion program.

By the end of 1943, however, it became evident that truck and bus tire production facilities would no longer be able to keep pace with requirements. Military needs were increasing rapidly and were heavily concentrated in the larger tires, which required more man-hours per tire and for which prewar demand—and consequently, prewar production capacity—had been relatively small. Furthermore, tires on the civilian buses and trucks of the nation were wearing out more rapidly after two years of subnormal replacement, and it was evident that by the summer of 1944, larger quantities would have to be provided to maintain domestic transport. Consequently, in December 1943, an allotment procedure for tires was set up for the first time.

Tire production, like all other phases of the rubber program, was at that time the responsibility of the Office of Rubber Director, which had been established in September 1942. While technically this office was a part of the War Production Board, the authority delegated to the Rubber Director was so broad as to make his office virtually an independent agency.

The December 1943 allocation, made by the Rubber Requirements Committee of the Office of Rubber Director, covered the first quarter of 1944. At that time, no effective mechanism had been set up for implementing the allotment decision, and the program was not successful. Military agencies in the first quarter of 1944 received only 75 percent of their allotments, while civilians received almost 125 percent. Pressures from the civilian economy for larger quantities of truck and bus tires were increasing, and in the absence of Government compulsion to adjust production patterns to include larger percentages of military types, it was difficult for tire producers to resist this pressure.

During the first quarter of 1944, therefore, attention was given to developing an improved plan of allocation, and the control mechanism necessary to enforce it. A control instrument was hastily drafted in January by the Office of Rubber Director and issued as Appendix IV to Order R-1. Its weaknesses were immediately apparent, and the chairman of the Rubber Requirements Committee appointed a task group representing the three largest claimants—Army, Navy, and ODT—plus representatives of the Office of Operations Vice Chairman and Office of Program Vice Chairman of WPB to revise it. The result was the amended Appendix IV, which came to be known as the Tire Allotment Plan.

TIRE ALLOTMENT PLAN

In brief outline, the tire allotment plan required claimant agencies to submit requirements and producers to submit production estimates for truck and bus tires in advance of each quarter, broken down in each case into six major size groups. Allocations were made separately for each group, and on the basis of these allocations, directives were issued to producers specifying the percentage of their shipments in each group which must go to (a) original equipment, (b) military replacement, and (c) nonmilitary replacement. "Military" was defined to include Army, Navy, Maritime, ARCO, and Lend-Lease. A certification and budgeting system was set up, and improved in subsequent quarters to keep track of the allotments. Just before the beginning of each quarter, producers reported unfilled capacity and claimants reported unaccepted orders to the Rubber Director, and a meeting was held at Akron to match up as many as possible.

This plan proved highly effective, though it was not without defects. The breakdown of truck and bus tires into six major groups was not sufficiently fine to permit

a close matching of requirements with reported capacity; within a group, military demand might greatly exceed mold capacity for some sizes, while there was no military demand for other sizes, and the percentage pattern, therefore, could not be adhered to. (Production estimates were based on the assumption of continuation of the order pattern on the manufacturer's books. This difficulty was later corrected by obtaining requirements and production estimates by major sizes within each group.) Moreover, the Office of Rubber Director had virtually unlimited directive power to change a producer's schedule, and in the early quarters this power was so extensively used as to change the original allocation pattern radically.

Evidence of the plan's immediate success was the report of second-quarter shipments, which showed that the overproduction for civilians of the first quarter of 1944 had been corrected.

SUPPLY AND REQUIREMENTS

While the Tire Allotment Plan improved distribution, it had no effect on the over-all shortage of truck and bus tires. All claimants came into the first quarter of 1944 with small deficits in 1943 deliveries. From then until the end of the war, production never caught up with total requirements (chart, p. 98).

Allotment requests mounted almost without interruption as deferred civilian needs began to pile up, the military services expanded vehicle programs and hence original equipment needs, and actuarial tables on tire life were proved to have underestimated tire mortality on the flak-saturated roads of Normandy and the coral beaches of the Pacific. Meanwhile, considerable difficulty was being experienced in increasing production. Manpower had been dissipated during the period of rubber shortage, and it became increasingly difficult to recruit men with the skill and brawn to build large tires. Synthetic rubber tires developed more internal heat than those of natural rubber, which made substitution of rayon tire cord for cotton cord necessary in heavy-duty tires, to keep the heat down; and rayon tire cord facilities had to be expanded to meet the new demand. When many of the problems had been licked, it turned out that carbon black, in adequate supply previously, was not available in sufficient quantities for the stepped-up tire program, and a carbon black expansion program had to be undertaken.

Despite the facilities expansion program of the second half of 1943 and a $14,000,000 program for "high flotation" military tires authorized in the second quarter of 1944, total truck and bus tire production in 1944 was only nominally above 1943, and in the most critical size group, A–3 (9-inch through 14-inch cross-section), shipments in 1944 were actually lower than in 1943, as the table shows:

TRUCK AND BUS TIRE SHIPMENTS

	Total A–1 through A–6	A–3—9-1 through 14-inch
1939	7,309,995	906,035
1940	8,170,978	1,147,407
1941	12,085,627	1,864,996
1942	12,621,403	2,838,817
1943	14,072,347	3,616,162
1944	14,649,499	2,699,486
1945 first half annual rate	20,201,210	4,242,836

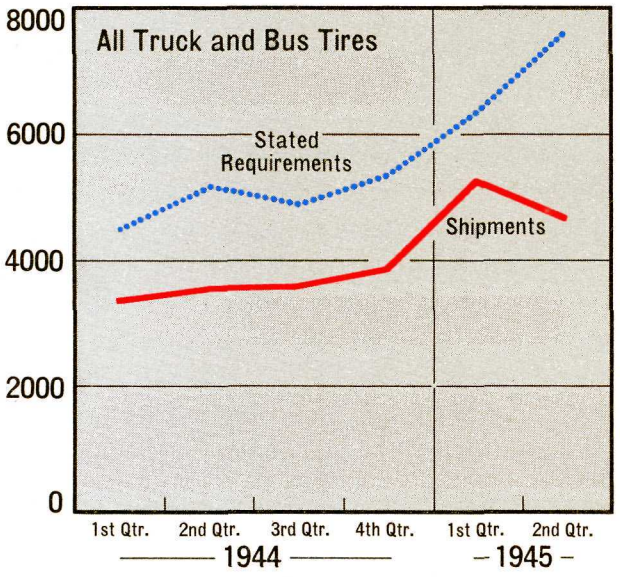
Toward the end of 1944, however, the seriousness of the tire shortage required drastic action. Late as it appeared to be in the war—the Battle of the Bulge was still a week or two in the future—it was decided to authorize a $155,000,000 expansion program. The War Production Board, Army, and Navy joined the War Manpower Commission in a concerted drive to channel manpower into tire plants. The Army furloughed about 1,300 experienced tire builders in the fourth quarter of 1944, and the Navy two or three hundred more. The tire labor unions signed a pledge to work a 7-day week for 120 days without a holiday.

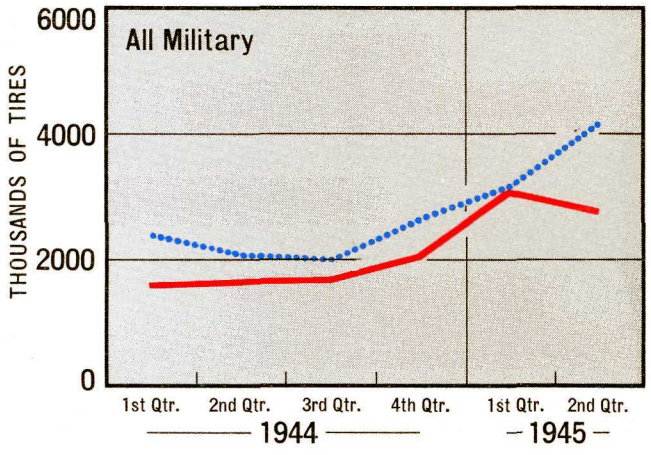
Chiefly as a result of the manpower drive, plus greater plant efficiency, shipments in the fourth quarter of 1944 were 300,000 tires above the third quarter. It was in the first quarter of 1945, however, that the real results of the efforts were seen. By that time, a little of the new equipment had been installed in bottleneck spots in tire plants, scheduling procedures had been improved, and the 7-day week was in full effect. Total truck and bus tire shipments mounted 1,400,000—more than 35 percent above the level of the previous quarter—and met 83 percent of the allotment requests, compared with 73 percent of the much lower requests of the fourth quarter, 1944.

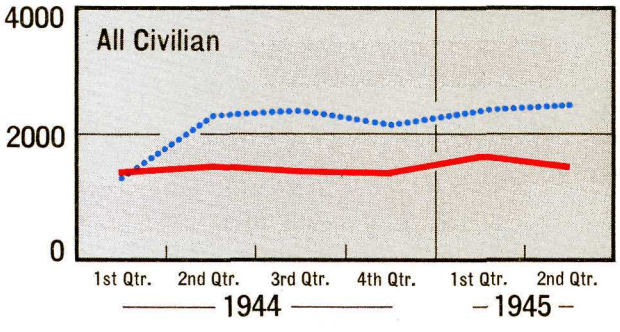
That was the high point in production. In the second quarter came a tightness in carbon black which led to

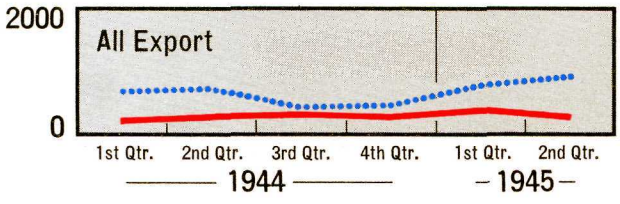
CRITICAL PERIOD IN TRUCK AND BUS TIRES

TOTAL (A-1 through A-6)

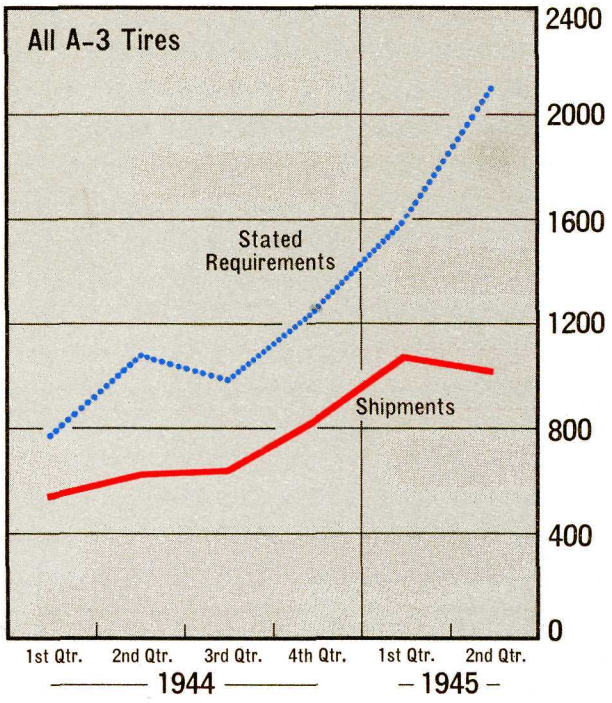


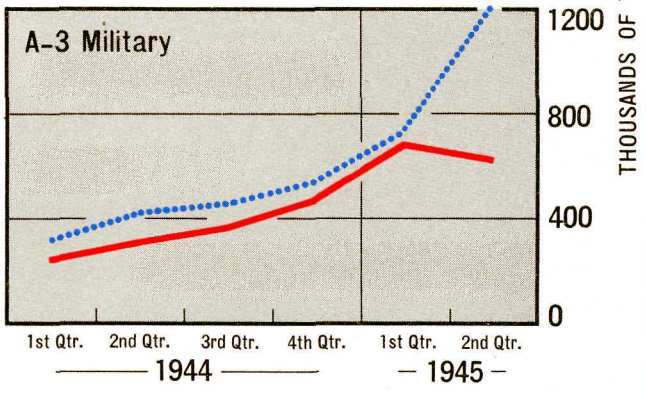


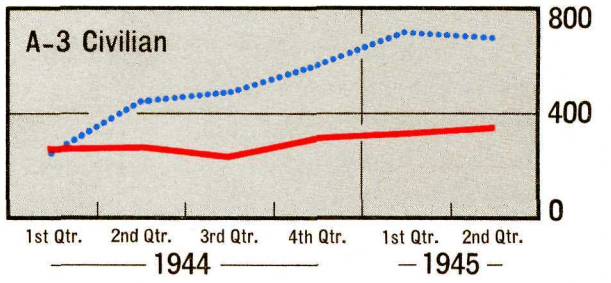


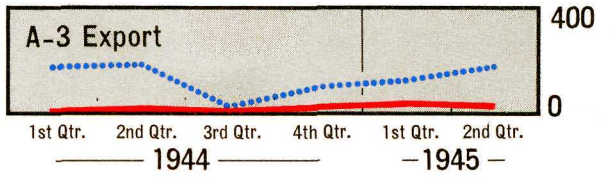


A-3 (9 inch through 14 inch)









partial abandonment of the 7-day week, and then the German collapse and a series of labor disturbances curtailed production even further. Additional labor troubles, further cuts in military orders before and since V–J Day, vacations, and shifts in the production pattern reduced third-quarter shipments sharply below the original expectations, but it is estimated that about four-fifths went to civilians, compared with less than one-third in the second quarter.

A LOOK AHEAD

Military demand in the fourth quarter will be negligible, and capacity for large tires has been so expanded that it is now more than adequate to take care of normal demand, once the accumulated requirements have been satisfied and inventories have been rebuilt. This will still take a few months, and rationing will have to be continued for a time. However, it is not expected that a shortage of truck tires will impede reconversion.

INTERNAL COMBUSTION ENGINES AND PARTS

The war brought a marked change in demand for internal combustion engines. In peacetime, the big production of such engines was in the passenger automobile plants, where a limited number of models was turned out on a mass-production basis. Capacity of the producers of "industrial" engines, manufactured for sale as engines, was limited. Their plants were operated as job shops, with limited runs of many different models and variations of those models, designed in most cases to fit specialized equipment rather than being offered as standard models around which equipment was designed.

It was not uncommon for the noncaptive engine producers to offer as many as 20 to 30 basic engine models, each with the alternative of four or five piston displacements, and with almost unlimited variations in specifications and accessory equipment—brackets here and there on the engine block for starters, oil filters, etc.; choice of downdraft or updraft carburetor of a number of different models; similar choices in electrical equipment; and any number of types of special accessories and parts. The parts producers who supplied these engine companies were forced to operate similarly on a job-shop basis; many of them also operated mass-production lines for the passenger car manufacturers, but these lines were not adaptable to the needs of the independent engine companies.

Wartime demands for engines of this job-shop type were heavy, far in excess of any peacetime sales. For some models, orders were large enough to necessitate mass production techniques, which had rarely been applied to engines of the size and power required for war uses. In addition to the engine demand, requirements for spare parts mounted explosively. Civilians, denied new engines, needed increasing quantites of spare parts to keep the old ones running. The military services needed large quantities of spares along with the engines, to stock depots and to provide for keeping in service equipment which could not receive normal peacetime care. As the number of engines in military service grew, replacement spare parts were likewise needed in increasing numbers. And military requirements tended to be overestimated—because of the lack of experience tables for guidance, because military maintenance people had to be given hurried training in stock control, and because it was not possible in the early stages to consolidate depot stocks of a given part which would fit two or more engines, so that separate inventories were maintained for each engine model.

STANDARDIZATION AND SIMPLIFICATION

In the early stages of the war, there was considerable debate about standardization and simplification of industrial engine models. Under Order L–254, models of air-cooled engines were simplified and standardized, and plants which before the war had turned out only 300,000 engines a year for washing machines, power lawn mowers, and similar uses produced in 1943 some 700,000 engines, ranging from small fractional horsepower to as much as 30 to 35 horsepower. These engines were used to heat pilots' suits at high altitudes, to provide electricity for military kitchens, antiaircraft searchlights, telephone and radio systems, and fire control of big guns, on sea and land; to power refrigerators for preservation of blood plasma and medical supplies; and to light ships

No such standardization and simplification program

was applied to liquid-cooled engines. Some models and model variations were ordered discontinued, but an extensive program along this line would have required redesign of trucks, construction machinery, farm equipment, industrial equipment, etc., built around existing models. Those who argued that the resulting delays in deliveries of these end-items would more than offset the advantages of standardization prevailed, and after order books of the engine makers had been loaded up, the argument became academic.

The wartime production record on engines was a good one. With the help of WPB-sponsored plant expansion and cooperative action from the armed services, production was built up in all engine types. The following table is illustrative; it excludes aircraft propulsion engines and slow-speed (under 750 r. p. m.) diesels used in big electric power plants and for ship propulsion:

INTERNAL COMBUSTION ENGINE SHIPMENTS

[In thousands of units]

Year	Liquid-cooled			Air-cooled (gasoline)
	Gasoline	Diesel	Total	
1940.....	559	63	622	[1] 300
1941.....	778	80	858	[1] 325
1942.....	1,210	109	1,319	[1] 350
1943.....	1,301	122	1,423	709
1944.....	1,793	152	1,945	675

[1] Estimated.

With the large production gains and the limitations on production of many types of engine-powered equipment, total engine production was approximately in balance with approved requirements. But throughout the war period, there were shortages in nearly all types of engines, and there was a constant demand for more and more engine parts.

In 1944, for example, production of liquid-cooled engines totaled 1,945,000 which was slightly in excess of WPB-programmed end-product requirements of 1,890,000, though short of the stated total requirements of 2,239,000. But in the larger engines—over 350 horsepower—programmed requirements were not met. The numbers were small in relation to total production—for example, 124,000 gasoline engines of 350 to 850 horsepower were produced, compared with 181,000 screened requirements. But the uses were urgent, and as a result, a further expansion program was initiated for the larger engines, and for parts for such engines, to be ready in mid-1945. The drop in military requirements came before the full benefit of this expansion had been felt.

SCHEDULING

Engines were used during the war for lift trucks, pumps, compressors, and other industrial equipment; for cranes, shovels, and tractors; for farm equipment, mining equipment, trucks; for logging and sawmill machinery; for power generation at Army bases and on ships; for propulsion of landing craft, amphibious vehicles, and other combat vehicles; for smoke generators and filtration units and refrigeration plants; and for countless other uses, military and war-supporting. Because of the wide variety of uses, distribution of internal combustion engines—and spare parts—was a difficult and continuing problem.

These engines were put under control of General Scheduling Order M-293 from the beginning of that order, early in 1943, and a wide variety of parts were also included. Scheduling was never a complete success—a balanced flow of parts could not be assured, and consequently engine production never came up to the levels of manufacturers' schedules—but it did serve to assure that the most urgent needs were met with minimum delays.

The failure to attain a well-balanced flow of components was due primarily to labor shortages in engine and component plants, plus the lack of close control over parts production and distribution and the emergency demands for spare parts, often requiring the robbing of production lines. At one time or another, there were difficulties with carburetors, fuel injection equipment for diesel engines, electrical equipment, cylinder liners, pistons, valves, ring gears, friction bearings, crankshafts, and many others. The worst problem of all was in engine block and head castings, where labor shortages consistently held production below demand.

The complexity of the problem, and the difficulties in scheduling, become clear when it is realized that the ordinary automotive-type engine has about 1,800 parts; that one of the larger industrial engine manufacturers will use 40,000 to 80,000 different parts numbers in its various models and designs. Thorough review of the

order boards of all manufacturers of critical parts at frequent intervals proved an impracticable job; one carburetor manufacturer alone submitted an order board which filled an entire drawer of a standard legal-size file cabinet. To assure sequence of deliveries in line with needs, dependence had to be placed on working with the engine producers to spot their shortages, as a basis for expediting action.

When the heavy new spare parts requirements of the Services for the final push of the war began to come in, late in 1944, a special expediting group was set up to supplement the efforts already being devoted to the problem, and this group was given broad powers under a special direction to Order M–293. Through the efforts of this group—the Engine Parts Coordinating Office—working in cooperation with the military services, parts production capacity was expanded, closer liaison was established with engine makers and parts producers through special WPB representatives in the plants, and shortages had been largely overcome by V–J Day.

With the coming of peace, the noncaptive engine producers find themselves with a greater production capacity than before the war, but it is altogether possible that this expanded capacity can be utilized at a high rate for a considerable length of time. There is a large accumulated civilian demand for these engines for replacements, and for many types of equipment in which the engines are used.

ANTIFRICTION BEARINGS

In the decade before the war, production of ball, roller, and needle roller bearings averaged around $100,000,000 annually. Output in 1939 was $94,800,000, of which at least half went to the automotive industry, and most of the rest to makers of electrical appliances, electric motors, and various other types of machinery.

The war more than quadrupled demand as these bearings found their way into combat planes, radar equipment, ships, tanks, and heavy guns; into civilian-type items produced in large volume during the war, such as farm equipment, locomotives, and other railroad rolling stock; into the machine tools and other machinery that went to make up the $15,000,000,000 of equipment installed in new wartime facilities; and into the repair and maintenance of all kinds of industrial and automotive equipment. The record is summarized in the following table of shipments, in millions of dollars:

ANTIFRICTION BEARINGS SHIPMENTS

Quarterly average		*Shipments by quarters*		
1939	23.7	1943:	Third	101.0
1940	35.8		Fourth	107.1
1941	57.9	1944:	First	114.2
1942	82.0		Second	109.5
1943	90.0		Third	99.8
1944	104.1		Fourth	93.0
		1945:	First	96.7
			Second	90.6

The increase in volume was complicated by the shift in demand from the types and sizes normally used. There was a marked increase in the small sizes (for use in aircraft, precision instruments, and electronic devices) and likewise in the very large sizes. Before the war, special aircraft bearings were produced in only negligible quantities, with the rest of the business about equally divided between ball and roller bearings. At the peak in the first quarter of 1944, aircraft bearings constituted 10 percent of the value of shipments, other ball bearings 53 percent, and other roller bearings, only 37 percent.

The problems in increasing bearing output paralleled those in other segments of war production, with bottlenecks first concentrated in facilities, then in materials, and then in manpower.

Facilities expansion during the war totaled about $100,000,000, of which roughly 65 percent was Government-financed. Most of the expansion was for aircraft bearings and small bearings. Because of the high skills and special knowledge needed in the industry, expansion was heavily concentrated in existing manufacturers' plants, with the eight largest companies accounting for 75 percent of the total; two large bearings users did, however, enter bearings production. Few entirely new plants were built, and the industry continued to be largely concentrated in the Connecticut Valley, Trenton, N. J., and Philadelphia areas, though there was some expansion around Chicago, Detroit, Indianapolis, and upstate New York.

With the expansions, facilities for bearings were ample to satisfy the war demand, but they could never be used

at capacity. This was partly due to varying demands for types and sizes, partly to materials problems, and partly to manpower shortages. At the most critical period, in late 1943, it was estimated that existing facilities could have produced 15 to 35 percent more bearings if enough manpower could be made available.

MATERIALS

The chief raw material for bearings is electric furnace alloy steel of high-carbon chromium and nickel-molybdenum types. Bearings races are made from forgings and tubing; the balls and rollers from wire or bar. During the period from early 1942 to the spring of 1943, shortages of alloy steel prevented full use of the new bearings facilities as they became available. High priority orders were filled, but there was not enough steel to permit the stockpiling of various sizes and types of bearings that could have prevented some of the critical shortages which developed in late 1943.

By the time CMP began to operate, expansion in alloy steel production and cut-backs in some competing requirements had eased the situation, and the essentiality of bearings was generally acknowledged. As a result, under CMP, antifriction bearings generally were allotted the full amount of alloy steel and other materials requested—about 90,000 tons a quarter.

MANPOWER

As materials ceased to be the limiting factor on production in mid-1943, manpower came to the fore. Bearings manufacture required a large amount of skilled labor, and a high proportion of the capacity was located in areas in which labor was very tight. Manpower recruitment was difficult in competition with the better-paid direct munitions industries. In the Connecticut Valley, for example, there was a constant competition for men with the big Pratt & Whitney aircraft engine plant at East Hartford and with other war plants.

In mid-1939 there had been only 17,000 production employees in the bearings industry. By the time of Pearl Harbor, employment was already up to 43,000, and it continued to climb. By the end of 1943, however, the gains stopped, with around 65,000 employees in the industry, and thereafter some losses occurred.

The increases were achieved in part by recruiting numbers of female employees, raising the percentage from 10 percent in 1939 to over 40 percent in early 1944. The industry was given top referral priority in the tight manpower areas in late 1943 and in addition attempts were made to ease the labor shortage by subcontracting to other areas on a limited scale. Few companies, however, could be found which were capable of conversion to bearings production.

DISTRIBUTION AND CONTROL

There are something like 35,000 sizes and types of antifriction bearings produced in the United States, about 5,000 of which are in common demand. While there are a number of standard sizes, which before the war were commonly manufactured for stock and sold off the shelf, the wartime jump in demand exhausted these stocks promptly and built up backlogs of orders, stretching out the procurement time far beyond the normal manufacturing cycle of about 90 days.

Planning was handicapped by the lack of accurate information on requirements. Changing military procurement programs and changes in specifications and designs for end products meant changes in bearings requirements, but insufficient information was available to translate end-product schedules promptly into bearings requirements. For the most part, it was necessary to calculate requirements on the basis of orders, but these were none too good an index because of duplicate ordering, failure to cancel orders promptly when requirements changed, and—particularly in the confused initial period of procurement—over-ordering of spares by the military services.

The formal controls placed on bearings by the War Production Board concentrated production of certain odd sizes of bearings in an attempt to prevent waste of effort in short production runs and established the mechanism for a limited scheduling of deliveries. Concentration under Orders L-145 and L-145-a did not embrace a large volume of production, but it did prevent some interruption of production by changing machine set-ups. Scheduling was accomplished under Orders E-10 and M-293, beginning in June 1943.

Under these orders, all companies were required to schedule 85 percent of their production for large orders and 15 percent for small orders, to protect small users. Unrated orders could not be accepted. By the first quar-

ter of 1944, 88 percent of orders shipped were rated AAA or AA–1, and less than 1 percent were shipped on ratings below AA–3. Purchasers were required to identify end use on orders and report percentages of spares. Inventories were limited to 60 days' stock. Large users were required to report their orders, inventories, production schedules, and the amounts of bearings needed to meet these schedules, and these procurement schedules were carefully screened.

Complete scheduling control in so complex a field was not attempted, but the scrutiny of orders of some 175 users who took 65 percent of all antifriction bearings, plus the 60-day inventory rule which held down purchases of small users, maintained a fairly high degree of control. There was never any over-all surplus, and occasionally munitions programs suffered delays because of bearings shortages, but demands were generally met.

OTHER CONTROLS

In addition to its general control orders, the War Production Board took a number of other steps to improve distribution of bearings. In late 1943, when the situation was most critical, all expediting activities were centered in WPB, and competitive expediting by the armed services was prohibited. This prohibition remained in effect until mid-1944. At the same time, the armed services were directed to reduce by 50 percent their purchases of concurrent spares for the period from December 1943 to June 1944, to stop the immobilization of large quantities of bearings in depot stocks. WPB worked constantly with the services on the improvement of inventory control and review of specifications, and on better utilization and salvage. Where excess inventories were discovered, the Board facilitated their redistribution into channels where they could be used.

POSTWAR PROSPECTS

Although the pattern of bearings types needed will change with reconversion, the expanded facilities of the industry should be able to turn out all that are needed, so that they are not expected to prove a bottleneck in the production of civilian goods. Shipments will, of course, drop off from the second-quarter level of $90,600,000, which was achieved by multiple-shift operation. It is expected that in 1946, production will average about $50,000,000 quarterly, half the 1944 rate but still double 1939 output and more than a third above 1940.

FRACTIONAL HORSEPOWER ELECTRIC MOTORS

Before the war, 90 percent of the fractional-horsepower electric motors produced in this country were installed in mechanized household appliances, such as washing machines, vacuum cleaners, refrigerators, stokers and oil burners, fans, etc. During the war, production of these small motors increased fivefold (in dollar value), and 90 percent of them went into the weapons of mechanized warfare. Fractional-horsepower motors and their derivatives—generators, dynamotors, inverters, amplidynes, and selsyns—were called for in increasing numbers for radio and fire-control equipment, and to provide extra muscles in tanks, in planes, and on shipboard. They opened bomb-bay doors, speeded the traverse of gun turrets, moved wing flaps and rudders, aimed searchlights and antiaircraft guns, and performed a thousand and one other military tasks. In a B–29 Superbomber, there are more than 300 individual fractional motors.

Military motors were, for the most part, quite different from the fractional motors of peacetime. They were direct current, rather than alternating, requiring quite different construction. They had to be smaller, lighter, and at the same time tougher and more powerful than those normally made. Each one required many more man-hours and a higher degree of skill; their cost would run to $50, $75, or even higher, as compared with the $5 or $6 apiece which the washing-machine manufacturer paid for his motors.

This meant a conversion job for motor manufacturers, accelerated sharply after Pearl Harbor and accompanied by extension of subcontracting and bringing in new facilities. The number of producers increased from 60 prior to the war to a peak of about 135.

In the early war years, production was handicapped not only by inadequate facilities but also by constant revisions in specifications, which meant continuing changes in production lines. The small motors had to be tailor-made to perform specific tasks, and new uses for them were constantly being developed. Such de-

velopment of new uses resulted in hasty placing of orders for large quantities, giving manufacturers inadequate lead time for procurement of such components as electrical sheet, magnet wire, ball bearings, and special castings. Motors, like a host of other products, faced recurring difficulties in obtaining adequate supplies of ball bearings and castings to meet their own schedules.

By January 1943, a backlog of 14 months' production had accumulated. As new facilities came into production, shipments gradually increased, and output of combat motors and generators soon stepped out ahead of new orders, to reduce the backlog. Output of AC motors, however, lagged behind requirements throughout the war. The record since the beginning of 1943 is indicated in the adjoining table.

When reconversion programs began to take shape in the spring and summer of 1944, the backlog of orders in the AC category increased, resulting in extended delivery promises and in some instances in accumulation of excessive inventories. To cope with this situation the WPB, in July 1944, adopted Order L–341 requiring users of more than 450 small motors per quarter to report past use, inventory, and requirements for succeeding quarters. This permitted quarterly review of advance authorizations and eliminated duplicate buying, unauthorized uses and excessive inventories. The order was revoked in July 1945 after requirements for combat motors had declined sharply and it became difficult to assess the relative urgency of the needs of reconverting industries. Consequently, in the third quarter, new orders for AC motors increased 58 percent over the preceding quarter.

Facilities are now rapidly being reconverted to increase AC motor output, but estimated production of 2,500,000 units in the fourth quarter of this year—25 percent higher than the annual rate in 1939—will barely meet expanding requirements.

To prevent maldistribution of this tight supply, the WPB plans to keep its inventory controls on motors in force until production catches up with demand. Shortages of silicon sheet steel, gray iron castings, and magnet wire are limiting factors which may prevent full utilization of manufacturing facilities, but by the second quarter of 1946, production is expected to reach a rate of 1,250,000 per month, double the 1939 rate.

FRACTIONAL HORSEPOWER MOTORS
Shipments vs. net new orders

[Thousands of dollars]

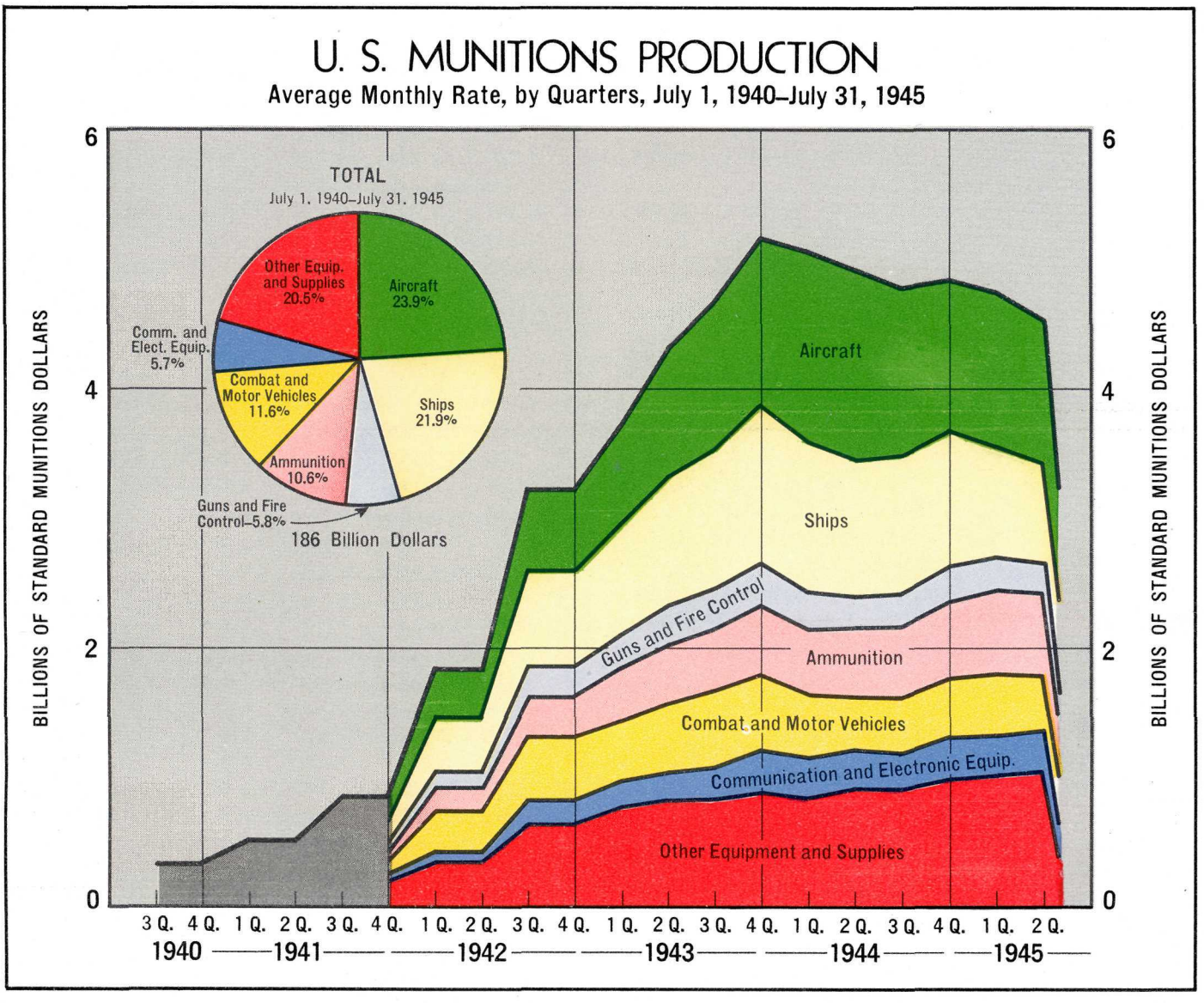
	Shipments	Net new orders
Total fractional horsepower motors and generators:		
1943:		
First quarter	79,094	76,361
Second quarter	94,382	71,995
Third quarter	101,809	88,517
Fourth quarter	98,704	102,195
1944:		
First quarter	102,330	112,111
Second quarter	110,593	129,035
Third quarter	116,901	93,531
Fourth quarter	114,672	62,460
1945:		
First quarter	111,396	149,263
Second quarter	106,230	72,873
AC fractional horsepower motors:		
1943:		
First quarter	10,544	13,846
Second quarter	12,290	17,816
Third quarter	12,635	20,411
Fourth quarter	13,746	20,445
1944:		
First quarter	16,131	26,526
Second quarter	17,789	26,165
Third quarter	15,234	23,908
Fourth quarter	17,137	26,704
1945:		
First quarter	18,535	23,522
Second quarter	19,910	40,865
Other than AC fractional horsepower motors:		
1943:		
First quarter	68,550	62,515
Second quarter	82,092	54,179
Third quarter	89,174	68,106
Fourth quarter	84,958	81,750
1944:		
First quarter	86,199	85,585
Second quarter	92,804	102,870
Third quarter	101,667	69,623
Fourth quarter	97,535	35,656
1945:		
First quarter	92,861	125,741
Second quarter	86,320	32,008

PRODUCTION OF SELECTED MUNITIONS ITEMS

July 1, 1940–July 31, 1945 (1945 preliminary)

[Millions of standard dollar weights]

Item	July 1, 1940, through December 1941	1942	1943	1944	Jan. 1, 1945, through July 31, 1945	Cumulative July 1, 1940, through July 31, 1945
Munitions, total	10,489	30,168	51,745	57,594	30,767	180,763
Aircraft	2,174	5,817	12,514	16,047	7,716	44,268
Ships	2,243	6,957	12,498	13,429	5,534	40,661
Guns and fire control	433	1,794	3,180	2,926	1,373	9,706
Ammunition	514	2,743	4,908	5,768	3,930	17,863
Combat and motor vehicles	1,523	4,778	5,926	4,951	2,942	20,120
Communication and electronic equipment	253	1,512	3,043	3,739	2,119	10,666
Other equipment and supplies	3,349	6,567	9,676	10,734	7,153	37,479



PRODUCTION OF SELECTED MUNITIONS ITEMS—Continued

July 1, 1940–July 31, 1945 (1945 preliminary)

ITEM	UNIT	July 1, 1940, through December 1941	1942	1943	1944	Jan. 1, 1945, through July 31, 1945	Cumulative July 1, 1940, through July 31, 1945
Aircraft:							
All military airplanes and special purpose aircraft	Number	23,240	47,836	85,898	96,318	43,137	296,429
	Airframe weight (1,000 lbs.)	94,966	275,949	654,616	962,441	486,304	2,474,276
Total combat	Number	11,106	24,864	54,077	74,135	35,157	199,339
	Airframe weight (1,000 lbs.)	68,151	216,419	548,674	825,794	413,827	2,072,865
Bomber	Number	4,738	12,627	29,355	35,003	15,042	96,765
	Airframe weight (1,000 lbs.)	45,958	162,492	422,942	609,229	298,131	1,538,752
Heavy, long range	Number	0	0	92	1,161	2,188	3,441
	Airframe weight (1,000 lbs.)	0	0	4,426	55,835	105,696	165,957
Heavy, 4-engine, medium range	Number	357	2,576	9,393	14,884	3,767	30,977
	Airframe weight (1,000 lbs.)	7,541	60,916	224,189	353,522	89,788	7,359,576
Patrol	Number	441	890	2,340	1,840	1,288	6,799
	Airframe weight (1,000 lbs.)	6,100	14,186	35,639	31,943	24,768	112,636
Medium	Number	483	3,270	5,411	5,228	1,586	15,978
	Airframe weight (1,000 lbs.)	6,251	42,803	75,519	72,648	21,252	218,473
Light	Number	3,457	5,891	12,119	11,890	6,213	39,570
	Airframe weight (1,000 lbs.)	26,083	44,589	83,187	95,288	56,627	305,774
Fighter	Number	5,578	10,769	23,988	38,873	19,478	98,686
	Airframe weight (1,000 lbs.)	20,183	48,808	121,850	215,536	113,079	519,456
2-engine	Number	211	1,323	2,246	4,733	2,010	10,523
	Airframe weight (1,000 lbs.)	1,587	10,462	18,349	42,902	19,085	92,385
1-engine	Number	5,367	9,446	21,742	34,140	17,468	88,163
	Airframe weight (1,000 lbs.)	18,596	38,346	103,501	172,635	93,994	427,072
Reconnaissance	Number	790	1,468	734	259	637	3,888
	Airframe weight (1,000 lbs.)	2,010	5,119	3,882	1,029	2,617	14,657
Total transport	Number	696	1,984	7,012	9,834	4,135	23,661
	Airframe weight (1,000 lbs.)	4,967	18,248	55,496	113,618	66,997	259,326
Heavy	Number	8	116	536	1,865	1,959	4,484
	Airframe weight (1,000 lbs.)	295	2,667	12,605	45,080	46,806	107,453
Medium	Number	365	1,236	2,906	4,927	1,431	10,865
	Airframe weight (1,000 lbs.)	3,730	14,051	33,978	59,715	17,586	129,060
Light	Number	323	632	3,570	3,042	745	8,312
	Airframe weight (1,000 lbs.)	945	1,531	8,919	8,826	2,605	22,826
Total trainer	Number	11,167	17,631	19,939	7,577	1,247	57,561
	Airframe weight (1,000 lbs.)	21,486	39,293	47,061	19,060	3,267	130,167
Total communication	Number	271	3,174	4,377	3,691	1,983	13,496
	Airframe weight (1,000 lbs.)	362	1,870	2,957	2,649	1,671	9,509
Total special purpose aircraft	Number	0	183	493	1,081	615	2,372
	Airframe weight (1,000 lbs.)	0	119	428	1,320	542	2,409

PRODUCTION OF SELECTED MUNITIONS ITEMS—Continued

July 1, 1940–July 31, 1945 (1945 preliminary)

Item	Unit	July 1, 1940, through December 1941	1942	1943	1944	Jan. 1, 1945, through July 31, 1945	Cumulative July 1, 1940, through July 31, 1945
Naval ships (new constructions).[1]	Number	1,344	8,035	18,434	29,150	14,099	71,062
	Thousand displ. tons	270	847	2,562	3,223	1,341	8,243
Combatants	Number	47	128	537	379	110	1,201
	Thousand displ. tons	162	431	1,402	1,047	518	3,560
Landing vessels	Number	995	[2] 6,902	[2] 16,005	27,388	13,256	64,546
	Thousand displ. tons	8	[2] 211	[2] 706	1,513	467	2,905
Patrol and mine craft	Number	111	715	1,156	590	189	2,761
	Thousand displ. tons	12	117	199	160	44	532
District craft	Number	182	235	543	521	395	1,876
	Thousand displ. tons	39	43	94	128	122	426
Auxiliaries and other	Number	9	55	[3] 193	272	149	678
	Thousand displ. tons	49	45	[3] 161	375	190	820
Total Maritime Commission ships.	Number	136	760	1,949	1,786	794	5,425
	Thousand DWT	1,551	8,090	19,296	16,447	7,855	53,239
Standard cargo	Number	77	49	156	124	73	479
	Thousand DWT	757	444	1,519	1,209	772	4,701
Emergency cargo	Number	7	597	1,238	826	369	3,037
	Thousand DWT	72	6,402	13,361	8,927	3,994	32,756
Liberty	Number	7	597	1,238	722	122	2,686
	Thousand DWT	72	6,402	13,361	7,798	1,314	28,947
Victory	Number	0	0	0	104	247	351
	Thousand DWT	0	0	0	1,129	2,680	3,809
Other dry cargo (excluding AKA).	Number	15	14	36	94	138	297
	Thousand DWT	148	89	124	392	642	1,395
Standard tankers	Number	37	62	252	229	120	700
	Thousand DWT	574	999	3,481	3,739	1,954	10,747
Military types	Number	0	19	125	375	90	609
	Thousand DWT	0	63	330	1,928	492	2,813
Transport attack, APA	Number	0	0	7	141	26	174
	Thousand DWT	0	0	44	775	122	941
Cargo attack, AKA	Number	0	0	0	52	32	84
	Thousand DWT	0	0	0	355	140	495
Other military	Number	0	19	118	182	32	351
	Thousand DWT	0	63	286	798	230	1,377
Other types	Number	0	19	142	138	4	303
	Thousand DWT	0	93	481	252	1	827

[1] Excluding small, rubber, and plastic boats.

[2] Excluding Maritime-constructed LST's—15 in 1942 and 60 in 1943.

[3] Excluding 2 Maritime-constructed APA's.

669713 O - 45 - 8

PRODUCTION OF SELECTED MUNITIONS ITEMS—Continued

July 1, 1940–July 31, 1945 (1945 preliminary)

Item	Unit	July 1, 1940, through December 1941	1942	1943	1944	Jan. 1, 1945, through July 31, 1945	Cumulative July 1, 1940, through July 31, 1945
Army guns and equipment:							
Heavy field artillery (complete equipment).	Number	65	647	2,660	3,284	1,147	7,803
Spare cannon for heavy field artillery.	do	0	0	323	3,601	4,321	8,245
Spare recoil mechanisms for heavy field artillery.	do	0	0	120	2,035	1,882	4,037
Light field and antitank guns.	do	4,705	20,536	19,096	7,685	4,345	56,367
Tank guns and howitzers	do	6,787	43,368	34,711	19,991	11,735	116,592
Guns for self-propelled carriages.	do	0	8,811	13,155	2,981	2,113	27,060
Bazooka rocket launchers	do	0	67,428	98,284	215,177	95,739	476,628
Mortars	do	9,518	10,983	25,781	24,842	39,224	110,348
Heavy	do	2,508	6,242	10,176	10,722	7,790	37,438
Light	do	7,010	4,741	15,605	14,120	31,434	72,910
Machine guns	do	87,172	662,331	829,969	798,782	302,798	2,681,052
Heavy	do	57,563	347,492	641,638	677,011	239,821	1,963,525
Light	do	29,609	314,839	188,331	121,771	62,977	715,527
Submachine guns	do	216,811	651,063	686,410	347,463	186,192	2,087,939
Rifles (excluding carbines)	do	357,496	1,425,926	2,723,696	1,400,608	616,898	6,522,624
Carbines	do	5	115,813	2,959,336	2,088,697	886,000	6,049,851
Pistols and revolvers	do	71,854	322,830	843,236	1,016,931	489,744	2,744,595
Portable flame throwers	do	23	2,799	5,676	21,059	10,660	40,217
Gas masks	do	3,761,730	4,286,525	9,002,634	6,813,754	2,712,654	26,577,297
Helmets (ground)	do	324,000	5,001,000	7,649,000	5,704,000	3,940,000	22,618,000
Naval guns:							
5-inch and over	Complete assemblies	213	966	1,912	3,363	1,239	7,693
3- and 4-inch	do	317	2,505	6,593	4,652	218	14,285
20-mm, 40-mm, and 1.1-inch.	do	915	31,833	51,626	45,710	12,547	142,631
Army ammunition and bombs:							
Ground artillery ammunition.	Short tons	57,476	678,203	799,850	1,447,016	1,262,140	4,244,685
Heavy field, weight	do	42,949	303,895	274,529	507,584	637,155	1,766,112
Light field, tank, and antitank, weight.	do	14,527	374,308	525,321	939,432	624,985	2,478,573
Heavy field, rounds	Thousand rounds	873	6,209	5,537	9,668	11,285	33,572
Light field, tank, and antitank, rounds.	do	2,165	70,881	86,025	85,639	48,985	293,695
Mortar shells	Short ton	1,974	35,002	70,928	141,729	125,876	375,509
Bazooka rockets	Thousands	0	155	1,945	7,422	5,700	15,222
Small arms ammunition	Million rounds	1,177	9,798	19,800	6,578	4,232	41,585

PRODUCTION OF SELECTED MUNITIONS ITEMS—Continued

July 1, 1940–July 31, 1945 (1945 preliminary)

Item	Unit	July 1, 1940 through December 1941	1942	1943	1944	Jan. 1, 1945, through July 31, 1945	Cumulative July 1, 1940, through July 31, 1945
Army Ammunition and Bombs—Continued							
Land mines	Thousands	0	1,332	11,420	9,155	2,347	24,254
Grenades, all types	do	1,222	15,977	24,981	40,654	27,136	109,970
Aircraft bombs (Army and Navy).	Short tons	45,000	630,000	1,548,000	1,953,000	1,646,000	5,822,000
General purpose and demolition.	do	42,000	493,000	1,005,000	956,000	1,068,000	3,564,000
Incendiary	do	0	38,000	176,000	407,000	235,000	856,000
Fragmentation	do	0	10,000	67,000	453,000	289,000	819,000
Armor piercing and other.	do	3,000	89,000	300,000	137,000	54,000	583,000
Naval ammunition:							
Gun ammunition and rockets.	do	35,192	100,589	277,300	524,058	408,932	1,346,071
Surface fire	do	15,659	38,082	65,724	168,056	126,967	414,488
High capacity	do	0	2,286	32,897	105,421	101,973	242,577
Armor piercing	do	15,049	23,185	21,055	39,229	13,022	111,540
Common and special common.	do	245	9,922	6,128	12,746	2,362	31,403
Illuminating	do	365	2,689	5,644	10,660	9,610	28,968
Antiaircraft	do	19,533	62,090	202,951	292,213	147,751	724,538
Rockets	do	0	417	8,625	63,789	134,214	207,045
Torpedoes, all types	Number	2,319	4,524	15,599	24,015	6,804	53,261
Depth charges	do	17,152	140,886	147,340	169,652	53,915	528,945
Marine mines	do	41,380		45,054	24,516	5,507	116,457
Combat and motor vehicles:							
Tanks	do	4,203	23,884	29,497	17,565	11,184	86,333
Armored cars	do	0	191	9,067	5,509	1,671	16,438
Scout cars and carriers	do	7,883	16,892	37,977	18,874	6,817	88,443
Tank chassis for self-propelled guns.	do	0	3,100	9,035	2,934	949	16,018
Trucks	do	208,034	647,342	648,404	620,532	331,652	2,455,964
Heavy-heavy (over 2½ tons).	do	9,108	24,593	39,872	55,306	31,857	160,736
Light-heavy (2½-ton)	do	64,975	190,779	202,994	230,645	149,485	838,878
Medium (1½ and under 2½-ton).	do	50,136	148,753	141,912	87,468	22,143	450,412
Light (under 1½ tons)	do	83,815	283,217	263,626	247,113	128,167	1,005,938
Tractors	do	111	14,886	34,250	47,356	23,184	119,787
Communication and electronic equipment.	Million dollars	253	1,512	3,043	3,739	2,119	10,666
Radio	do	122	823	1,471	1,393	608	4,417
Radar	do	49	365	913	1,430	974	3,731
Other	do	82	324	659	916	537	2,518
Field and assault wire (included in "Other").	Thousand miles	226	906	968	1,608	1,555	5,263

PRODUCTION OF SELECTED MUNITIONS ITEMS—Continued

July 1, 1940–July 31, 1945 (1945 preliminary)

Item	Unit	July 1, 1940 through December 1941	1942	1943	1944	Jan. 1, 1945 through July 31, 1945	Cumulative July 1, 1940, through July 31, 1945
Other equipment and supplies:							
Clothing (Army):							
Boots, service combat	Thousand pairs	0	147	605	12,653	12,940	26,343
Drawers, cotton shorts	Thousands	27,041	36,121	32,940	46,658	34,660	177,420
Jackets, field M–1943	do	0	0	275	7,470	5,263	13,008
Trousers, wool serge, olive drab	do	9,351	10,487	13,669	8,673	10,227	52,407
Overcoat, wool melton, olive drab	do	2,705	5,857	5,025	538	1,786	15,911
Socks, wool, light and heavy	Thousand pairs	38,368	29,651	60,606	73,212	57,933	259,770
Equipage (Army):							
Bag, wool sleeping	Thousands	0	0	253	5,749	2,819	8,821
Blanket, wool M–1943	do	8,528	13,706	15,265	5,983	8,512	51,994
Tent, squad M–1942	do	0	0	18	229	506	753
Tent, shelter-half	do	203	11,299	3,621	3,803	5,746	24,672
Medical supplies (Army):							
Atabrine tablets	do	[1]	[2] 97,900	1,317,500	2,171,752	834,000	4,421,152
Sulfadiazine tablets	do	[1]	135,994	675,697	463,306	306,565	1,581,562
Sodium penicillin (100,000 oxford units)	Thousand ampules	[1]	[1]	[2] 72	10,276	12,621	22,968
Navy clothing:							
Shoes, leather, black, low	Thousand pairs	845	3,229	6,351	10,206	4,825	25,456
Overcoat, kersey	Thousands	297	1,017	1,601	1,331	475	4,721
Drawers, nainsook, shorts	do	3,728	11,085	28,664	23,231	26,732	93,440
Trousers, blue	do	761	2,237	5,017	3,232	828	12,075
Jumper, blue dress	do	401	850	2,264	2,163	530	6,208
Shirts, chambray	do	857	5,203	12,757	19,063	15,246	53,126

[1] Not available.

[2] Fourth quarter.

U. S. GOVERNMENT PRINTING OFFICE O—1945