

UNITED STATES DEPARTMENT OF LABOR

Frances Perkins, Secretary

BUREAU OF LABOR STATISTICS

Isador Lubin, Commissioner (on leave)

A. F. Hinrichs, Acting Commissioner



Post-War Capacity and Characteristics of the Construction Industry

Prepared in the

DIVISION OF CONSTRUCTION AND PUBLIC EMPLOYMENT

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Contents

	Page
Summary.....	1
Factors governing capacity.....	3
Organization of the construction industry.....	4
Plant facilities of the industry.....	6
Availability of machinery and equipment.....	6
Requirements for machinery and equipment.....	9
Building materials and related products.....	11
Supply situation, by types of building materials.....	12
Sand, gravel, and crushed stone.....	12
Brick, structural tile, and related products.....	12
Cement.....	13
Lumber and related products.....	14
Millwork.....	18
Steel.....	18
Miscellaneous iron and steel products.....	20
Builders' finish hardware.....	20
Plumbing supplies.....	21
Heating supplies.....	22
Electrical supplies.....	23
Lighting fixtures.....	24
Domestic appliances.....	24
Construction labor.....	26
Measures to facilitate post-war construction.....	27

Letter of Transmittal

UNITED STATES DEPARTMENT OF LABOR,
BUREAU OF LABOR STATISTICS,
Washington, D. C., August 19, 1943.

The SECRETARY OF LABOR:

I have the honor to transmit herewith a report on post-war capacity and characteristics of the construction industry.

A. F. HINRICHS, *Acting Commissioner.*

HON. FRANCES PERKINS,
Secretary of Labor.

**Bulletin No. 779 of the
United States Bureau of Labor Statistics**

[From the MONTHLY LABOR REVIEW (May 1944) with additional data]

**Post-War Capacity and Characteristics of the
Construction Industry¹**

Summary

RAPID expansion of construction activity is commonly expected to provide a major source of employment opportunity in the post-war period. By 1943 construction expenditures (adjusted for the 1940 cost level) had already dropped from the 1942 peak of almost \$11,500,000,000 to approximately \$5,900,000,000, as a result of the enforced curtailment of all nonessential construction as well as the completion of major war construction programs. Although the 1943 total was the lowest since 1938 and, until Germany is defeated, further reduction is expected, the total is not expected in any event to fall below \$3,000,000,000 at 1940 costs.

The accumulating demands for construction raise the question of the productive capacity of the construction industry in the post-war period. In the appraisal of the industry's post-war capacity given in this article it was assumed that Germany would be defeated before Japan and that reduced military requirements during the Asiatic phase of the war would permit the extensive release of industrial plant and a corresponding reduction in the war use of materials. It was further assumed that the factors governing the selection of establishments for total or partial release would include (1) their importance in the civilian economy and (2) their importance in industrial preparation for the post-war period.

On the basis of these assumptions it appears that the productive capacity of the construction industry can expand rapidly and, within a year after the end of the war with Japan, can reach an annual rate of \$11,000,000,000 at the 1940 level of building costs. The characteristic flexibility in the organization and methods of operation of the construction industry permits a rapid expansion in the volume of work; members of the industry are accustomed to starting work on short notice and to expanding their operations rapidly.

Construction equipment is now sufficient for a rate of at least \$12,000,000,000 per year, and is likely to remain so. Its age and condition will present some difficulties during the early months after the war if no prior improvement is possible, but will not restrict volume. During the period when hostilities continue against Japan only, repair parts and replacement machines will probably be produced in considerable quantity for civilian buyers. Within a short time after the defeat of Japan these will be available in any desired quantity. The construction-machinery industry expanded its operations for the war effort to a rate which, if maintained after military purchases

¹ Prepared in the Bureau's Division of Construction and Public Employment by Alexander C. Findlay.

cease, would replace the entire civilian inventory within approximately 2 years.

Productive capacity for all types of building materials, except plumbing fixtures and lumber, is sufficient for a construction rate of \$15,000,000,000 per year. In the lumber industry, the plant limitation is logging equipment, which is badly deteriorated but can be restored rapidly; sawmill capacity is sufficient. Capacity for plumbing fixtures is adequate for a construction program of \$12,000,000,000 per year, with likelihood of expansion before this rate is reached.

Reconversion is a problem only as regards metal products, and varies considerably in importance among them. If reconversion is started after war requirements are completely met, it should be finished within 6 months for all products except electric refrigerators; for many products reconversion should be well advanced, if not completed, within 3 months or less. If, as is more likely, reconversion is started soon after the defeat of Germany and extended progressively as cancellation and reduction of military orders permit, the reconversion process will extend over a much longer period but will be closer to completion at any specific date than if no start were to be made until the end of the war.

Resumption of civilian manufacture, with or without reconversion, will in some cases require official action regarding Government-owned machinery. In some plants this is so interspersed with privately owned machinery that there is no productive entity except for governmental orders.

Inventories of many materials are virtually exhausted. With civilian production resumed at the end of the war, it would take 6 months to restore such commodities to basic working volume and variety, and another 6 months to approximate their pre-war level. The problem is the most serious for electrical supplies. Expansion of civilian production during the interim period after Germany's defeat will ease the inventory situation greatly, and for most materials will probably mean that inventories can reach at least a basic working level by the end of the war. The rate of inventory accumulation will, however, be governed more by current expectations regarding sales volume and price level than by considerations of capacity, particularly in the case of such materials as lumber for which prices have increased sharply. Both manufacturers and dealers will be hesitant to accumulate large inventories if major price decreases seem likely.

There will be keen competition among materials, especially since pre-war usages have been modified so greatly in order to conserve critical materials. Some war-expanded industrial capacity will probably be used for increasing the output of building materials formerly produced only in small amounts. Some products introduced during the war are likely to be improved considerably and reduced in price, and a few other products are scheduled for introduction early in the post-war period. Beyond question, however, building materials on the whole will be very similar to those of the recent past, and subsequent changes in the entire building-material pattern will be gradual.

Little change in buildings themselves is anticipated. Designers will have somewhat greater choice of materials, and there will be an increasing range and acceptance of factory-made assemblies ready for installation. At the same time, revolutionary changes in design or materials are most unlikely.

On the whole, personnel will be sufficient for expanded manufacture of building materials and related products. Before demobilization of the armed forces, reduction or termination of war orders will release workers. Many of those released will have skills useful in the manufacture of building materials. Because of the specialization of factory work and the feasibility of brief training courses, other necessary jobs can be filled by workers with little or no experience.

For increased lumber production, however, additional skilled woodsmen are essential. These have been lost in great numbers, both for military service and for work in shipyards and airplane plants.

The personnel situation for construction proper is difficult to predict. It will be controlled to some degree by the demobilization pattern of the armed services and war industry, in conjunction with the extent to which construction skills have been acquired in military service and in war employment. Available information indicates that, within a year after the end of the war, the number of construction workers will be sufficient for a construction rate of \$11,000,000,000 per year at 1940 costs.

Unbalanced prices of building materials can be a serious hindrance to production and the accumulation of inventories. Unduly low prices will discourage production. On the other hand, possibility of inventory losses on items for which price reductions seem likely will discourage the piling up of inventories. Competition among various materials and products would probably correct the price situation ultimately, but in the meantime the post-war construction program might be needlessly delayed.

Unless the situation is changed before the end of the war, the most serious obstacle to rapid expansion of the construction industry is likely to be lack of preparation on the part of owners, including private corporations and public agencies. The rate of expansion will also be affected greatly by construction costs. These considerations and others related to demand will be discussed in a later report forecasting volume.

Factors Governing Capacity

The construction industry is subject to wide cyclical and seasonal fluctuations. After the previous war construction expenditures rose gradually and were sustained at a level of approximately \$11,000,000,000 per year² for the 5 years from 1925 through 1929. This was followed by a period of rapid decline to approximately \$3,000,000,000 in 1933. The downward trend was reversed in 1934, but improvement was gradual and even as late as 1940 the total was below \$7,000,000,000. The war construction program brought expenditures to a peak of almost \$11,500,000,000 in 1942. The tapering off of this program and shortages of materials for other construction reduced the 1943 total to approximately \$5,900,000,000.

These changes in volume as well as the changes in proportions of privately and publicly financed projects shown in the accompanying table have been considered in evaluating the factors governing the industry's physical capacity for resuming activity in the post-war period. The great changes in relative volumes of different types of work have also been considered. The following four types of supply

² To permit approximate comparisons of physical volume, all expenditure figures were converted to 1940 cost levels.

factors are analyzed in the sections which follow: Organization and method of operation of the construction industry, its plant facilities, supplies of building materials and related products, and availability of construction labor.

New Construction Expenditures in Continental United States, 1920-43¹

Year	Expenditures (in millions of dollars) at current cost levels ²			Expenditures (in millions of dollars) converted to 1940 cost levels ³		
	Total	Private	Public	Total	Private	Public
1920.....	5,791	4,458	1,333	5,488	4,379	1,109
1921.....	5,380	3,841	1,539	5,974	4,547	1,427
1922.....	6,814	5,158	1,656	8,239	6,582	1,657
1923.....	8,341	6,744	1,597	8,221	6,844	1,377
1924.....	9,263	7,402	1,861	9,733	8,122	1,611
1925.....	10,154	8,046	2,108	10,763	8,863	1,900
1926.....	10,697	8,584	2,113	11,274	9,345	1,929
1927.....	10,739	8,371	2,368	11,279	9,109	2,170
1928.....	10,382	7,976	2,406	10,794	8,569	2,225
1929.....	10,337	7,926	2,411	10,689	8,346	2,343
1930.....	8,207	5,430	2,777	8,647	5,928	2,719
1931.....	6,225	3,648	2,577	7,132	4,307	2,825
1932.....	3,523	1,729	1,794	4,772	2,387	2,385
1933.....	2,416	1,200	1,216	2,979	1,568	1,411
1934.....	2,965	1,479	1,486	3,272	1,761	1,511
1935.....	3,357	1,908	1,449	3,864	2,291	1,573
1936.....	4,904	2,730	2,174	5,473	3,188	2,285
1937.....	5,545	3,507	2,038	5,647	3,656	1,991
1938.....	5,248	3,162	2,086	5,370	3,264	2,106
1939.....	6,035	3,530	2,505	6,541	3,968	2,573
1940.....	6,986	4,232	2,754	6,986	4,232	2,754
1941.....	11,135	5,251	5,884	10,790	5,283	5,507
1942.....	13,544	2,877	10,667	11,487	2,437	9,050
1943 ⁴	7,353	1,606	5,747	5,899	1,228	4,671

¹ Includes all new construction—building, highway, utility and other—performed on contract or by force account, but not construction performed on work-relief projects; includes alterations and additions, but not maintenance or minor repairs.

² Estimates for the years 1920 through 1938 derived from estimates of Bureau of Foreign and Domestic Commerce, U. S. Department of Commerce, by omission of certain maintenance expenditures. Estimates for the years 1939 through 1943 made by Bureau of Labor Statistics.

³ Conversions of data in first 3 columns to 1940 cost levels made separately for each major type of construction by use of cost index for construction of that type. These conversions subject to revision after further study of construction cost levels.

⁴ Preliminary.

Information was secured from published sources and, especially in the case of the current status and post-war changes necessary for specific industries, through interviews with officials in governmental agencies, trade associations, and companies manufacturing building materials and equipment.

ORGANIZATION OF THE CONSTRUCTION INDUSTRY

The construction industry has been made up principally of general contractors,³ special-trade contractors,⁴ and builders.⁵ Their method

³ General contractors construct all or the major part of buildings and other structures on contract for owners. They sublet part of the work to special trade contractors, and usually execute the work of one or more major trades themselves. Their field of operations is divided into buildings, highways, and heavy construction, with most contractors engaging in only one of these divisions.

⁴ Special-trade contractors perform the work of a single trade (or two or more related trades, such as roofing and sheet-metal work) on buildings and other structures. This work is done for the general contractors in some cases, and in other cases directly for the owners.

⁵ Builders construct buildings (usually residential) initiated on their own account, for sale or for investment, and assume the coordinating responsibilities of general contractors on such projects.

of operation has prepared these three groups for rapid expansion. Prefabricators were a small element in the field prior to the war, but have since expanded their activities greatly.

Operations of both general contractors and special-trade contractors are characterized by great flexibility. The normal operation of any firm consists of a series of separate projects, each with its own distinctive pattern of work to be done and site conditions, and each marked by fairly rapid expansion to peak activity. Production must be governed by contracts on hand and readiness of related work at the construction sites. Any production during dull periods in anticipation of future contracts is obviously impossible for site work, and is severely limited as regards items manufactured by the special trade contractors in their shops because most of these are made to individual measurements. There are major seasonal variations in the total volume of construction, caused mainly by weather conditions, and very great cyclical variations.

The contractors as a group have adjusted their manner of operation to these conditions by maintaining much higher flexibility of employment than is customary in most other fields. The general procedure is to reduce to a nuclear organization when necessary, retaining foremen and a few carefully selected workmen for such work as can be obtained, or even laying these off when the firm has no work. The contractors are prepared to expand within a very short time—a few days, if necessary—by hiring workmen, foremen, and even superintendents, as needed.

Each project is a distinct entity, for which a working force must be assembled at the site. As the structure progresses, the number of mechanics, helpers, and laborers for the various trades changes continually in response to the changing pattern of work to be done. On most jobs, requirements for machinery and equipment change similarly. Under these circumstances, the starting of one or more projects by a contractor who has been idle scarcely differs from the starting of additional projects when he is busy, except that he must hire all the site workers instead of transferring some from work approaching completion.

According to the 1939 Census of Construction, there were more than 35,000 general contractors and more than 176,000 special-trade contractors, of whom 14,900 and 14,500, respectively, received contracts or performed work totaling \$25,000 or more during that year. The organization and method of operation of these contractors will permit them to expand their operations in response to any predictable increase in demand.

The builders differ from contractors in that they initiate construction, rather than perform work authorized by others. Under nonwar circumstances most of their projects consist of one-family houses built for immediate sale, and the projects built for rent have commonly been intended for ultimate sale as investment properties. In any event, operations have been carried on only when a quick and profitable market was expected, and in general have not been continuous. Promotional building has commonly been conducted as part of a dual enterprise or as a side line, which need not yield a continuous income.

One of the principal requirements for a successful builder has been ability to evaluate and respond quickly to the potential market. The

work itself can be started or expanded on short notice, ordinarily within a very few days after financing arrangements have been made, because land is usually available without further preparation, there are many local contractors capable of doing the work which is to be sublet, and usually stock plans and materials are used, with or without minor variations. Since rapid expansion has been the customary response to favorable sales conditions, the builders' rate of expansion may be expected to match the demand for promotional structures.

Prefabrication⁶ was such a small part of total construction prior to the war that it may be regarded as a new element in the industry. Its wartime growth, stimulated by a combination of favorable circumstances, has been phenomenal. Extensive changes in organization and in manner of operation are to be expected among the prefabricators, and it seems most unlikely that all present firms will remain in the field. Those remaining will be sufficient for the effective demand for buildings of this type during the early post-war years.

PLANT FACILITIES OF THE INDUSTRY

The plant facilities of the construction industry are made up of a wide range of items, within the following major classifications:

Permanent shop equipment, in reality factory equipment, used by the special-trade contractors in fabricating materials which they later install. The prefabricators' plant may be regarded as belonging in this classification.

Miscellaneous field equipment, consisting of motor trucks, air compressors, scaffolding, ladders, work benches, space heaters, certain power-operated hand tools and a great variety of other items.

Construction machinery proper, consisting mainly of larger power-operated units and of numerous supplementary items.

The distinction between the second and third classifications is somewhat arbitrary. In general, the construction-machinery industry regards its field as including equipment for moving or processing bulk materials used in construction, along with supplementary items except trucks.

Availability of Machinery and Equipment

Shop equipment.—The permanent shop equipment of the special-trade contractors has been affected only slightly by the war. Little of it has been suitable for war work other than fabricating materials for war construction or closely similar work. It will therefore be available when needed without reconversion. As in most competitive fields, the firms have generally provided shop capacity for the volume of business which they expected to attain. Hence, within any area of operation, capacity of all shops for a given trade has ordinarily been ample for the peaks of construction activity.

Prefabricators have multiplied shop capacity greatly during the war because of governmental purchases of prefabricated units for war housing projects. Current factory capacity is at least 165,000 houses⁷ per year, and a number of firms plan post-war expansion which would increase this rate to at least 200,000 houses per year. Whether or not these plans are carried out, it is apparent that in plant equip-

⁶ Prefabrication as here used means the assembly of structural elements (floors, walls, partitions, roof) prior to erection, for complete buildings to be permanently attached to land. Thus it excludes manufacture of trailers and other portable units. It could, but ordinarily does not, include some degree of pre-erection assembly of plumbing, heating and electric work. It may be carried out in a temporary plant near the construction site (on-site prefabrication) or in a permanent factory (off-site or factory prefabrication).

⁷ This figure excludes trailers, "huts," tent houses, and nonresidential buildings.

ment the industry is prepared for increased public acceptance and more effective distribution channels.

Field equipment.—Miscellaneous field equipment, other than motor-trucks, will likewise present few problems. Some of it is extremely durable, some of it can be improvised, and much of it consists of items which individually are simple and can be manufactured quickly. Manufacture of many items for civilian use has been virtually stopped, so that civilian inventory has been wearing out. Nevertheless, the total amount and condition of this equipment is sufficient for the post-war construction activity permitted by other supply factors.

The situation with respect to trucks is less definite. Since the construction industry has operated only a small part of all trucks, changes in the total national inventory do not warrant conclusions regarding this industry.

The types of trucks used in construction include almost all those manufactured, but most of them are medium (gross weight over 9,000 pounds, but less than 16,000 pounds) or heavy (gross weight 16,000 pounds or more). For many types of construction the larger heavy-duty trucks with power-operated dump bodies are especially important, and for some types of work off-the-highway models are needed.

Production of trucks of all capacities for civilian use was greatly reduced during 1942 and then virtually discontinued, followed later by limited resumption. A considerable quantity of trucks in manufacturers' and dealers' stocks was subsequently released to private buyers and governmental agencies, but these were only a small part of a normal year's output and a disproportionately small number were of heavy-duty types.

Meanwhile production rates for light trucks (gross weight under 9,000 pounds) and medium trucks have been reduced from pre-war figures, while the rate for heavy trucks has been increased well above any peacetime figure, because of military requirements. Since much of the output for military purposes has mechanical features or equipment which were relatively uncommon in civilian production, a considerably larger number of civilian trucks can be produced with the same facilities and manpower. Furthermore, the increased production of heavy units has brought changes toward mass-production methods which are likely to mean a permanent increase in the capacity of existing plants.

No real reconversion will be involved in a change from military to civilian production of medium and heavy trucks, although designs differ substantially. A reduction in military requirements will therefore permit prompt expansion of output for civilian users, if material and manpower conditions permit. It seems likely that such expansion will occur after Germany is defeated, and possibly even earlier. Whenever expansion comes, however, construction and related industries will have to share the output with others.

Trade inventories of new trucks are very low. That situation will mean some delay until shipments are received, but will not be a serious obstacle to distribution. There will be military inventories of relatively new trucks in this country at the end of the war, but because of special designs only a minority of these will be suitable for construction and related uses.

Construction machinery.—The output of the construction-machinery industry in 1943—valued at approximately \$700,000,000—was the

highest in its history. Deflation for minor price increases gives a valuation, at 1940 prices, of almost \$650,000,000, which is more than twice the previous peak. Even greater production is expected in 1944.

Although figures cannot be presented, it may be stated that a large part of the current output of construction machinery is purchased by the Army, the Navy, and other Governmental agencies for direct war use. All but a negligible percentage of this consists of standard models suitable for construction use, although the distribution by type and size differs from the pre-war pattern.

The civilian inventory of construction machinery proper has been reduced during the past 2 years. Private purchase of new machines has been severely limited, and the inventory of privately owned units has been bought in considerable quantity by the Government, largely through recapture.³ An incomplete inventory taken by the War Production Board, as of March 15, 1943, listed 310,000 pieces of all descriptions in civilian ownership, from which the Board estimated the total as 450,000 pieces. Other information indicates that this estimated total may be somewhat low, and is certainly not too high.

No information on construction machinery was obtained in the 1939 Census of Construction. Because of differences in the extent of coverage of different types of equipment, the inventory does not permit an estimate of the number of units of each type. There are, however, numerous indications that all types are available. One indication is found in the classified advertising section of an engineering magazine which for many years has been the principal advertising medium for used construction machinery and equipment. In recent issues the space occupied by items offered for sale greatly exceeded that for items wanted, the ratio being in some issues as high as 20 to 1. The items offered for sale included those bought and recaptured by the Government in largest quantities—power shovels, cranes, tractors and tractor-powered units such as bulldozers.

Total valuation, when new, of privately owned machinery is estimated by persons in the industry at \$1,300,000,000. An independent estimate made by the Bureau of Labor Statistics by an entirely different method gives almost the same figure. To this should be added at least \$400,000,000 for trucks and \$250,000,000 for miscellaneous equipment, giving a total inventory of \$1,950,000,000 for all construction equipment.

The WPB tabulation shows that more than a third of the machinery was produced before 1930, approximately a quarter from 1930 through 1937, and more than a third from 1938 through 1942. It is thought that the average age of the machinery is probably less than indicated, because of more complete reporting of older units. The age distribution of different items varies considerably. Some machines are in poor condition, and some are of obsolete designs, but they are not junk; all are at least potentially usable. Most items are basically of great durability, and although certain parts are subject to severe wear, the units can be kept in service almost indefinitely by adequate repairs with rebuilding at longer intervals. This process is not profitable indefinitely, especially for items which are becoming obsolete, but during any temporary shortage of specific items it permits use of

³ "Recapture" is the purchase of machinery or other equipment for which rent has been paid. It occurs ordinarily at the option of the purchaser, by payment of the difference between total rent which he has paid and the agreed value of the unit involved, or automatically and without further payment when total rent payments reach a stipulated figure.

machines which under other circumstances would be scrapped. Feasibility of this procedure is shown by the long-standing practice in the construction-machinery trade of rebuilding deteriorated units for sale. It is noted that machinery manufacturers in recent advertisements have started to emphasize the satisfactory service obtained by users of rebuilt machinery.

However, it seems likely that military need for construction machinery and other products manufactured by the industry will be reduced after Germany is defeated. Use of the released facilities to produce replacement parts freely for civilian buyers would facilitate greatly their preparedness for postwar construction work. The greatly expanded capacity of the industry makes it seem likely that complete new machines will also be available to some appreciable extent during this interim period. If so, there will be at least limited opportunity for increasing the total civilian inventory, less post-war need for temporary use of obsolete units having low productivity, and reduction in the rebuilding of obsolete and badly deteriorated units.

Moreover, the construction-machinery industry is practically intact, and small as well as large companies are busy. On conclusion of the war it could operate at a rate which would replace all existing machinery within approximately 2 years. It will, of course, be able within a few months to produce replacement parts sufficient for rebuilding of deteriorated machinery.

An additional favorable factor is that although most machinery now being purchased by the Government is for ultimate use overseas, it obviously cannot be shipped directly from the factory to the point of use. Consequently, there is at any time a substantial quantity of unused machinery in the distribution channels of the owning agencies within this country and to some degree at primary distribution points abroad. It seems most unlikely that machinery which has been used abroad in conjunction with combat activities or for rehabilitation will be returned to this country. However, that remaining in primary depots abroad and that within military distribution channels in the United States at the end of the war will be modern new machinery, available for such use as may be officially authorized. Prompt release of these items to civilians by sale or even by rental would permit immediate replacement of the oldest and most deteriorated units in the private inventory. The extent to which this measure will be advisable will depend on the production of parts and complete machines for civilian buyers after the defeat of Germany. The unused military inventory can also be lent to contractors for use on publicly financed projects, and provided to governmental units for their construction and maintenance work.

Requirements for Machinery and Equipment

The machinery and equipment needed for a given dollar volume of construction vary greatly with the type of work. Most compilations on the subject are misleading because comparisons are made with work actually performed, uncorrected for extensive idle time between contracts. In addition there are uncertainties about the valuations used, and about the equipment items included.

For highway construction, equipment having a value, when new, of 15 percent of a full season's completed work is sufficient, with some margin for unfavorable conditions. This estimate was made

by a civil engineer with many years of highway experience, who has acted as equipment consultant to numerous road contractors and as a consultant on special problems to State highway departments. It assumed capable planning of operations resulting in efficient use of equipment, continuous work throughout the season with no idle time between contracts, reasonable proximity of successive projects, and average weather. The ratio varies for different kinds of highway work, but does not exceed 15 percent for any. This figure was regarded by the engineer making the estimate as providing a sufficient margin for unfavorable conditions to be applicable to a complete program, although it may be insufficient for some individual projects. This ratio means that a highway program of \$3,000,000,000 per year would require machinery and equipment having new value of \$450,000,000.

Heavy construction (dams and reclamation work, tunnels, dredging, etc.) is commonly regarded as requiring only slightly less equipment than highway work for the smaller projects, although of course the distribution among types of equipment is considerably different. A partial compilation made by a prominent trade association, of work of this type done by some of its members, indicates that a ratio of 15 percent is sufficient for this type of work. For the largest projects, using specially designed installations of machinery and equipment, the ratio is higher—approximately 25 percent. For heavy construction as a whole, a reasonable ratio is 20 percent. Thus a heavy-construction program of \$3,000,000,000 per year would require machinery and equipment costing \$600,000,000.

Building construction requires very much less equipment than do either of the other major fields. Mechanization is most extensive in the bulk operations, such as excavation, concrete work, and hoisting of materials, but these constitute a minor part of the total work at the site. The remainder is largely hand work, in which mechanization does not extend beyond a limited range of power-operated hand tools. The new value of equipment needed on building construction is not more than 5 percent of a year's contracts for the entire range of work, provided there is continuity of work to keep it in efficient use. A large part of this equipment consists of trucks and nonmechanical items such as scaffolding, outside the field of construction machinery proper. A building-construction program of \$6,000,000,000 per year would require construction equipment costing \$300,000,000.

A total program of \$12,000,000,000 per year in the three subdivisions of construction would require machinery and equipment with new value of \$1,350,000,000. The new value of that likely to be on hand at the end of the war is estimated at \$1,950,000,000, plus any additions which may take place after the defeat of Germany. The difference would provide a margin for some shortages in individual items not revealed by over-all figures, and for lower productivity of some of the older equipment. However, a construction rate of \$12,000,000,000 per year will not be attained immediately on conclusion of hostilities, probably not for much more than a year at the least. The period until post-war construction reaches a sustained volume will be sufficient for overcoming shortages of individual items and for replacement of equipment to whatever extent the construction industry believes necessary.

BUILDING MATERIALS AND RELATED PRODUCTS

Post-war limitations on the supply of building materials will in general be temporary, caused by reconversion and inventory problems rather than by more permanent circumstances. When these are overcome, the supply of all materials except plumbing fixtures and lumber will be sufficient for a construction program of \$15,000,000,000 per year. The productive capacity for plumbing fixtures will permit a program of \$12,000,000,000 per year, with appreciable likelihood that this capacity will be increased rather promptly. The lumber supply will be restricted for a time by shortages of logging equipment and skilled woods labor, but these should be overcome without serious delay.

Availability of building materials in the quantities and varieties needed will be governed by four principal factors, although not all of these represent problems for all materials. These are productive plant (reconversion, restoration, and pre-war capacity), trade inventories, supply of basic materials, and labor supply.

Reconversion will be a problem only for the fabricated metal products, and for these its importance is roughly proportional to the degree of fabrication. It is less serious than seems to be generally surmised. For most materials reconversion will be well advanced, if not completed, within 3 months after it is started and for all except electric refrigerators will be completed in 6 months.

Restoration of physical plant will be essential for logging operations, if output is not to fall seriously. Trucks, tractors, and tractor-operated equipment have had exceedingly hard service in getting out logs for war use, replacements have been available in only the most limited quantities, and there has been a serious shortage of repair parts. Trucks and other equipment will be needed for gravel-pit operations, although the need there will be considerably less urgent than for lumber. For other materials, little physical replacement of plant will be necessary.

For some of the more highly complicated products, removal of legal barriers will be necessary. The larger companies engaged in the more complex manufacturing operations are those which have converted most completely to war products. This conversion has been accompanied by mixture of company-owned and Government-owned machinery in single plants, with the result that in such plants no complete production entity exists, except for war products. Resumption of civilian manufacture in these will be impossible until some provision is made for removal or use of the Government-owned machinery.

Some persons primarily concerned with reconstruction in Europe and China believe that the demand for building materials may be so great as to create a world-wide shortage. Further information is needed before an appraisal can be made as to whether essential foreign rebuilding may limit building activity in the United States. It would seem, however, that export requirements will be greatest for lumber and considerably less for those products for which productive capacity abroad can be expanded by construction of additional factories near the areas of consumption.

Wartime depletion of inventories has been serious for lumber and for fabricated metal products. The time required for restoration will be greatest for those types of materials, such as electrical supplies,

which consist of a great number of different items. Production and purchase for inventory purposes may be hindered by uncertainty regarding future price levels, in the case of those materials the prices of which have increased most sharply.

All statements and forecasts made by representatives of the building-materials industry regarding ability to proceed with peacetime production were predicated on availability of materials as needed. Any delay, whether from failure to modify wartime restrictions promptly or from other causes, will retard the entire construction program.

These statements and forecasts were also predicated on the availability of workmen as needed. In general, this assumption is unchallenged. The industries extensively converted to war products, primarily those producing or using metals, are in most cases operating at higher employment levels than before the war. Their problem will be little more than that of shifting employees between departments or products, and in many cases not even that change will be necessary. Some manufacturers think that experienced production workers temporarily promoted to supervisory positions in the manufacture of war products may be dissatisfied with their former work, but this should not be a serious difficulty. Workers with skills useful in the manufacture of building materials will be released from other war plants, and inexperienced workers can be used for many factory operations.

For lumber production, however, there has been a serious shortage of capable woods labor for which corrective measures are necessary.

SUPPLY SITUATION, BY TYPES OF BUILDING MATERIALS

In the sections which follow, the pertinent facts are stated separately for each major type of building materials. Numerous minor products were omitted from the study, but these are of limited importance. It seems reasonable to assume that any difficulties which they present will be considerably less serious than those presented by the materials included.

Sand, Gravel, and Crushed Stone

Sand, gravel, and crushed stone are local products having no inventory or reconversion problems, and for which productive capacity is enormous. Some replacement of crushers, screens, and conveyors will be necessary, and some operators will probably want to rebuild their plants when machinery is readily available. Additional trucks will also be needed. These needs will not reduce production below the volume that can be sold.

Brick, Structural Tile, and Related Products

Present capacity of brick and tile is equal to the largest recorded consumption as measured in "brick equivalent."⁹ If necessary, this can be increased by 15 percent, without additional facilities, by changes in operating schedules and minor rearrangements at plants where capacity has not been utilized fully by past schedules. No recon-

⁹ "Brick equivalent" is a unit of volume, equal to the volume of a standard common brick.

version is involved, but capacity production will require reopening of several hundred plants now shut down because of reduced consumption. These are for the most part in good condition, and can be reopened whenever it seems likely that the product will be salable. Inventory is of minor importance, except for products used in small quantities. Plants producing common brick, face brick, and structural tile are well distributed throughout the country. Direct shipment or trucking from plant to construction site has been a common practice on the larger projects, even for special products coming from plants several hundred miles away.

The industry has recently introduced new products for which it expects gradually increasing acceptance, and has adopted a new system of dimensions as an alternate to that formerly used. Neither development will affect its ability to meet post-war requirements.

Cement

Portland cement is produced by approximately 150 plants with a practical capacity of 215 million barrels per year.¹⁰ Not all plants can run at practical capacity however, because of the combination of seasonal variations in construction activity and limited storage capacity. That capacity is approximately 15 percent of annual capacity, or somewhat over 30 million barrels; largest manufacturers' inventory was 26 million barrels, reached in March 1941 and also in March 1942.

The largest recorded use is 187 million barrels per year, reached during the peak of war construction in 1942. The previous peak was 172 million barrels in 1928. Nonmilitary exports have been small, the peak in recent years being 1.3 percent of total mill shipments, reached in 1940. Prior to that year, exports were equalled or exceeded by imports. Maximum exports after the previous war were less than 3 million barrels in 1920. The industry expects a very small export demand after the war, because of price differences between the European and American products. Industry opinion is that plants in the major producing countries—England, Denmark and Germany—will on the whole be in usable condition but that the French plants will be temporarily unusable.¹¹ It is expected that imports from the United States will be for only the most urgent projects which cannot be supplied from European sources, and that other projects will be postponed until European capacity is increased. A small volume of exports to Africa and also to Brazil and Mexico is expected. Both Mexican and South American capacity have been increased in recent years, and further plant construction is likely.

Approximately 15 small American plants have been converted to ore roasting and similar war activities, but can be reconverted at slight expense within 3 months or less. It is believed that all plant owners will want to reconvert as soon as possible.

It is possible that some relocation or modernization of plants may result from the final court decisions on pending litigation regarding the industry's pricing method. Productive capacity seems sufficient, however, to prevent shortage during any such adjustments.

¹⁰ Practical capacity differs from nominal capacity (250 million barrels per year) in that it is corrected for unavoidable interruptions to production—shutdowns for relining of kilns, etc.

¹¹ It is entirely possible that defeat of Germany may be accompanied by extensive destruction of productive facilities of all sorts throughout the territory being surrendered.

Lumber and Related Products

The long-range outlook for lumber¹² is good, but in the immediate post-war period there will be a shortage unless factors now limiting production can be corrected quickly. This shortage can be prevented.

Increased military use of lumber and related products has been accompanied by drastic reduction in civilian consumption. Consequently the drain on forest resources has not been increased abnormally, except for a few special-purpose woods not used in construction. For the construction woods, there has been no significant increase in destructive methods of cutting.

The industry and the United States Forest Service agree that there will be a downward post-war trend in the quantity of logs consumed for a given volume of construction because of increasing use of plywood,¹³ which provides requisite strength with less thickness than conventional sheathing and which is manufactured with less mill waste. Plywood can be made from much smaller logs than the "peeler logs" of the northwest which are now standard, so that continued manufacture is not dependent indefinitely on this supply. Increasing use of panels made from materials other than veneer is also expected.

It seems almost certain that the wartime trend from metal to lumber for structural framing in factory and warehouse construction will be reversed. Availability of sheet metal will end the wartime use of lumber and plywood as substitutes. Building ordinances will probably be revised with the passage of time, to permit higher stresses in wood members, thereby reducing lumber consumption. There will probably be continuation of the pre-war trend toward greater replacement of lumber and millwork by metal products for the non-structural elements of residential and commercial structures.

Production has been restricted to an increasing degree during the past 2 years. Sawmills need additional workers, and at logging camps the labor shortage has been so severe that the estimate of 1943 lumber production has been reduced. Repair parts and similar operating supplies are needed by the sawmills. The logging camps are in the most urgent need of off-the-highway trucks, tractors, and equipment auxiliary to tractors for building logging roads and hauling logs, and of repair parts for these units. As a result, trade inventories have been severely depleted despite strict control of civilian consumption. The lumber shortage has been so great that structural framing of certain war plants was designed in steel, although wood framing was originally contemplated to reduce steel consumption, and undried lumber has been used extensively in war construction.

Production can be expanded rapidly as these limitations are overcome, but capacity of sawmills is much less definite than that of most factory operations because the majority of mills are intended for

¹² Lumber is defined as follows in Simplified Practice Recommendation R16-39 of the National Bureau of Standards: "Lumber is the product of the saw and planing mill not further manufactured than by sawing, resawing and passing lengthwise through a standard planing mill. crosscutting to length and working. Lumber of thickness not in excess of one-quarter inch to be used for veneering is classified as veneer." By this definition, and as understood in the trade, lumber does not include logs used after cutting to length for poles, posts, mine timbers, firewood or other purposes; logs processed directly into paper pulp, fiberboard, excelsior, shingles, plywood, chemical products, barrel staves or headings, or certain other products; or the products made from such logs.

¹³ Plywood consists of several layers of veneer laminated with the direction of the grain at right angles in adjoining layers, bonded together with adhesive. The veneer is produced in a continuous sheet by "peeling"—that is, rotating a log against a long knife. Improvements of recent years in waterproof adhesives and methods of bonding have increased the value of plywood very greatly for many construction uses.

intermittent operation. Physical capacity of the saws is only one among several limitations. If all sawmills in the country were operated 52 weeks per year, the annual output would be approximately 100 billion board feet, but such an operating schedule would be feasible only in the most extreme national emergency.

Thousands of small mills are operated by farmers for only a few weeks or days each year. Their proprietors and employees regard lumbering as a sideline, to be followed only in the dull farming season. Furthermore, local timber supplies require that operation be intermittent; in many cases they would be exhausted within a year or so by continuous cutting. Many larger mills likewise avoid operation at full physical capacity, in order to prevent excessive drain on their timber stands.

Estimates of the practical physical capacity in post-war years range from 36 billion to 42 billion board feet per year. The lower limit reflects to some degree the industry's expectations regarding post-war prices as well as strictly operating considerations. Even so, it is approximately equal to domestic consumption in 1928 and also in 1941, and higher than such consumption in any intervening years. The upper limit is based on operating conditions only.

The start of expansion will be governed by seasonal considerations to some degree, but less than might be expected, because the seasons in the various lumbering regions do not coincide. After sawmill production is increased, there will be delay for processing and filling inventory channels. For construction, as well as most other uses, drying is necessary.¹⁴ Practically all construction hardwood, used in medium- and better-grade buildings mainly for finish floors and for the exposed parts of doors and other millwork, is kiln dried. This process takes 5 to 10 days, a negligible period. The bulk of the structure—all framing, sheathing, siding, sub-floors and in cheaper structures finish floors and all millwork as well—is softwood, except as this has been replaced by other materials.¹⁵ Roughly half of this is air dried, for which 60 to 90 days are required. The average drying time for all softwood is approximately 6 weeks.

Much more time will be required for accumulation of inventories. Total trade inventories have been large—usually a 4-month supply and at times a 6-month supply. The metropolitan lumber yards, receiving frequent shipments, have had a stock turnover of six, seven, or even in a few cases eight times a year; they can operate effectively with a 2-month supply or, in some cases, less. Yards in small cities, having a low volume of business and therefore receiving infrequent shipments, need to maintain large stocks to meet the needs of their customers. At these smaller yards turnover is commonly only 1½ times per year, with inventory ranging around an 8-month supply.

For the lumber yards as a whole, 2 months' production of construction lumber will be sufficient to bring inventories from present levels to a point where they no longer hamper construction activities. Since these inventories can be accumulated only from the difference between shipments received and deliveries to customers, it would

¹⁴ Douglas fir lumber is used extensively in construction without further drying than that which occurs in shipping, but omission of drying for other woods is not accepted as satisfactory for construction use.

¹⁵ Within recent years lumber has been replaced to an increasing degree by plywood, by fiber boards and insulating boards made from wood fibers and other fibrous materials, and by products made in an extensive variety of sizes and shapes from inorganic materials. Continuation of this trend is expected.

take at least 4 months to approach this condition, and probably a few months longer to achieve it fully.

Actual accumulation may take considerably longer, however. Prices of lumber have increased, to date, much more than those of other building materials, and firms with large inventories would lose heavily in a reduction. The trade is somewhat apprehensive about the post-war price level, and most of the firms are expected to govern their purchases or production by price indications in conjunction with current sales. Thus variety will be built up earlier than total quantity; but indications of active construction would stimulate both inventory purchases and production.

The end of the war with Germany will result in a reduction in total military requirements. Any reduction in total military purchases will bring an approximately proportional decrease in military requirements for crating and other lumber, as well as a great release of labor from most war industries. It seems likely that large quantities of unissued stores will be available for shipment from the European-Mediterranean fronts to the Pacific-Asiatic fronts. If so, reduction in military purchases other than food may be greater than the reduction in expected rate of consumption.

Almost from the time of this country's entrance into the war, the shortage of logging workers has been increasingly serious. For a time the importance of lumber production was not recognized in deferment policies, with the result that skilled workers departed to the armed services and to officially recognized war industries. Inexperienced persons suited to active outdoor work are useful, but are by no means equivalent to experienced workers. If additions to total force consist mainly of those without experience, the increase in production will for a time be much less than proportional to the increase in employment, and average unit costs will increase.

It is essential therefore that efforts be made to direct capable logging workers back to their former employment when they are no longer needed in other war work. As shipyards and war plants reduce their forces, it is important that choice of those to be released be governed in considerable part by the need for their skills in other work. By this procedure, skilled woodsmen might be released in force reductions whenever the U. S. Employment Service had calls for their services.

Workers at the end of the war can be sufficient for a production rate of 33 billion to 36 billion board feet, depending on the industrial and military demobilization pattern after the defeat of Germany. A year later, it is likely that there will be enough workers for an output of 40 billion board feet, if there is sufficient employment for these workers.

Cessation of European hostilities will be followed shortly, however, by an active start of civilian reconstruction for which large imports of lumber from non-European sources will be needed. In the absence of definite knowledge about governing conditions, any estimate of the volume of these can be little more than a guess. The extent of destruction in Europe when Germany is defeated cannot be predicted, and little is known about the state of European forests. Policies of the various governments are yet to be determined. Credit arrangements for private transactions are not yet made. It is possible that military stocks of lumber already in Europe will be used for recon-

struction. Export from the United States of used lumber obtained in demolition of temporary war housing and other temporary war construction is also possible.

Prior to the war, Europe as a whole was self-sustaining in lumber except for a billion board feet per year imported by England from Canada because of the Empire-preference tariff provisions. Before this enactment, the continent had been almost exactly self-sustaining, with imports of consuming countries balanced by exports of producing countries.

Up to 1929, total European imports had been approximately 10 billion board feet per year. Subsequently they were smaller, and in 1938, the last year for which an accurate estimate is possible, were approximately $6\frac{1}{2}$ billion board feet. Those familiar with the field believe that Sweden and Finland together will probably be able to export $3\frac{1}{2}$ billion board feet a year, and suggest $1\frac{1}{2}$ billion board feet as the possible volume for the remainder of the continent. This last figure is highly tentative, because of uncertainty regarding the state of the forests.

Should post-war imports of new lumber be 10 billion board feet per year, half of this would need to be obtained from non-European sources. One billion board feet could come from Canada and the remaining 4 billion would presumably come from the United States. Potential supplies from other exporting countries are very small, and unlikely to reach European markets.

In addition, Africa has imported approximately 500,000,000 board feet of lumber a year from the United States, China from 300,000,000 to 400,000,000 board feet, and several countries smaller quantities. Japan has imported from the United States at rates as high as $1\frac{1}{2}$ billion board feet per year, but its requirements will quite possibly be subordinated to those of the United Nations.

In the absence of knowledge about controlling conditions, conversion of possible lumber production into possible construction volume requires arbitrary assumption of lumber exports. The export rate corresponding to sustained European consumption prior to 1930 provides a usable base, from which adjustments can be made for specific increases in European consumption. This base rate of exports is 4 billion board feet per year to Europe, and 1 billion board feet to countries elsewhere.

Production of 33 billion board feet per year would permit a construction rate of approximately \$9,000,000,000 per year at 1940 cost levels after inventories are restored, in addition to the export rate of 5 billion board feet per year. Production rates of 36 billion and 40 billion board feet per year would permit construction rates of somewhat over \$10,500,000,000 and \$12,500,000,000 per year, respectively. These construction rates are for a distribution of construction among different types in accordance with past experience and present indications of the post-war pattern. They would be modified by increased relative importance either of structures such as detached houses having high lumber requirements or of projects which use comparatively little lumber.

It is most unlikely that the construction rate at the end of the war will be \$9,000,000,000 per year, or that a year later it will have increased to \$12,500,000,000. It is also unlikely that export demand will be as low as 5 billion board feet per year, because of the magnitude

of the rehabilitation program. It seems likely that exports of 10 billion board feet per year can be supplied, for a period of a year or more, without hindrance to our construction program, after initial adjustments have been made. Thereafter the margin for exports would fall to 5 or 6 billion board feet per year, as construction expanded further.

Millwork

Capacity is more than ample for any predictable construction demand for millwork. This consists of planing-mill products other than surfaced lumber, and is made up principally of doors, sash, frames, moldings, stair work, and cabinets. Changed standards of design have eliminated the elaborate ornamental woodwork formerly so common, and have simplified elements such as door trim. Metal products, of which the best known is steel sash, have replaced millwork to varying degrees for a wide variety of building elements. Consequently the quantity of millwork used has been decreasing in proportion to total construction. At the same time, capacity was increased prior to the depression, before the significance of these trends became so apparent.

There is no accurate enumeration, or even close estimate, of the number of producing establishments in the millwork field. Most of the largest plants make one or more stock products which, like other factory products, are sold largely through permanent dealers. The remaining mills operate essentially as subcontractors, supplying but not installing a complete line of millwork items for individual projects.¹⁶ Some normally make building woodwork exclusively, either to individual designs and specifications for more expensive structures or to semi-stock designs. Others divide their production between millwork and other woodwork such as store fixtures, with the main product varying from time to time. In addition, there are thousands of small mills operated in conjunction with other enterprises.

Plants of all sizes were shut down during the depression, and many are operating currently only on simple work such as ammunition boxes. It is the opinion of those familiar with the field that any necessary production can be attained almost immediately, when lumber and workers are available.

Inventory is important mainly for doors, the greater numbers of which are produced by specialized manufacturers but which are needed only near the end of any project. One plant alone can produce 250,000 doors per month, and there are several others of comparable capacity, so that inventory shortage should be only a brief problem. Any shortages in other items for which quantity production in stock designs has been extensive can be overcome by manufacture in local mills, until the distributors have built up their inventories.

Steel

Pre-war steel capacity exceeded consumption by a substantial margin, and has been enlarged for war requirements. There is no question of capacity for post-war demand; rather, the industry is concerned about uses, and the advisability of abandoning some of the less efficient plants is receiving consideration.

¹⁶ These mills ordinarily buy doors but make all remaining items, except that in some localities stair work is a specialty produced and installed by local stair builders.

Reconversion will be a rather brief problem. Every general type of product is being made for war uses, although of course the tonnage distribution among types has changed greatly and many individual items have been discontinued.

The only serious reconversion problem is that of continuous strip mills which are now making plate. In this case reconversion will be simpler than the original conversion, since it involves mainly the reinstallation of equipment which was removed whereas conversion involved construction of additional factory space and the production as well as the installation of new equipment. At the same time, there will not be the wartime urgency which accelerated the previous change. Six months will be sufficient in all cases, and 3 months or even considerably less in most cases. Some of the largest users—makers of automobile bodies, among others—will not be ready for operation until this reconversion is well advanced. Meanwhile, sheet steel will be produced on those continuous-strip mills that were kept in operation for war requirements. Principal construction uses are for conventional sheet-metal work, and in the manufacture of appliances and fabricated materials such as ranges, refrigerators, shower stalls, partitions, and cabinets of various sorts.

Manufacture of most steel-mill products will require only a change of rolls. This is a routine procedure carried out whenever there is a change to a rolled product of different cross section, and requires only a fraction of an hour for the smaller rolls and somewhat longer for the larger rolls. Change of steel formula, as from a formula suitable for armor plate to one suitable for welded pipe, is likewise accomplished in the course of operation. Certain special machines, such as those for making metal lath, have been idle but can be restored to use almost at will.

Inventories will not be a serious problem. Most of the tonnage is sold and shipped directly to the larger consumers. The small fabricators who buy through distributors use comparatively few items of the entire range produced. Consequently, the trade channels to be filled are less extensive than those for numerous other building materials.

Although there are large inventories at shipyards and other war production establishments, these would afford little help to construction if released for civilian purchase following a reduction in war requirements. The shipyard inventories consist of plates and ship-building shapes. Plates are rarely used in construction except for the manufacture of boilers and tanks; and the shapes are quite different from those used in structural-steel work. Inventories of manufacturing establishments are on the whole less similar than those of shipyards to construction steel, although a part of them may be suitable for fabrication into building materials.

It is important that steel capacity freed by reduced war requirements be used for civilian products, and that reconversion of continuous strip mills be permitted whenever there is permanent reduction in the need for plates. When available, steel will relieve the lumber shortage by ending the fabrication of wood into articles which are admittedly emergency substitutes and by permitting manufacture of steel building materials which have been alternates for lumber or millwork.

Miscellaneous Iron and Steel Products

A great variety of items fabricated from iron and steel, ranging widely in importance, has become standard to varying degrees for building use. These items cannot be discussed individually. Some, such as medicine cabinets and industrial types of steel sash, were manufactured in stock sizes; others were produced on special order and commonly to individual specifications.

On the whole, production of these can be resumed without delay when steel is available. Manufacture of some, such as hollow metal doors, was continued in substantial quantity for war uses. There are indications that manufacturers are planning increased emphasis on stock designs and stock sizes for some items, with the ultimate effect of increasing the productive capacity of current facilities.

There will probably be inventory delays of a few months for the major stock-design products, during which these will be available in a limited but gradually increasing range of sizes and models. Most of these products can, if necessary, be made locally in ornamental-iron or sheet-metal shops. Most of them are alternates for wood products for the same purposes. Consequently, the inventory problems will be, at worst, a hindrance.

Builders' Finish Hardware

Builders' finish hardware¹⁷ is made by approximately 110 companies, all of which have been active on war orders. Pre-war output ranged from \$80,000,000 to \$90,000,000 per year. Although the current production of the same firms is much larger, most of this is ordnance; only about \$50,000,000 represents output of builders' hardware. Much of the latter consists of hinges for ammunition boxes and other articles which the industry classifies as builders' hardware, although not suitable for building use. Current trade inventories are very low, and are made up in part of odd and obsolete items of doubtful usefulness.

Conversion of plant has not been extensive. Facilities for war products which could not be made on the industry's usual machinery have been secured principally by installation of new machinery in additional space, and some part of the additional machinery is suitable for pre-war products as well. A very rapid return to pre-war products, for which patterns, dies, and other supplementary productive agents are on hand, is possible. There has been unused capacity in the industry, and further increase of output can be obtained by multi-shift operation.

Restoration of inventories is complicated by the great number of different items in a complete line, many having a variety of finishes and ornamental designs on the exposed parts. The more prominent brands have been distributed directly to certain large hardware stores acting as local representatives, and through wholesalers to smaller hardware stores elsewhere. The other brands have generally been distributed through wholesalers. At least 3 months' production will be required to build up minimum basic inventories, and another 3 months to give buyers some choice of products for a particular purpose. It will be several months more before buyers have the extensive choice to which they have been accustomed.

¹⁷ Builders' finish hardware is, in general terms, the hardware visible in a completed building (largely door, window, transom, and partition hardware). It does not include nails or other rough hardware, or the numerous small metal parts used in plumbing, heating, and electrical work.

Plumbing Supplies

The plumbing-supply industry is divided into three major parts, producing, respectively, china fixtures, enamelled iron fixtures, and brass goods. A few large companies produce all three lines, but most companies make only one. Special commercial or industrial fixtures, such as restaurant sinks, are classified as business equipment rather than plumbing supplies.

Production of discontinued articles can be resumed within a few days and does not involve appreciable reconversion of plant, but several months will be required for the building up of inventories. Capacity is only slightly greater than 1941 production, and some manufacturers believe that post-war production will be dependent on increased prices.

China fixtures are being made currently for war construction, and output can be increased in response to demand at any time, if additional workers are available. Inventories are at minimum working level, and restoration to pre-war quantity and variety will require approximately 6 months. These fixtures, however, are limited principally to closet bowls, closet tanks, and lavatories. Although china sinks and some china bathtubs have been made for war construction. China is the standard for closet bowls and tanks in all buildings, but china lavatories are normally used only in more expensive buildings, and china sinks and bathtubs are ordinarily most uncommon.

Approximately four-fifths of the lavatories, and practically all sinks and bathtubs, have ordinarily been made of porcelain enamel on a base of cast iron or, for some fixtures made in recent years, on a base of pressed sheet steel. Production for normal domestic use was discontinued entirely until issuance of the WPB order on December 30, 1943, permitting manufacture of 50,000 bathtubs, and trade inventories have been virtually exhausted. The foundries are engaged principally in making other castings for war uses, but have their old patterns and can reopen their enamelling furnaces almost at will. Production can therefore be resumed in a matter of days, but it will then require 4 months to build up basic working inventories, and almost a year altogether to build up full inventories which would give buyers normal range of choice.

Maximum efficient capacity for enameled-iron fixtures was nearly reached by the 1941 construction program of almost \$11,000,000,000, including 715,000 dwelling units. With present facilities, an increase of more than a few percent above 1941 output would complicate the manufacturing operations and increase costs. Increased capacity for the cast-iron fixtures is unlikely, but there are strong indications that capacity for the sheet-steel fixtures will be increased substantially within a few months after the end of the war and more later if justified by increased public acceptance.

Those in the industry believe that early post-war models will be unchanged from those made before the war and that subsequent changes will be gradual. Any drastic changes which may come will be introduced on a small scale, probably either by small companies or by companies new to the industry. These opinions are supported by the history of previous new products in the industry. Further support is given by a recent survey of preferences in plumbing equipment made among 200,000 householders by a large manufacturer

which showed an overwhelming preference for fixtures of the type produced in 1941.

Brass goods are made up of "trimmings,"¹⁸ valves, and all other metal parts except the fixtures themselves, pipe, and pipe fittings. They are made by a large number of manufacturers, many of whom are relatively small and confine themselves to a restricted line of products. Inventories of completed goods are negligible, except for "war models" in which brass has been largely replaced by other materials, and inventories of these war models have been restricted by doubts regarding their post-war salability, as well as by other limitations. Some manufacturers have small stocks of parts of their standard models, however, from which assembly could be started within a few days. The foundry and machine equipment for making these parts are now used for war products, but return to former products will involve little more than change of patterns and machine settings and should introduce no appreciable delay. There was unused capacity in 1941 and other busy years, especially among the smaller manufacturers, and increased production can be obtained as needed by multi-shift operation. However, it will require approximately 4 months to build up basic working inventories throughout the trade, and at least 4 months more to bring inventories to customary standards.

Heating Supplies

Heating supplies will be available sooner than plumbing goods, but it will be fully 6 months before the industry can offer buyers even an approach to a full choice of installations. Permanently installed heating plants are generally regarded as divided into two basic groups—radiator systems and warm-air systems.

The former use a boiler from which steam or hot water is circulated to radiators of various types, and consist of boiler, radiators, trimmings, and pipes. Boilers and radiators for residential use are ordinarily of cast iron, for which production can be resumed at any time on short notice. These are made by numerous companies having regional distribution, as well as by the better-known national companies. Trimmings for small systems are likewise made by numerous companies, although the highly developed specialties for control of heat distribution are made by relatively few. The pipe is made in the steel industry.

Warm-air systems have been much more common for smaller houses. Simple "gravity" systems, in which the heated air rises through supply ducts and is replaced by cooler air passing through return ducts, have been made by about 200 manufacturers in almost all parts of the country. The gravity systems have been made to some degree for war housing and for necessary replacements. The processes involved are simple, and the range of parts is rather small. The ducts themselves have ordinarily been made by the local sheet-metal shops which made the installations. Hence expansion of manufacturing and accumulation of inventories to a usable degree will require only a few weeks. The more elaborate forced-air systems¹⁹ vary extensively with respect to both the furnace itself and the remainder of the

¹⁸ "Trimmings" are faucets, waste connections, traps and the various other items mounted on or immediately adjacent to the fixtures.

¹⁹ In these systems the warm air is circulated by a motor-driven fan and rather commonly is filtered and humidified; they are commonly called "winter air conditioning" or some other variant of air conditioning, although most installations are not true air conditioning.

equipment. Some are made by small manufacturers, while others are made by divisions of the large companies most completely converted to war work. Consequently these forced-air systems will become available over a period of some months, the simpler of them shortly after the gravity furnaces are resumed and the more elaborate after a period of 6 months or more.

Heating stoves will be available in any quantity needed, with little if any delay. Slightly more than 3,400,000 were manufactured during the year ending June 30, 1941, of which approximately 950,000 were for gas, 980,000 for coal or wood, and 1,470,000 for oil.

Electrical Supplies

Electrical supplies consist of the materials used for distributing and controlling current at buildings—wire and cable, conduit, outlet boxes, switches, convenience outlets, load centers, fuses, and numerous others. They do not include current-using devices such as lighting fixtures, lamps, and electric appliances. Production has been greatly expanded during the war and reconversion problems are minor, but restoration of inventories will be a lengthy process. The war effort has required tremendous quantities of electrical supplies, so that all manufacturers have been busy, most of them at higher rates of physical production than ever before. Many of the products are essentially, if not exactly, the same as peacetime products; production of other peacetime items has been curtailed or discontinued; some products totally unsuited to construction uses have been needed in large quantities; and development of recent products which may have later application in construction has been greatly hastened.

Production of most peacetime items will be merely a continuation of present operations, with no changes other than of dies or machine settings. For others, machinery which has been out of use can be returned to production without delay. The only reconversion operation of any magnitude is that of some of the machines for assembling BX cable,²⁰ which will take approximately 2 months. Other machines for the same purpose were kept in operating condition.

Only a few days will be needed to resume production at almost full capacity after current limitations are removed, and only about 2 months to put the remaining facilities into operation. The range of items is so great, however, that not even the largest manufacturers attempt to produce all simultaneously. A complete line consists of approximately 2,000 active items, normally kept in stock continuously, plus approximately the same number made up principally on special order. Under normal circumstances most of the standard items are made intermittently, with the machines used successively for a series of similar but not identical products, and with production of each item regulated carefully to maintain plant inventories within predetermined limits. These plant inventories were extremely large, one manufacturer alone regarding 40 full carloads as his minimum stock of a single group of products. In addition, jobbers and wholesalers had extensive stocks, and even the smallest contractors maintained inventories of some sort.

²⁰ BX cable consists of two or more insulated wires enclosed in a helical wrapping of narrow sheet metal; it is also known as metallic sheathed cable. Manufacture of this product was stopped for several months.

All these inventories are now exhausted, and cannot be replaced quickly, especially with the intermittent manufacture necessary for many of the items. One of the largest manufacturers estimates that it will require 6 months to build up a basic working inventory, and another 6 months to build up a good trade inventory. Some relief will be obtained if arrangements can be made for release of military inventories when no longer needed. This will be less, however, than the gross value of such inventories would suggest, because they include many items unsuitable for construction wiring. An indication of the seriousness of the inventory problem is given by the estimate of one of the smaller manufacturers, making items sold through the 10-cent stores and similar outlets, and supplying them through several large warehouses. He expressed the opinion that after all limitations were removed it would be 2 years before the difference between production and sales would bring his warehouse inventories up to their pre-war volume.

Some improvement in the inventory situation is possible in the interval between defeat of Germany and that of Japan. If materials, plant facilities, and manpower not needed after reduction or cancellation of war orders can be released for such use, civilian manufacture can be started immediately. The magnitude of the inventory problem shows how important it is that such manufacture be permitted at the greatest rate consistent with war requirements.

Lighting Fixtures

Lighting fixtures will be available as needed. The cheaper incandescent fixtures, used in most residential buildings, were produced mainly by assemblers rather than manufacturers. The assembling establishments were small but numerous, and in the past increased rapidly in response to any increase in demand. The capacity of the parts manufacturers has been ample for peak demands. The better incandescent fixtures have ordinarily been produced by establishments manufacturing many of their own parts, and the capacity of these has also been ample. Incandescent fixtures of standard design were also made in considerable quantity for installation in stores, offices, and factories, but the post-war demand for these will be small.

Fluorescent fixtures will be in post-war demand principally for commercial buildings, both for new work and modernization. The initial cost will restrict their sale for residential use. They will be standard for new industrial buildings, but will scarcely be used for replacement of older factory fixtures except in establishments which had not been engaged in war work. Modernization of lighting was encouraged so strongly as an aid to war production, with priorities readily available, that eligible establishments which have not already made the change are unlikely to do so in the post-war period. Capacity for the manufacture of fluorescent fixtures continued its rapid pre-war expansion into 1942 and may be expected to expand further if sales indications are favorable.

Domestic Appliances

For residential construction, the major domestic appliances are comparable in importance to building materials. All appliances except mechanical refrigerators will be available in abundance and without serious delay if materials are available.

Ranges.—In 1941 approximately 2,275,000 domestic gas ranges were produced by about 100 manufacturers. Their single-shift capacity was approximately 3,000,000, and 3-shift capacity, at least 8,000,000.

There is no serious reconversion problem. Some of the manufacturers have been making "war model" ranges for war housing units, and much of the industry has been engaged in direct war production for which its existing plant was suitable. Manufacture of former products can be resumed within a short time, from a week to a few weeks in most cases, when limitations are removed and materials are available.

Domestic gas ranges are regarded by the industry as having a life of 8 years, but this is established by obsolescence resulting from the continued improvements of recent years combined with style changes. Since early production will be of 1941 models, replacement demand will not be abnormally stimulated.

About 700,000 domestic electric ranges were manufactured in 1941, more than three-fourths of them by a very few large manufacturers. War work in these plants has brought greater physical conversion than in the gas-range factories, but reconversion can be sufficiently advanced within a period of 3 months for some approach to pre-war output. Thereafter, production can expand rapidly.

Water heaters.—The greatest output of gas water heaters was 895,000 units of all types (storage, instantaneous and sidearm) reached in 1929. Single-shift capacity at that time was known to be somewhat greater, although there are no exact figures. Subsequently several of the manufacturers increased their capacity by changes in production methods, and others entered the field on a large scale. The industry estimates its 3-shift capacity as being at least 5,000,000 units per year, and probably more. Production can be resumed almost as quickly as that of gas ranges, when limitations are removed, provided copper tubing is readily available.

Electric water heaters and others not using gas are also in common use. The delay until these are available will vary with the type, but will not hinder the construction program.

Refrigerators.—Manufacture of electric refrigerators was the most highly developed in the appliance field, with the result that problems of reconversion will be the most serious. While there have been numerous small manufacturers, the greater part of the output was made either by large companies with a background of highly technical manufacturing or by subordinate units of such companies. Conversion of these refrigerator plants to war work has been among the most extensive in all manufacturing. There has been transfer of equipment among various plants of given companies, the individual machines being moved to the plants where they could be used best on war products. In some cases, there has been interspersing of company-owned and Government-owned machinery. After the machinery used on war products is released and arrangements are made, either for removal or for use of Government-owned machinery, it will be 6 months before production in quantity can start, and another 12 months before it can reach its expected post-war peak of roughly 5,000,000 units per year. The pre-war peak was 3,500,000 in 1941, but this did not represent full capacity because many of the large plants were closed during part of the dull sales season.

Manufacture of small motors for refrigerators and other appliances will be little more than a continuation of their manufacture for war uses. The changes in design will cause only a negligible interruption to production.

CONSTRUCTION LABOR

Information is considerably less complete on the supply of construction labor than on other factors bearing on post-war construction volume. No direct statements may be made regarding the number of skilled construction workers who have entered the armed services, because those tabulations which have been made to date are confidential.

More than half of the construction mechanics²¹ reported in 1940 Census of Occupations as employed or as experienced and seeking work were above the maximum age now established for general military service. In only three major classifications—electricians, roofers and sheet-metal workers, and structural- and ornamental-metal workers—were half of those then employed under 40 years of age. In all other major classifications, half of those employed were 42 or over. In all classifications, those experienced and seeking work were older than those employed. Although skilled construction workers above the normal age range for enlisted men have been accepted for specialized groups such as the "Seabees," the total strength of these groups is small compared to the armed services as a whole.

Construction laborers were considerably younger than the mechanics. More than 55 percent of those reported in the 1940 Census as employed, and slightly over 50 percent of those experienced and seeking work, were under 38 years old. It is to be expected therefore that the number of these in the armed services is proportionately greater than the number of mechanics. This will be a negligible limitation on the volume of construction, however, because the operations performed can be learned quickly.

To obtain the number of construction workers in 1940, it is necessary to adjust the Census figures for those in specific occupations, because they combine maintenance workers with construction workers for the various building trades. Maintenance workers are a considerable part of the total for certain trades, especially carpentry, painting and paperhanging.

It is estimated that there will be 1,120,000 construction mechanics in civilian life in the country at the end of the war, exclusive of maintenance mechanics in the same trades. In addition, it is estimated that there will be 440,000 helpers and experienced laborers. To these can be added 400,000 inexperienced persons capable of doing construction laborers' work, to bring the group into balance with the mechanics.

An indefinite but large number of all of these workers are now employed in war industries. Many will be released at the end of the war, and it is likely that others will resign voluntarily when jobs in their own trades are available.

These workers are sufficient for a construction program of approximately \$8,750,000,000 per year at 1940 cost levels, if employed steadily. Steady employment is regarded as 1,650 hours per year, or 50 weeks of 33 hours each, which is 40 hours per week minus time lost for bad weather, and without overtime. The time lost because

²¹ Craftsmen, as distinguished from helpers and laborers.

of weather varies seasonally, of course, and also differs between sections of the country. The possible volume will be increased as demobilization proceeds, and will also be increased through gradually increasing productivity. It is estimated at \$11,000,000,000 per year, 1 year after the defeat of Japan.

As already mentioned, there is likely to be strong competition among materials and products. Substitution of materials, as between metal and wood, will be further stimulated by any local shortages of a customary product when another satisfactory product for the same use is available. Such circumstances might call for adjustments between the various construction unions involved, with new agreements clarifying their respective fields of work, and providing a greater degree of flexibility in the materials which specific craftsmen may use.

Measures to Facilitate Post-War Construction

It is apparent that, within a year after the end of the war, physical capacity can be sufficient for a construction volume about equal to the greatest peaks that have been attained in the past. It is equally apparent, however, that capacity at the end of this first post-war year can be cut down greatly by avoidable complications. The following measures would be valuable in preventing unnecessary delays and limitations:

1. Provision for removal or private use of Government-owned factory machinery which has replaced or is intermingled with privately owned machinery, as soon as no longer needed for war production. If policies for permanent disposition can not be formulated now, authorization of removal and temporary storage of those machines not suited to the plants' post-war operations, and of some form of lease for machines which they can use effectively, pending adoption of permanent policies.

2. Permission for reconversion of machines or plants as soon as it is known that they will not be needed for further war production.

3. Periodic review, from the standpoint of changed military requirements, of Governmental inventories and purchasing schedules of building materials, construction machinery, trucks, and related products, and prompt effectuation of any indicated reductions. Surpluses would be sold for civilian use, to the extent that these can be absorbed readily. Sale would be made to users through normal trade channels with the purpose of relieving shortages without bringing price disorganization, and with every reasonable precaution to prevent sale of scarce commodities to speculators.

In selecting establishments in which war orders are to be reduced or cancelled, the importance of their normal products to the peacetime economy would be among the criteria used.

4. (a) Permission—as soon as reduced military requirements give a margin of productive capacity and to the extent that the manpower and material situation allows—for increased production for civilian use of construction machinery, trucks, and building materials. (b) Temporary control of distribution of those articles for which the shortage is most serious. Thus, new machines for logging (off-the-highway trucks, tractors, and certain units based on or operated by tractors) would be given priority, with logging operators given preference in the purchase of these items until their shortage is no longer a limitation on lumber production.

5. A detailed study of costs of production and distribution in comparison with ceiling prices for all major building materials, especially those for which prices have risen most sharply. This would be followed by revisions in ceiling prices to correct imbalance and thus remove potentially serious impediments to inventory accumulation and increased production in the post-war period.

6. All possible efforts to stimulate prompt revision of building codes with respect to permitted construction materials for various uses and the quantities of materials required. Development of new products, improvement of the strength or other characteristics of older products, and improved control giving greater uniformity and reliability in products have occurred since many of the codes were adopted. Consequently many of them require use of materials which must be considered wasteful by newer standards. Inefficient use of materials and needless variations in local standards would be particularly detrimental during the period of inventory shortages.

The Building Code Correlating Committee of the American Standards Association, the membership of which includes representatives of numerous professional and trade associations in fields allied to construction, is working currently on this problem. Pending completion of its work, valuable correction can be brought about by the activity of local groups interested in construction, even though further revisions are likely to result from the Committee's recommendations.