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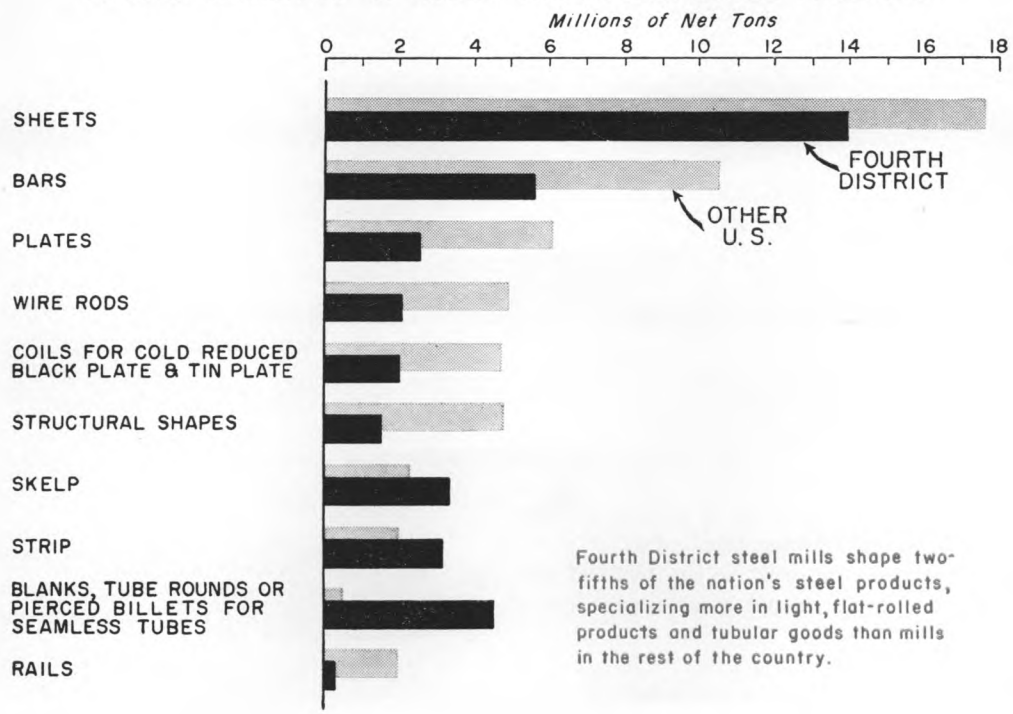
ANNUAL CAPACITIES OF MAJOR HOT ROLLED STEEL PRODUCTS



Fourth District steel mills shape two-fifths of the nation's steel products, specializing more in light, flat-rolled products and tubular goods than mills in the rest of the country.

Steel Finishing Capacity

Fourth District

THE FOURTH FEDERAL RESERVE DISTRICT encompasses two-fifths of the nation's capacity for making steel ingots and steel for castings, with mills clustered around Pittsburgh, Youngstown, Cleveland, Wheeling and along the Ohio River.(1) On a product basis, however, District mills are equipped to turn out more than one-half of the country's pipe, tubing and galvanized flat products and 45 percent of such important finished mill products as cold finished bars and hot and cold rolled sheet and strip. On the other hand, the District contains a far smaller share of the nation's capacity for making rails, structural shapes, plates and wire.

Steel plays an important role in the District's industrial economy. In some cases, steel finishing capacities of District mills reflect the raw material needs of the major steel-consuming industries in the District. In other cases, they indicate surplus (or deficit) productive capacity. Also, it should be borne in mind that estimates of steel-finishing capacity cannot give an accurate gauge of the outputs of particular product lines which may be expected to flow from the mills, particularly because a considerable variety of alternative products can oftentimes be produced on the same rolling equipment. In any event, steel mill product capacities, as discussed below, do provide a general picture of the difference between the "product mix" characteristic of the mills in the District and that which exists in other steel producing centers of the nation.

(1) See *Monthly Business Review*, June 1954.

SELECTED FOURTH DISTRICT STEEL FINISHING CAPACITIES—1954

(Capacities in thousands of net tons)

Product	Capacity	Percent of U.S.
Hot Rolled Steel Products[1]		
Rails	219	10
Structural shapes	1,449	23
Plates	2,553	30
Sheets and Strip[2]	19,129	44
Bars	5,607	35
Steel for further conversion into wire and tubular products[3]	9,948	57
All other hot rolled	551	21
Total—hot rolled	39,456	41
Other Finished Steel Products[4]		
Pipe and tubing	7,883	55
Plain Wire	2,008	30
Cold finished bars	1,755	47
Cold rolled sheets and strip	9,306	46
Galvanized sheets and strip	2,188	58
Long terne sheets	232	80
Tin and terne plate	2,834	39

Source: Basic data from *Directory of Iron and Steel Works of the United States and Canada*, Twenty-Seventh Edition (New York, American Iron and Steel Institute, 1954)

(1) Capacities of hot rolled products are limited to steel available from mills' own ingot capacity plus estimated steel normally obtained from others.

(2) Includes coils for cold reduced black plate and tin plate.

(3) Wire rods, skelp, and blanks, tube rounds or pierced billets for seamless tubes.

(4) Capacities of other finished steel products are annual capacities without regard to available supply of ingots or semifinished steel or hot rolled products.

Sheet and Strip

About 45 percent of the nation's sheet and strip producing capacity — both hot rolled and cold rolled — is located in the Fourth District. On a tonnage basis, one-half of the District's hot rolling capacity is devoted to making sheet and strip (including coils for cold reduced black plate and tin plate). The cover chart compares District capacities of the major hot rolled steel products with the rest of the country's mills. An accompanying table gives District capacities for selected steel products, expressed both as tonnages and as percentages of total United States capacity.

The concentration of sheet and strip capacity in this District reflects the fact that stamping and sheet metal work weigh heavily among its industries. No recent measurement of the exact extent of the concentration of metal consuming industries in the District is available. Nevertheless, an indication of the importance of some major metal-using industries in the District may be obtained by comparing employment figures for Ohio with U. S. totals.

During 1953, one-fifth of all nonagricultural workers in Ohio were engaged in the fabricated metals, automotive and electrical and nonelectrical machinery industries, as compared with 10 percent so employed in the country as a whole. Nearly one-sixth of the nation's workers in these four groups of industries were employed in Ohio during 1953. For each industry, and for some of their major components, Ohio firms employed the following percentages of all U. S. employees during 1953:

Fabricated metal products	12%
Machinery (except electrical)	16
Metalworking machinery	19
Industrial machinery	14
Service industry and household machines	24
Electrical machinery	9
Motor vehicles and equipment	10

This showing is significant, especially when coupled with the fact that the state of Ohio employs only 6 percent of the nation's nonfarm workers in total. Adding in the metalworking industries of Western Pennsylvania would, of course, raise even further the estimate of the District's participation in these four major durable goods industries.

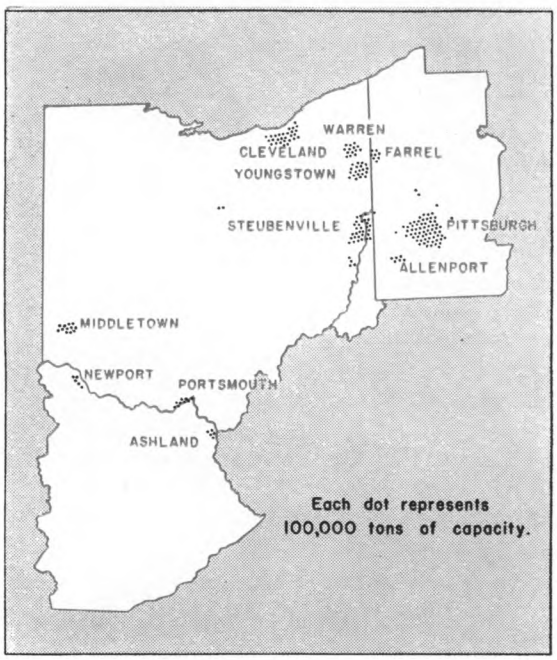
The fabricated metals, automotive and electrical and nonelectrical machinery industries take three-fifths or more of the sheet and strip output. Insofar as it is possible to trace mill shipments to the ultimate consumer[2], roughly two out of every five tons of sheet and strip shipped in 1953 went to the automotive industry. Another one-fifth or more went directly to producers of machinery, industrial equipment, electrical machinery, appliances and other domestic and commercial equipment. In other words, the industries that consume 60 percent or more of the nation's sheet and strip employ approximately 20 percent of the District's nonfarm workers.

The other major users of sheet and strip are the construction industry (including the makers of contractors' products) and the container industry; these two groups received 12 percent and 6 percent, respectively, of the mill shipments of sheet and strip made in 1953.

Demand for sheet and strip has risen rapidly during the past fifteen years. Relative to the output of all other steel mill products, sheet and strip production shows the sharpest uptrend during the 1940-53 period. In fact, when the output of separate mill items is expressed as a percentage of the production of all other steel mill products, tin mill products and pipe and tubing are the only other two major steel product groups showing *relative* growth trends during this period, according to an analysis of national trends made by one of the District's major steel companies. Other product capacities have been expanded during this time, of course, but not so fast as that of sheet and strip.

(2) Steel shipments, as reported by the American Iron and Steel Institute, show large tonnages going to jobbers, dealers and distributors, thus making it impossible to determine directly the end use of this tonnage. In 1953, warehouses and distributors received 14 percent of mill shipments of sheet and strip.

LOCATION OF FLAT HOT ROLLING CAPACITY IN THE FOURTH DISTRICT, 1954



The geographical distribution of flat hot rolling capacity in the Fourth District is shown by the accompanying chart. Each dot represents 100,000 net tons of capacity for rolling sheet, strip, plate and flat breakdowns for other plant finishing (except skelp). The dispersion shown by the chart follows closely the grouping of steel-making furnaces in the District. About one-third of the District's flat hot-rolling capacity is in the Pittsburgh area, about one-fifth is in the Youngstown vicinity and the remainder is split about evenly among the Cleveland, Wheeling and South Ohio River producing areas.

Plate

Fourth District mills reported only about 30 percent of the country's plate capacity[3] at the beginning of this year. The fact that this share is no larger may be due, in part, to the relative smallness of the District's shipbuilding industry, since that industry is one of the large users of plate. But, plate has many applications. In 1953, for example, nine-tenths of the plate shipments went to the following users:

Construction	23%
Machinery and industrial equipment	16
Warehouses and distributors	15
Ordnance and military	15
Rail transportation	13
Shipbuilding	8

During wartime, of course, plate is extremely important for ordnance and shipbuilding.

There has been no new plate capacity added to the nation's total for quite a while, but 7 million additional tons of light plate could be rolled on strip mills now producing sheet and strip without major changes of mill equipment, according to one industry source. For example, although the nation's plate capacity was reported as less than 9 million tons this year, more than 13 million tons of plate were rolled during both 1943 and 1944, and 9.9 million tons were turned out in 1953.

Structural Shapes and Rails

Fourth District mills are relatively low in structural and rail rolling capacity, accounting for less than one-fourth of the nation's structural shape rolling capacity and less than one-tenth of its rail capacity. Both are specialized products catering to a limited market, with production centralized in a relatively small number of companies. Present rail capacity is more than sufficient to meet foreseeable market demand.

Bars

About one-sixth of the nation's hot rolling capacity is devoted to making bars and 35 percent of this capacity is located in the Fourth District. However, nearly one-half of the nation's facilities for cold finishing bars is in the District. The accompanying map shows that hot bar-making capacity is clus-

(3) Plate is thicker than sheet and strip. In general, sheet and strip are up to about 0.20 inch thick, while plate is over 0.20 inch in thickness. All have a high ratio of width to thickness.

LOCATION OF HOT ROLLED BAR CAPACITY IN THE FOURTH DISTRICT, 1954

tered around the Pittsburgh, Youngstown and Cleveland industrial centers.

The bar classification covers a wide variety of mill products used by many industries. Generally speaking, bars may be grouped into three main categories; hot rolled, cold finished[4], and tool steel. The latter, as the name implies, is a specialty product, accounting for a very small proportion of total bar tonnage. The large consumers of hot rolled bar shapes are the automotive, construction (mainly for concrete reinforcement and for light structural applications), machinery and industrial equipment, ordnance, fastener (bolts, nuts, rivets, screws) and forging industries; altogether, these groups took over 60 percent of 1953 mill shipments of hot rolled bars. The automotive and machinery industries are important District users. These two industry groups also use 40 percent or more of the cold finished bar output on a national basis, thus helping to explain the District's predominance in cold finished bar capacity.

(4) A cold finished bar is a hot rolled bar that has been further processed (without heating) by drawing, turning or grinding in order to improve its surface or mechanical properties.

Pipe and Tubing

Fourth District mills are capable of producing more than one-half of the country's pipe and tubing, on a tonnage basis, and a much larger proportion on a linear basis. Most of the nation's small diameter pipe-making facilities are located in the District. However, electricweld facilities for making the large diameter (24 to 36 inch) pipe used in gas transmission lines are mostly located near the markets in the Southwestern gas fields. In terms of tons, large diameter pipe capacity weighs heavily in the total.

The concentration of pipe and tubing mills in the District may appear somewhat surprising, from certain points of view. Although pipe mills must be located near their raw materials (skelp, tube rounds, sheet, strip or plate) consideration of markets would also appear to be in order.[5] It is hard to pinpoint these markets from the data on mill shipments, as provided by the American Iron and Steel Institute, because about half of the pipe and tubing shipments go to warehouses and distributors. But, some idea of the many applications of pipe and tubing can be gleaned from total mill shipments by product classification.

Mill shipments of pipe and tubing[6] during 1953 were split among the five major product classifications as follows:

Line pipe	36%
Oil country goods	21
Standard pipe	28
Mechanical tubing	11
Pressure tubing	4

Line pipe is mainly the heavy, large diameter pipe used in cross-country gas and oil

(5) Electricweld mills for making large diameter gas transmission pipe have been located near their markets. In this instance, it is easier to ship the plate than the finished pipe. Most of this capacity has been added since the end of World War II.

(6) Pipe is differentiated from tubing by wall thickness; tubing has the thinner wall.

LOCATION OF TUBULAR GOODS CAPACITY IN THE FOURTH DISTRICT, 1954

transmission and is made largely at mills outside the District. It is in the production of the remaining four groups of tubular products that the District leads the rest of the country. Oil country goods are a specialized product, used largely outside the District. The last three kinds of pipe and tubing cover a wide variety of tubular goods, however, having many different industrial applications. These range from the more familiar plumbing applications to furniture, automobile exhaust pipes, conduit, fence posts, high pressure steam lines, printing press rolls, bushings, shaftings, and bridge and roof trusses, to name a few. The automotive, machinery, appliance, and other industrial and commercial equipment industries are the major consumers of pipe and tubing in the District. All are large users of tubular goods and important District industries.

The location of 55 percent of the tubular goods capacity of the nation is shown by the accompanying map. It is clustered around steel facilities in Lorain, Youngstown, McKeesport and Aliquippa.

Wire

Providing a sharp contrast with the District's predominance in pipe-making is its relatively small share of the nation's wire drawing capacity; only 30 percent of the latter is located in the Fourth District, according to A.I.S.I. data. Wire is an important raw material of the automotive, machinery, and equipment industries, and to the producers of fasteners — all of which are important industries locally.

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The emphasis placed upon sheet and strip rolling capacity and upon tubular goods augurs well for the District's industrial future. These two groups of products—along with tin-mill products—have been the major areas of steel industry growth in recent years. Whether or not the District can maintain its position in sheet and strip capacity depends, in large part, upon the expansion of major steel-consuming industries in the District.

Outlays By State Governments

THE 48 state governments in the United States make up a significant group of customers for the nation's output of goods and services. Outlays by these administrative units in the aggregate totaled nearly $17 billion during the fiscal year 1953.[1] Such a sum represented an increase of 6 percent from the preceding year. It was more than four times as great as the total of expenditures by state governments in 1939, although in the interval, the rise in the wholesale price level had been considerably less than threefold. In recent years, the total of outlays by state governments has actually exceeded expenditures by the Federal Government for all purposes other than national defense.

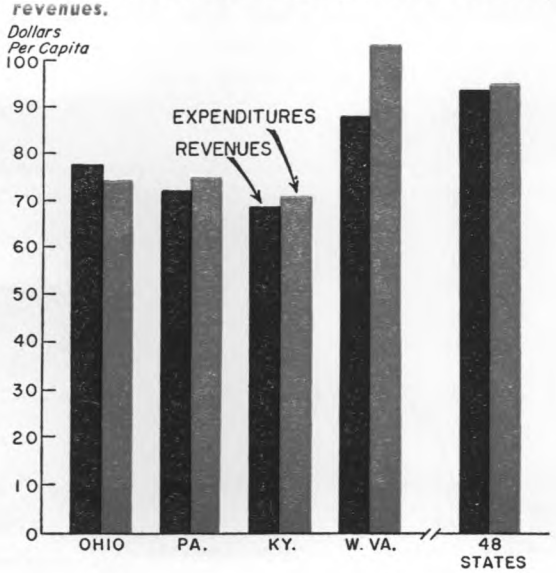
State government outlays, along with expenditures by certain other segments of the economy, have been receiving an increasing share of attention among business observers, at a time when announced reductions in Federal spending for national defense have been put into effect. Among the possible sources of increased demand for the nation's potential output, state governments rank high, especially in view of the pressures exerted by rapidly expanding populations for such characteristic state functions as educational facilities and highways.

The extent to which state governments can provide for the increasing requirements of their residents is, as with all economic units, dependent upon the financial resources available to the various administrations. Comparative data on state government revenues, outlays, debt, etc. for the fiscal year 1953 are available from a recently published study.[2] From these data, the four states included in whole or in part within the Fourth Federal Reserve District have been singled out for special attention in the materials below.

General Revenues and Expenditures

General expenditures by all state governments in the aggregate exceeded general revenues by a margin of 1 percent during the fiscal year 1953.[3] This is illustrated by a pair of bars on the accompanying chart

For Ohio, general revenues exceeded general expenditures during fiscal 1953; for Pennsylvania, West Virginia and Kentucky, expenditures exceeded revenues.



(1) The fiscal year for state-government accounting ends on June 30 in 42 of the states, including three of the four states specially considered here. The fiscal year for Pennsylvania ends on May 31.

(2) *Compendium of State Government Finances in 1953*, U. S. Department of Commerce, Bureau of the Census.

(3) *General* revenues and *general* expenditures refer to all state government revenues and outlays except those involving borrowing and debt redemption, and transactions in connection with state liquor stores and insurance trust funds.

which shows *per capita* general expenditures and general revenues for each of the four states with which the Fourth District is identified, as well as *per capita* amounts for the 48 states in the aggregate. The gap between expenditures and revenues in 1953 was smaller than in any of the three preceding years. During 1950, for example, outlays totaled nearly 9 percent more than revenues.

Revenues failed to match expenditures during 1953 in three of the four states shown separately on the chart. The imbalance for that year was largest for West Virginia, where expenditures exceeded revenues by 17 percent. Of the states shown on the chart, only Ohio had a surplus of revenues over expenditures for the year.

General expenditures were smaller than the national aggregate, on a *per capita* basis, in three of the four states. In fact, *per capita* outlays by these three states, Kentucky, Ohio, and Pennsylvania, ranked among the six lowest in the nation during 1953. For West Virginia, however, *per capita* outlays in 1953 amounted to $103.23 as compared with a national average of $94.73.

An important consideration to bear in mind in interpreting the above information on expenditures is the fact that the differences in the level of expenditures by the various states may result from differences in the distribution of responsibilities for certain functions as between state and local governments. The details of such differences in responsibility are too complex for specific treatment here.

Sources of General Revenue

General revenue by all state governments amounted to more than $14.5 billion in 1953. Almost three-fourths of this total was obtained from various taxes as indicated by the right-hand circle on the chart. The balance of revenues consisted largely of intergovernmental revenues from the Federal Government for such specific functions as public welfare, highways, and education. Grants to states from the Federal Government amounted to more than $2.5 billion in 1953.

The most important sources of tax revenue to the state governments are the sales and gross receipts taxes. Last year, these taxes (which include retail sales taxes, motor vehicle fuel taxes, and taxes on alcoholic beverages and tobacco products) accounted for 43 percent of total revenues by all state governments. In those states which had a general retail sales tax, for example Ohio and West Virginia, sales and gross receipts tax collections brought in well over half of all general revenues.

License tax revenues made up 11 percent of general revenues by all state governments in 1953. These taxes, the most significant of which are the motor vehicle license fees and

Sales and gross receipts taxes accounted for well over half of Ohio's revenues in 1953; other types of taxes were relatively more important in Pennsylvania and Kentucky.

(Each circle represents total general revenue for the state.)

OHIO	PENNSYLVANIA	KENTUCKY	WEST VIRGINIA	48 STATES
$636,174,000	$772,555,000	$201,613,000	$172,243,000	$14,511,307,000

corporation licenses, were relatively more important in the highly industrialized states of Ohio and Pennsylvania than was the case for the aggregate of all states.

In Pennsylvania and Kentucky, which had no general retail sales tax in 1953, taxes of other kinds made up a larger share of general revenues than was the case for Ohio and West Virginia. For Pennsylvania, the corporation net income tax yielded a substantial proportion of general revenues, while in Kentucky, the individual income tax was an important source of revenue.

Although it is too early as yet to determine accurately what effects the recent decline in business activity may have had on state government revenues, various reports indicate that tax collections have fallen off somewhat as a result of the reduced pace of retail sales and other business activity during the latter part of 1953 and early 1954. So long as the decline in revenues is not too severe, it does not seem probable that outlays will be reduced appreciably in the near future, especially in view of the relatively inflexible nature of numerous commitments by the administrations.

Distribution of Outlays

Highways and educational facilities together accounted for more than half of all general expenditures by state governments during 1953. Outlays for highways alone made up about one-fourth of the total for all state governments, as may be seen from the accompanying chart.

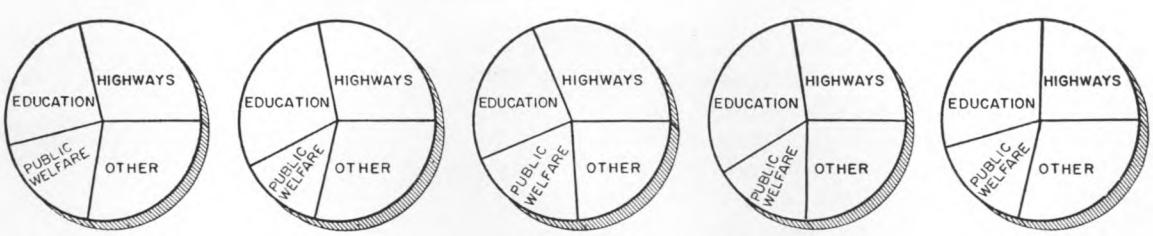
Expenditures for *highways* took a larger share of the budget in each of the four states than was the case for all states in the aggregate. The proportion of total outlays allotted to highways by the four states ranged from 27.4 percent in West Virginia to 31.3 percent in Kentucky. (Of all the states in the nation, Nevada devoted the largest share of outlays to highways, allotting 44.0% of its budget for this purpose in 1953.)

Outlays for highways have risen faster than any of the other major items in state government budgets during recent years. In 1953, highway expenditures totaled over $3.5 billion, an increase of 34 percent since 1950. In spite of the growing emphasis on toll expressways during the post-war period, more than $2.6 billion, or 72 percent of all highway expenditures by state governments in 1953, was spent for regular highway facilities.

Toll highway facilities assumed relatively greater importance in highway expenditures in the Fourth District areas than was the case for most of the other states. In Pennsylvania, outlays in connection with toll highways amounted to over $17 million in 1953, while in West Virginia, almost $12 million was spent on toll highway construction. Outlays for toll highway facilities in Ohio

Highways and educational facilities together accounted for more than half of all general expenditures by state governments during 1953.

(Each circle represents total general expenditures for the state.)



amounted to somewhat less than $6 million during the fiscal year 1953 as initial work on a $300 million project got under way.

Highway expenditures appear to be due for further increases in the years to come. Estimates by the Federal Government indicate a need for annual outlays of at least $5 billion over the next decade to provide for adequate highway facilities for the nation's expanding population. The achievement of such a rate of highway expenditures would provide considerable additional stimulus to general business activity.

Expenditures for *education* by the 48 state governments in 1953 amounted to $4.4 billion or 30 percent of all general expenditures. The share of total outlays allotted to education was somewhat smaller than the national average in three of the four states shown on the accompanying chart. In West Virginia, however, the proportion of the budget spent for education was slightly larger than the national figure.

For the most part, state government outlays for education take the form of grants to local units of government charged with the responsibility for actual operations of public schools. In 1953, such grants to local governments by all states totaled $2.7 billion. State institutions of higher education accounted for most of the balance of education expenditures. Outlays in connection with state colleges and universities totaled $1.3 billion last year.

Expenditures for education seem bound to increase appreciably in the coming years if adequate standards of public education are to be maintained. The full impact of postwar population gains has yet to make itself felt upon the nation's public schools. Estimates based upon birth rates of recent years indicate that substantial increases in the school-age population will continue for a number of years. Although only about a third of the total cost of operating public elementary and secondary schools in fiscal 1953 was assumed by the state governments, increases in educational costs such as can be anticipated for the near future will call for a considerable expansion in state-government outlays for this purpose.

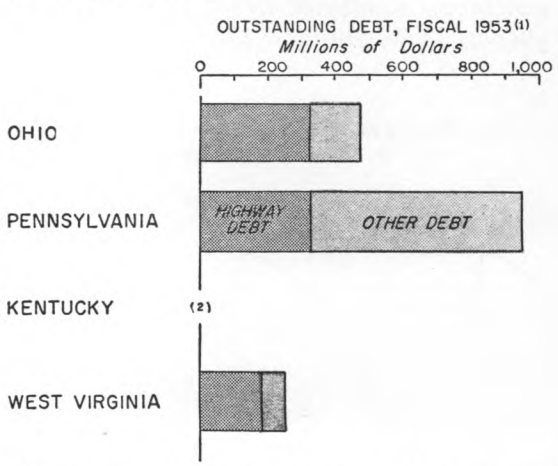
Another important group of state-government functions is summed up under the heading of *public welfare*. Such outlays, which include old-age assistance, aid to dependent children, aid to the blind, etc., totaled over $2.5 billion, or 17 percent of the total budget of all states in 1953. Ohio and Kentucky, as may be seen from the chart, allotted a slightly higher proportion of general expenditures to public welfare than the national average, while Pennsylvania and West Virginia spent a smaller share of their outlays for public welfare.

More than half of total public welfare expenditures by state governments consists of funds obtained from the Federal Government in the form of grants for specific welfare functions. This is the only major area of state government administration where Federal aid provides such a substantial proportion of outlays.

Debt

Total debt outstanding by all state governments amounted to $7.8 billion at the end of the fiscal year 1953. This includes both

More than half of the total debt outstanding in Ohio and West Virginia at the close of fiscal 1953 had been incurred for highways.



(1) End of fiscal year. No allowance made for reserves against outstanding debt.
(2) $10,188,000.

short and long-term debt and makes no allowance for reserves held against the obligations. Highway debt alone accounted for over $3 billion, or more than a third of total obligations.

An accompanying bar chart shows the volume of debt outstanding at the end of the fiscal year 1953 by each of the four states with which the Fourth District is identified.[4] The colored portion of each bar indicates the amount of debt for purposes of highway facilities. Pennsylvania, with obligations totaling $952 million, had the largest volume of debt outstanding at the end of the fiscal year of any of the four states shown. No single function accounted entirely for the relatively large total debt; indebtedness for each of several functions was larger than for the other states.

More than half of the total debt outstanding by Ohio and West Virginia represented indebtedness in connection with highway facilities. The state of Ohio issued $326 million of long-term debt during fiscal 1953 for purposes of construction of a toll highway across the state. This issue accounted for the major portion of the state's total outstandings.

Employment

The 48 state governments employed nearly one million persons out of a total of about six million public employees in all types of government during 1953. As shown on the accompanying chart, this amounted to about 64 full-time state government employees per 10,000 population.

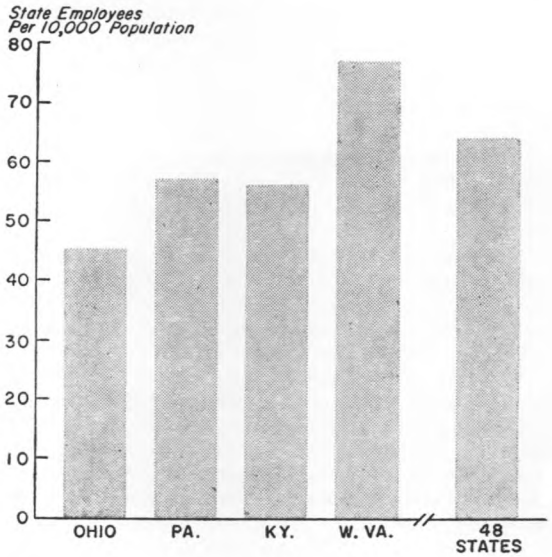
West Virginia had a larger number of employees relative to its population than the average for all states. In Pennsylvania, Kentucky and Ohio, the state governments had fewer employees in relation to population than the national average.

. . .

Almost every phase of state government finance, both income and outlay, has shown substantial increases during the postwar years. Outlays have been rising both as a result of increased requirements by a larger population for the services provided by state governments and as a result of higher costs for these services. Tax revenues have increased also, along with the expanding pace of general business activity.

For a number of years to come, state governments will be under pressure to provide more and more facilities for their residents. These demands result from a backlog of needs built up during the depression period of twenty years ago when lack of adequate funds prevented keeping pace with the needs of the states; the backlog also stems from the war and immediate postwar period of scarcities of materials and from the population growth of the last decade. How well the state governments will be able to provide the required facilities, especially in the area of public education and public highways, will depend on revenues available in the years ahead — the prospect of which revenues makes possible today's borrowing power and spending power.

Ohio had a relatively small number of state employees in relation to population, as of October 1953.



(4) It must be understood that the capacity of various states to sustain successfully a large debt varies for many factors not discussed here, — including population, income of individuals and corporations, statutory debt limits and many other circumstances.

A New Frontier in Metals

By DR. BRUCE W. GONSER, *Battelle Memorial Institute*

SCIENTISTS are probing more deeply into the effects of extremely small or trace amounts of impurities on the properties of metals. By so doing, they hope to find ways to create new materials, make "unusable" metals usable, extend markets for commonplace metals, and open avenues for further engineering progress. Purer metals have already brought new and better alloys for use in making automobile valve springs, ball bearings, jet turbine buckets, nuclear power plants, tool steels, transistors, vacuum tubes, and watch springs.

Most metals have been refined to a state pure enough to determine their principal properties. Purity, in this sense, usually means about 99.9 percent purity. The new frontier in metals is that remaining 0.1 percent before absolute purity.

Trace impurities may involve any element in the periodic table. Not only the common impurities, like carbon, manganese, phosphorus, sulphur, and silicon, must be considered, but also those normally in the gaseous state, oxygen, nitrogen, and hydrogen, and the rarer metallic elements, such as cerium, lanthanum, and thorium.

That trace impurities can control, or even obscure, the true properties of metals is now well demonstrated. A classic example is, of course, titanium, which was brittle and practically useless until a practical method was found to remove the oxygen and nitrogen below the last tenth of a percent. Other metals, like chromium, that are regarded as brittle, are actually ductile in pure or near-pure states.

Removing trace impurities from metals frequently leads to new or improved properties and expanded uses. Zinc is a case in point. The earliest market for zinc was in galvanizing operations. Successive improvements in production processes led to the development of 99.99 percent pure zinc and greatly expanded use of the metal in making die cast alloys for a wide variety of parts.

In some cases, the addition of controlled amounts of trace impurities to metals can lead to desirable properties. For example, the addition of from 10 to 60 parts of boron to every million parts of steel can improve the capacity of certain steels to harden without adversely affecting their physical properties or safe performance.

In the making of transistors, germanium and other semiconductor materials, such as silicon and aluminum-antimony, must be refined to an extremely pure state. Control of electrical properties in the transistor is then obtained by adding to the semiconductor material a very tiny, measured amount of arsenic, indium, or gallium.

Strict control of residual atmospheric gases must be exercised in metals used for oxide cathodes and other electron tube parts. Even after metals of low gas content have been formed into tube components and joined together, further removal of gases is necessary to eliminate traces of oxygen that can "poison" the cathode. Such extreme control of gaseous impurities is required if electron tubes are to operate at peak performance for long periods of time in radios, television sets, and military signal equipment.

Aluminum, refined to 99.99 percent purity and electropolished, permits a wide variety of finishes having a more brilliant, more permanent lustre than is possible with lower grades of the metal. The same type of aluminum, strengthened by alloying with small amounts of magnesium, has given rise to a new series of alloys. Possible applications for these alloys include ornamental trim for automobiles, refrigerators, television sets, and other items where light weight and attractive finish are desirable.

Iron has been used for hundreds of years but there is still much to be learned about it. Studies, for example, show that iron containing less than fifteen parts of impurities for every million parts of iron is unusually soft, workable, and corrosion resistant. The market for this quality iron may never be calculated on a tonnage basis. However, the information gained from its production should be of permanent value in the development of better iron and steel products.

Molybdenum and chromium are both of potential interest as materials of construction in high-temperature applications. Commercially available grades of the two metals, however, contain trace impurities that cause brittleness which may render them unsuitable for such purposes. The preparation of high-purity grades of molybdenum and chromium in the laboratory has brought noteworthy progress towards overcoming brittleness. This progress could lead to increased use of these metals in high-temperature applications.

The mechanical properties of commercially available grades of high-purity titanium and vanadium are sensitive to minute variations of trace impurities of oxygen, carbon, nitrogen, and hydrogen. For example, it has recently been found that the presence of hydrogen in quantities above about 50 parts per million has a very detrimental effect on the impact or shock resistance of certain titanium alloys. Future development of titanium for existing and new applications will require closer control of impurities. The same applies to high-purity zirconium, which is about as sensitive to oxygen, carbon, and nitrogen as titanium.

Enough has been learned about the effects of trace impurities on metals to convince scientists that the full potentialities of metals are still to be realized. As more knowledge is acquired about the effects of trace impurities and as better methods are developed for removing and controlling them, expanded versatility for both old and new metals should result.

Editor's Note—While the views expressed on this page are not necessarily those of this bank, the *Monthly Business Review* is pleased to make this space available for the discussion of significant developments in industrial research.