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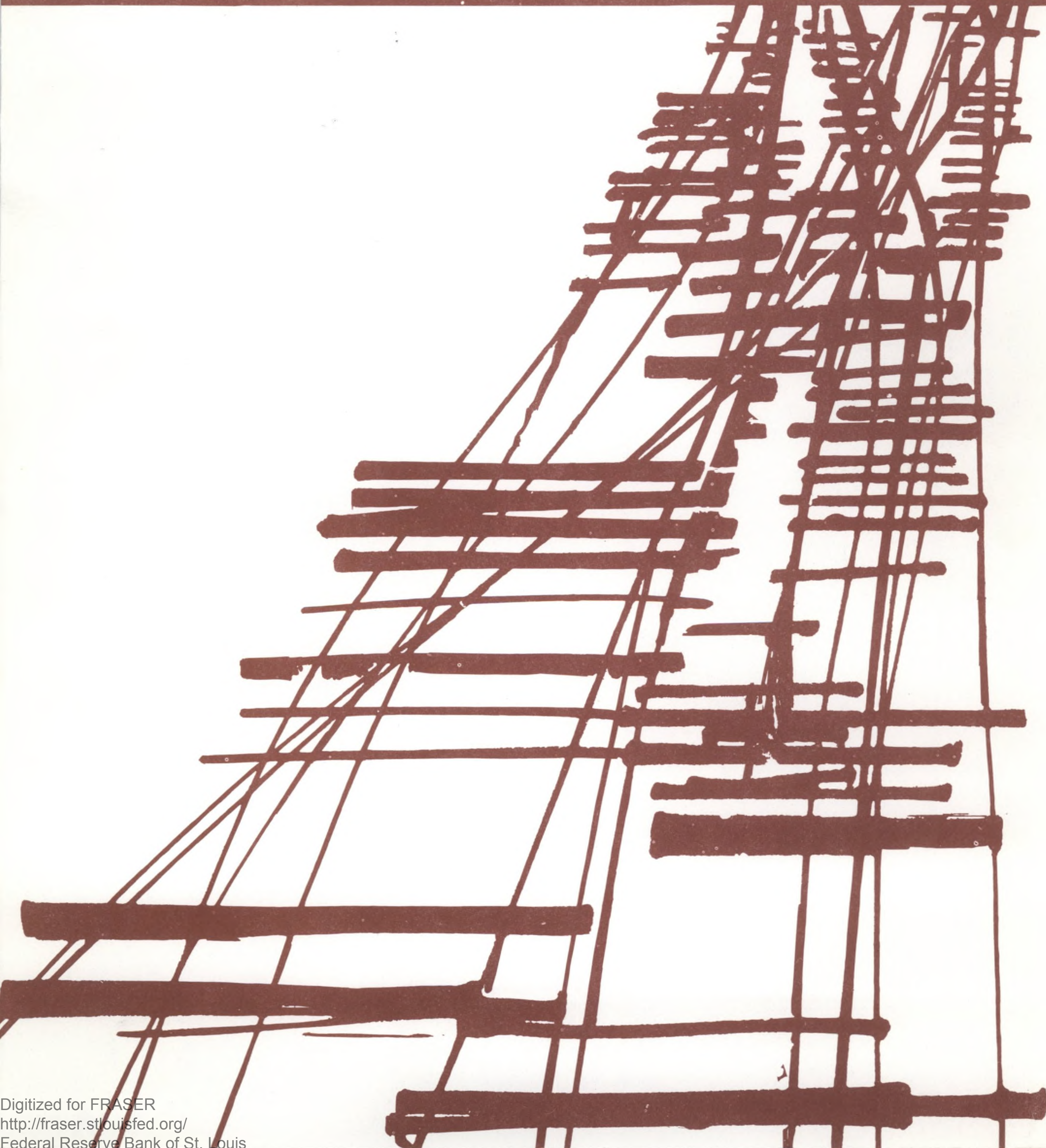
Bulletin 1717

U.S. DEPARTMENT OF LABOR
Bureau of Labor Statistics



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U.S. DEPARTMENT OF LABOR
J. D. Hodgson, Secretary

BUREAU OF LABOR STATISTICS
Geoffrey H. Moore, Commissioner

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Preface

This bulletin describes changes in technology in the Railroad Industry, one of the major industries of the economy, projects their impact on productivity, employment, and occupational requirements, and discusses methods of adjustment. It is one of a series of reports designed to help meet the requirement of the Manpower Development and Training Act that the Secretary of Labor "evaluate the impact of and benefits and problems created by automation, technological progress and other changes in the structure of production and demand on the use of the Nation's human resources; establish techniques and methods of detecting in advance the potential impact of such developments; . . ."

The study was based on discussions with company, union, and government officials and with railroad equipment manufacturers. It was based also on attendance at conferences and exhibits as well as on information obtained from Bureau sources and others in government, and on trade and technical publications. The Bureau of Labor Statistics is deeply grateful to many individuals who furnished valuable information and reviewed and commented on the draft of this report. Special acknowledgement for photographs is due the Association of American Railroads, Reading Lines, Western Maryland Railway, Louisville and Nashville Railroad, Santa Fe Railway, Norfolk and Western Railway, Seaboard Coastline Railroad Company, Illinois Central Railroad Company and *Railway Age*.

This bulletin was prepared by Richard Johnson under the supervision of Morton Levine. Mable Elliott prepared the material on communications and assisted in the research and the preparation of statistical material for many parts of the report. The chapter on worker adjustment is based on research materials collected by Audrey Freedman and Kenneth Levin. The study was made in the Office of Productivity and Technology under the general direction of John J. Macut, Chief of the Division of Technological Studies.

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Summary and Highlights

The railroad industry is an excellent example of an industry that has undergone technological change almost continuously since its inception in the early 19th century. These changes, as well as railroad mergers, consolidations, line and facility abandonments and passenger train discontinuances, have often contributed to increased output per man-hour (productivity) and frequently have had important manpower and employment implications.

This report examines the technological changes that are currently affecting the industry and evaluates their future impact on productivity, manpower and labor-management relations. The following summary highlights the major elements of the report.

Technology in the 1970's

Modernization of the railroads in terms of adoption of technological advances in equipment, procedure and plant, advanced management techniques and an enterprising approach to the marketing of rail services has recently enabled the industry to achieve and maintain a relatively stable share of all intercity freight traffic. The degree of this trend toward modernization differs among the various railroads, influenced to a large degree by the availability of capital.

During the 1970's one of the more important technological advances in the industry will be the widespread use of computers. This change will permit the continued diffusion of the automatic car identification system (ACI), and will allow for improvements in other areas such as recordkeeping. Basically the ACI system accounts for the whereabouts of cars and their contents by the computer. ACI will make it easier to establish regional control points for keeping inventories of cars owned by several roads. With growing use of computers for train operations such as dispatching and scheduling, train mileage under centralized traffic control (CTC) will probably also continue to increase. The number of automatic classification yards with reliance upon computer control of retarders for braking and switching of cars also is likely to grow. Route mileage of railroad microwave is likely to expand greatly because of the growing volume of data, voice message traffic, and facsimile transmission. The diffusion of the more powerful and more maintenance-free second generation diesel locomotives will continue through the 1970's; by 1975, these may account for two out of every three locomotives, compared with one out of every four in 1967. Piggyback transportation may possibly reach 1½ to 2 million carloadings by 1975, up from about 1.3 million in 1969; the use of unit trains, another form of expedited freight transportation is expected to grow over the same period. Mechanization of maintenance-of-way activities will continue to increase because of growing use of multipurpose machinery and upgrading of other tools which the work force will use.

Potential for productivity growth

For the past 20 years, output per man-hour in the railroad industry has increased rapidly, placing it among the industries with the highest average increases in productivity. During the 1947–60 period, the average change was 4.3 percent per year. During the recent 1960–70 period, output per man-hour has increased more rapidly than over the 1947–60 period—averaging 6.0 percent annually. This higher rate of increase is expected to continue into the early 1970's. Among the sources of productivity growth are the widespread diffusion of technological developments noted earlier.

In addition, increases in capital efficiency resulting from larger capacity, longer trains, and more powerful locomotives, as reflected in various indicators such as car-miles per car-day and gross ton-miles per train mile, also point to continued gains. The number of miles a car can travel each day and its level of gross-ton-miles per train-mile are expected to continue to rise because of the wider diffusion of more powerful second-generation diesels and the increasing use of light weight, specialized freight cars. The relatively new practice of using unmanned remote control locomotives in the middle of long trains will also contribute to the anticipated rise in gross ton-miles per train mile.

Traffic prospects

After World War II, freight traffic fluctuated around a level which, although nearly double its prewar volume, was substantially below wartime traffic. However, from 1961 through 1969, the amount of freight carried by the railroads rose sharply, surpassing previous records established during World War II. Even though this upward trend is likely to continue, the railroads may not be able to increase their relative share of freight traffic carried, which was about 41 percent in 1968 and 1969 after having remained at about 43 percent over the 1961–67 period.

Long-haul (noncommuter) railroad passenger traffic continued its long-term decline during the 1960's. The possibility of reversal of this trend depends on many factors, including the successful outcome of such innovations as the operation of high speed corridor trains like the Penn-Central Metroliner and "Amtrak," The National Railroad Passenger Corporation now operates most of the country's intercity passenger trains.

Employment outlook

Employment in the class I railroad industry had dropped to 578,277 workers in 1969, from nearly 1.4 million persons in 1947, because of new developments in technology, competition from other modes of transportation, mergers, and consolidations. Total employment is expected to decline further even if the economy continues to grow at its long-term average rate. Nevertheless, an estimated 235,000 job openings are expected, as a result of the number of retirements, between 1967 and 1975. However, in spite of declining employment levels, the unemployment rate in the industry is lower than for the economy as a whole, reflecting, in part, prevailing worker adjustment provisions found in union-management agreements.

Occupational trends

Since 1957, the most recent and relevant period in terms of occupational change, declines in employment have taken place in every major occupational group in the industry. However, the proportion of total employment represented by specialized and high-level manpower has tended to rise. Employment in selected professional and clerical occupations has been rising because of changes such as the introduction of the computer, and new directions in management and marketing operations. In the case of skilled labor, where proportionate declines have occurred, these changes have been relatively small. Occupations requiring little formal education, training, or experience, such as helper or laborer, have been most adversely affected.

Women employed by railroads

Since the end of World War II, women have represented about 6 percent of total railroad employment and about three-fourths of them work in office occupations. Because the impact of technology and other changes on office employment has been less severe than on class I railroad employment generally, and because of the increasing need for operating data, employment prospects will continue to be relatively good for women.

Minority group employment

Employment prospects for minority group workers are improving. Shortages of employees in various technical fields are likely to continue, opening many opportunities for higher-level employment to qualified employees, including members of minority groups. At present, Negroes and persons with Spanish surnames make up a relatively small proportion of railroad employment and are found mainly in blue collar jobs (often as operatives or laborers) and in service occupations.

Adjustment to technological change

Adjustments to problems arising from technological change are covered by an extension of some principles and provisions of the "Washington Agreements of 1936," originally designed to protect employees faced with layoff because of consolidation and coordination of facilities. Only since the 1950's have specific provisions for such problems been included in nationwide contracts, notably in those covering nonoperating shopcraft and nonshopcraft employees. These contracts include a number of protective provisions: advance notice of proposed technological change; moving allowances, and retraining rights and benefits. They include also various guarantees of job security, like crew size regulations, transfer rights, limitations on subcontracting of work and provisions for shorter work periods; income maintenance plans; and unemployment and retirement benefits. Resolution of worker adjustment problems arising from technological and related changes may continue to be a key determinant in the railroad industry's future development.

Chapter I. The Changing Railroad Industry

The railroad industry, for nearly a century the Nation's primary means of shipping freight, employed about 578,000 workers in the class I sector or about one out of four transportation employees engaged in intercity commerce in 1969.[1] Like many other old and established industries, the railroads have gone through various phases of rapid growth, stability, decline, and revival. Due to competing modes of transportation, railroad passenger traffic has declined precipitously since the close of World War II. Trains now rank below the private automobile, bus, and air transportation as a carrier of passengers. Nevertheless, the railroads carried a higher proportion of ton-miles of freight in 1969 than any other mode of transportation, even though their share of freight business has been dropping since 1947. (See tables 2 and 3 for detail.)

This chapter briefly defines the industry, describes its relationship to other industries and sets forth its changing competitive position. It provides the background for subsequent chapters on technological innovations and their implications for productivity, employment, job requirements, training needs, and manpower adjustment procedures.

Definition of the Industry

The industry (SIC 40), includes companies mainly engaged in line-haul railroad operations (SIC 4011), such as electric railroads and interurban railways and the building, rebuilding, and repairing of locomotives and cars by railroad companies. It also includes switching and terminal companies (SIC 4013), which provide terminal facilities for passengers and freight in line-haul service and which move railroad cars between terminal yards, industrial sidings, and other places. Also, it includes companies operating sleeping and other cars to furnish berths and seats to passengers, and companies furnishing dining car service (SIC 2021)[2] as well as railway express service (SIC 4041). The railroad transportation industry does not include railway companies that provide commuter services only within a single municipality, contiguous municipalities, or a municipality and its suburban areas. Railroads are primarily engaged in providing freight and passenger transportation, but in carrying out this function, their varied activities also include manufacturing of railroad cars and other equipment they use as well as a construction program that carries out major capital improvements.

The railroad industry—a coordinated system

One of the salient features of railroad technology is the ability of the industry to function as an integrated system, because of standardization of equipment and track achieved in the last half of the 19th century. Previously, there had been 24 different gauges of railroad track with widths ranging from 2 to 6 feet. When a shipment moved from one company area into the territory served by another, freight and passengers were necessarily transferred to different cars, resulting in a great deal of unloading and reloading. Today, use of standard track and cars, assisted by modern communications, expedite integrated operations by several hundred companies. Cars of industry-approved design equipped with standard coupling arrangements shuttle from one part of the country to another by the switching of whole carloads at interchange points. The most important result of this standardization is to permit the industry to operate nationwide some 28,000 locomotive units, 18,000 passenger train cars and more than 1.8 million freight cars over a nationwide system of 320,000 miles of track.

[1] The study is concerned with class I railroads, of which there were 76 in 1968, defined by the Interstate Commerce Commission (ICC) as companies reporting average revenues of $5 million or more for 3 years, consecutively. These railroads account for 87 percent of total railroad employment and 98 percent of total freight revenue ton-miles.

[2] The Pullman Company, which has long been the principal company in the industry (SIC 4021), turned over its sleeper service to the railroads as of Jan. 1, 1969.

Relationship to other industries

In 1969, class I railroads originated (were the initial carriers), 1.5 billion tons of freight and transported 296 million passengers. Despite the rise of other methods of transportation, railroads remain the crucial link in the nation's system of production. Any prolonged interruption in rail service would curtail operations in many of the country's largest industries, where they connect various stages of production. For example, trains haul iron ore from concentrating plants to furnaces, steel slabs from primary casting facilities to rolling mills, and alumina from initial refining plants to reduction or smelting plants. Electric power production relies to a great extent on coal hauled by railroads from the mine.

Railroads also represent the major mode of transportation for moving the goods produced by many industries. For example, in 1967 over 50 percent of ali product ton-miles were carried by the railroads in the following industries: Food and kindred products; tobacco products; lumber and wood products; pulp paper and allied products; stone, clay and glass products; chemical and allied products; primary metal products; transportation equipment; and waste as scrap material. The railroads also carried a very high proportion of goods produced in industries such as furniture and fixtures; fabricated metal products; and machinery including electrical machinery. (See table 1.)

Changing competitive position of the railroads

The changes in the relative position of various transportation modes are illustrated by the statistics on constant dollar gross product originated, which cover the entire output, both passenger and freight traffic. Gross product originated in the railroads declined between 1947 and 1961, but the figure has risen since 1961. (see table 2.) Gross product originated in the other transportation sectors has also risen steadily since 1961, growing at a faster rate in air transportation and motor freight than in the railroad industry.

Since 1947, transportation as a whole has declined in relative importance in the economy with railroads furnishing a substantial part of the decline. For example, in 1947 railroads accounted for 3.5 percent of the all-industry total but, by 1969 had decreased to 1.6 percent. Gross product originated in all industries (in constant dollar terms) grew by 135 percent in the 1947–69 period, compared with a 64 percent increase in all transportation industries. Almost all of the growth in transportation was accounted for by a 284 percent increase in motor freight and a 1,500 percent growth in air transportation. During the early years of the period (1947–61), gross product originated in local and highway passenger transportation (not shown separately) decreased sharply as private automobile traffic rose after World War II. This decline in local

Table 1. Ton-miles of shipments—means of transport and commodity, 1967

Transport commodity code [1]	Commodity	Ton-miles of shipments (millions)	Percent distribution by means of transport							
			All means of transport	Rail	Motor carrier	Private truck	Air	Water	Other	Unknown
20	Food and kindred products	91,854	100.0	66.1	21.1	9.9	....	2.6	0.1	0.2
21	Tobacco products	1,146	100.0	64.0	25.1	.4	0.1	9.8	.2	.4
22	Basic textiles	5,925	100.0	15.8	64.6	16.6	.2	2.0	.8	....
23	Apparel, including knit apparel, and other finished textile products	2,331	100.0	12.2	67.7	8.3	1.9	.5	9.3	.1
24	Lumber and wood products, except furniture	45,145	100.0	77.9	5.4	6.8	....	9.8	....	.1
25	Furniture and fixtures	3,860	100.0	33.4	48.9	13.4	.1	3.4	.6	.2
26	Pulp, paper, and allied products	36,333	100.0	77.4	15.2	3.9	....	2.9	.4	.2
28	Chemical and allied products	62,117	100.0	60.2	20.3	4.5	.1	14.6	.2	.1
29	Petroleum and coal products	288,356	100.0	3.4	1.8	.7	....	94.1	....	....
30	Rubber and miscellaneous plastic products	5,754	100.0	34.2	56.8	6.0	.5	.4	1.8	.3
31	Leather and leather products	694	100.0	8.7	63.9	18.2	.6	.7	7.8	.1
32	Stone, clay, and glass products	25,525	100.0	50.8	31.9	9.8	....	7.3	.1	.1
33	Primary metal products	51,756	100.0	60.2	25.5	3.9	....	10.2	.1	.1
34	Fabricated metal products	14,262	100.0	39.7	46.0	10.1	.5	2.9	.7	.1
35	Machinery, except electrical	12,341	100.0	39.1	48.2	8.3	.9	.9	2.5	.1
36	Electrical machinery and equipment	8,781	100.0	42.8	46.0	6.5	1.4	.8	2.4	.1
37	Transportation equipment	16,350	100.0	72.6	21.9	3.9	.4	.8	.3	.1
38	Instruments, photographic goods, optical goods, watches, and clocks	665	100.0	30.5	57.0	2.7	4.0	.4	5.0	.4
39	Miscellaneous products of manufacturing	1,629	100.0	28.6	54.9	8.3	.4	1.2	5.7	.9

[1] The basis for classifying commodities in the Census of Transportation.

SOURCE: **1967 Census of Transportation,** "Commodity Transportation Survey," U.S. Department of Commerce, Bureau of the Census, Pages 30–53.

Table 2. Gross product originated in transportation, by mode, selected years, 1947–69
[billions of 1958 dollars]

Year	All industries, total (GNP)	All transportation, total	Railroads, SIC 40	Air transportation, SIC 45	Motor freight and warehousing, SIC 42	All other transportation [1]
1947	309.9	21.1	10.7	0.4	3.1	6.9
1957	452.5	22.5	9.5	1.5	6.4	5.1
1961	497.2	22.5	8.7	1.9	7.5	4.4
1962	529.8	23.8	9.2	2.1	8.0	4.5
1963	551.0	25.2	9.7	2.4	8.5	4.6
1964	581.1	26.2	10.2	2.7	8.6	4.7
1965	617.8	28.6	11.0	3.3	9.7	4.6
1966	658.1	31.2	11.7	4.2	10.5	4.9
1967	675.2	31.4	11.2	5.1	10.4	4.8
1968	707.2	33.3	11.3	5.8	11.1	5.0
1969	727.1	34.5	11.3	6.4	11.9	4.9
	Average Annual Percent Change					
1947–61	3.4	0.5	−1.5	11.8	6.5	−3.2
1961–69	4.9	5.5	3.3	16.4	5.9	1.4

[1] Standard Industrial Classifications 41 (local and highway passenger), 44 (Water transportation), 46 (Pipeline), and 47 (Transportation services).
SOURCE: U.S. Department of Commerce.

and highway passenger transportation is reflected in a decrease in gross product originated in the category "all other transportation."

In the 1961–69 period, growth occurred in all transportation categories shown. In recent years, the railroads have been making a concerted effort to retain existing traffic and to generate new traffic, thus reversing the decline that had occurred earlier. However, the growth of railroads has not been keeping pace with that of other modes of transportation. Total transportation output grew by 53 percent during the 1961–69 period while railroad growth was only two-thirds as great, motor freight was approximately equal to this total growth, and air transport growth about 5 times as fast. A major reason for the slower rate of growth in railroads was the continuous decline in rail passenger service, offsetting some of the gains in freight carriage. The following two sections give more details of actual volume of traffic moved by various modes, as estimated by the Interstate Commerce Commission.

Freight Traffic. In 1939, the first year for which an estimate of traffic carried by various transport modes was published by the ICC, railroads accounted for over 64 percent of total freight traffic, although motor vehicles already carried over 9 percent. The railroads' position was then enhanced, relative to both motor transportation and water transportation, during World War II, because of wartime induced shortages (see table 3). Beginning in 1947, the railroads' share of freight traffic declined steadily, stabilizing at 43 percent in 1961, and declining only slightly since then. During the same time, trucking increased its share from 9.6 percent to 21.3 percent, while water transportation and pipelines also increased their relative shares—the latter doubling its percentage of the traffic.

Passenger Traffic. In 1944, an all-time high point in rail carriage of passengers, the railroads accounted

Table 3. Percent distribution of total estimated intercity ton-miles of freight, by mode, selected years, 1939–69

Year	Total ton-miles (billions)	Percentage distribution [1]			
		Rail [2]	Motor vehicle	Inland waterway and great lakes	Pipeline
1939	574.8	64.4	9.2	16.7	9.7
1947	1,060.8	66.6	9.6	13.8	9.9
1957	1,354.0	47.6	18.8	17.1	16.5
1961	1,310.3	43.5	22.6	16.0	17.8
1962	1,371.5	43.8	22.6	16.3	17.3
1963	1,454.4	43.3	23.1	16.1	17.4
1964	1,542.8	43.2	23.1	16.2	17.4
1965	1,638.6	43.3	21.9	16.0	18.7
1966	1,747.4	43.0	21.8	16.1	19.1
1967	1,757.3	41.6	22.1	15.6	20.5
1968	1,834.3	41.3	21.6	15.7	21.3
1969 [3]	1,894.2	41.2	21.3	15.6	21.7

[1] Air cargo excluded as amount carried is only 0.2 percent in 1969.

[2] Because of data limitations, rail figures for years 1939–57 include nonrevenue ton-miles; thereafter coverage is for revenue ton-miles only. In 1959, the figure including nonrevenue ton-miles was 599.3 billion ton-miles compared with 582.5 billion excluding nonrevenue ton-miles.

[3] Preliminary.

SOURCE: Interstate Commerce Commission.

for 75 percent of the intercity total carried by public transportation, and the airlines only about 2 percent. In the years since World War II, the airlines and the railroads have reversed their relative positions in passenger miles carried by public carriers. By 1969, the airlines accounted for over 70 percent of all passenger miles carried by public carriers, the railroads less than 8 percent. (See table 4.)

Private automobiles continue to carry the major share of total intercity passenger miles. In 1947, they carried 273 billion passenger miles or 78 percent of the total; by 1969, they carried over 3 times the 1947 level, or about 86 percent of all intercity travel.

Changing structure of the industry

One of the significant changes in the industry has been the reorganization of railroads into fewer but larger companies through mergers. The current merger movement in the railroad industry dates from January 1955, when the Interstate Commerce Commission was petitioned to approve the merger of two southern railroads, effective August 1957. This merger followed by 10 years (1947) the last major merger approved by the ICC. On the other hand, it was the first of 17 significant mergers involving class I railroads, effected between 1957 and 1969.

Altogether, 31 companies were involved in the 17 mergers, some having been affected more than once. By early 1969, these 31 companies had been reduced to 11. For the industry as a whole, merger, purchase, and control of other railroads had reduced the total number of operating railroads from 415 in 1957 to 370 in 1967.[3] Accompanying this general decline was a decrease in the number of railroads that operated over 1,000 miles of road—from 40 in 1957 to 34 at the end of 1967. However, the percentage of miles of road operated by these companies increased from 85.2 percent of the total to 86.4 percent over the same period. As of July 1, 1969, there were 13 companies seeking to merge with other railroads.

Marketing and managerial changes

Important changes in railroad management in the 1960's have turned the absolute decline in rail traffic into a gain and stabilized the railroads' competitive position with respect to total intercity freight traffic. First, there has been a reorientation from a relatively passive approach to marketing of services to an aggressive search for new business. Second, there has been an increased emphasis on the recruitment of more broadly trained personnel—frequently from colleges—contrasted with the traditional railroad progression "up through the ranks."

Traditionally, the railroads have focussed on the carriage of commodities for which they are uniquely suited—notably, high density, bulky cargoes with low unit values. (See table 5.) As a result they allowed high unit value cargo to go to the trucking in-

[3] Includes classes I, II, and circular and unofficial railroad companies.

Table 4. Distribution of intercity passenger traffic in the United States by mode, selected years, 1949–69
[Billions of passenger-miles]

Year	Total intercity travel	Private automobile	Public carriers			
			Total[1]	Railroads and electric railways	Buses	Air carriers
1944	280.3	151.3	131.0	97.7	26.9	2.2
Percentage	100.0	54.0	100.0	74.7	20.5	1.7
1947	351.6	273.0	78.6	46.8	23.9	6.1
Percentage	100.0	77.6	100.0	59.5	30.4	7.8
1957	748.3	670.5	77.8	26.3	21.5	28.1
Percentage	100.0	89.6	100.0	33.8	27.6	36.1
1967	1,020.6	889.8	130.8	15.3	24.9	87.2
Percentage	100.0	87.2	100.0	11.7	19.0	66.7
1969[2]	1,130.0	977.0	153.0	12.0	26.0	111.0
Percentage	100.0	86.4	100.0	7.8	17.0	72.6

1 Addition of the separate sectors in the public carrier section add to less than the amount shown in the "total" column due to the omission of passengers carried by water.

[2] Preliminary.

SOURCE: Reports of the Interstate Commerce Commission; Civil Aeronautics Board; and Corps of Engineers, U.S. Army.

Table 5. Commodities carried: class I railroads, 1968

Commodity groups, ranked by tonnage	Revenue freight originated (millions)		Percent distribution [1]	
	Carloads	Tons	Carloads	Tons
Total (excluding small packaged freight)	27.6	1,430.4	99.8	100.0
Coal	5.2	379.1	19.0	26.5
Nonmetallic minerals, excluding fuel	2.3	170.7	8.4	11.9
Farm products	2.3	116.0	8.2	8.1
Metallic ores	1.4	111.7	5.2	7.8
Food and kindred products	2.8	105.2	10.0	7.4
Lumber and wood products, excluding furniture	2.1	98.1	7.7	6.9
Primary metal products	1.7	91.0	6.0	6.4
Chemical and allied products	1.6	87.1	5.9	6.1
Stone, clay and glass products	1.4	77.3	5.0	5.4
Pulp, paper and allied products	1.2	40.8	4.3	2.8
Waste and scrap material	.8	34.5	2.9	2.4
Petroleum and coal products	.8	28.9	2.4	2.0
Transportation equipment	1.2	27.3	4.4	1.9
Fabricated metal products, excluding ordnance, machinery and transportation	.5	12.5	1.6	.9
Miscellaneous mixed, excluding forwarder and shipper association traffic	.5	10.6	1.8	.7
Freight forwarder traffic	.3	4.7	1.0	.3
All others	1.7	35.6	6.0	2.5

[1] Percentages do not add to 100 percent due to rounding.

SOURCE: Interstate Commerce Commission Statement 69100.

dustry by default. In the mid-1950's, some railroads set about stemming traffic declines by setting up marketing offices, which took on a more aggressive marketing stance. Salesmen with research reports and cost-benefit analyses actively demonstrated potential savings to prospective customers.

Investment and modernization

Capital investment in new plant and equipment in the railroad industry averaged $1.4 billion a year over the 1947–69 period; these expenditures ranged from a low of $800 million in 1961 to a high of $2.4 billion in 1966. Expenditures in the 1947–57 period averaged $1.3 billion, then dropped to an average of $1.1 billion in the 1957–61 period. During the 1960's (1961–69), these expenditures rose to reach an average of $1.6 billion. Appendix I-1 shows year-by-year figures for capital investment. These figures, however, do not include all outlays for new equipment rented and leased. The Association of American Railroads (AAR) estimates that in 1969 leases and rented equipment added about $400 to $500 million to class I railroads' outlays. Specific examples, of these quasi-capital expenditures include the leasing of over 150,000 tank cars, as well as rental of computers. As of January 1969, the railroads paid an average monthly rental of $3.5 million for computers.

Table 6, which shows a percentage distribution of gross capital expenditures by category, is based on figures reported to the Interstate Commerce Commission. It serves to illustrate how, in the recent past, capital expenditures have been allocated by class I railroads. Over the 10-year period, 1956–65, expenditures for new rollingstock—diesel locomotives and cars—accounted for about 70 percent of the $10.7 billion spent; next in importance were expenditures for right-of-way, track, and structures and improvements which accounted for 17 percent of the cumulative total. The purchase of roadway machines and the installation of communications and signaling equipment accounted for another 6 percent of the total. In recent years, the emphasis in capital expenditures appears to have been shifting toward these latter two areas.

It has been suggested that expenditures include provisions both for regular replacement of equipment and also for an expansion of capacity to meet

Table 6. Percentage distribution of gross capital expenditures of class I railroads, by category, 1956–65

Description	Percent of total expenditures 1956–65 [1]
Total	100.0
Locomotives [2]	15.6
Freight and passenger cars [3]	54.6
Right of way, track, and structures improvements [4]	16.9
Roadway machines [5]	1.6
Communications and signalling [6]	4.4
All others [7]	6.8

[1] Percentages do not add to 100 percent due to rounding.

[2] Interstate Commerce Commission (ICC) account numbers 51, 52.

[3] ICC account numbers 53, 54.

[4] ICC account numbers 1–7, 8–12, 13–24.

[5] ICC account number 37.

[6] ICC account numbers 26–27.

[7] All other numbers, table 138, part I, **transport statistics in the United States ICC.**

SOURCE: Interstate Commerce Commission.

requirements of future growth of the economy. This means that railroad capital expenditures should remain approximately constant relative to all industry capital expenditures. However, railroad investment has not kept pace with investment in all other industries, nor in other transportation modes in these relative terms. While other transportation modes have retained their relative position in the framework of all industry capital expenditures, railroads have not. (See appendix I-1 for absolute and relative figures.)

The anticipated goal for capital expenditures stated by the Association of American Railroads in the mid-1960's—$2 billion per year through 1975—was far in excess of current experience.[4] Moreover, a 1970 restatement of these capital requirements puts industry needs at a higher figure—about $3.6 billion per year between 1970 and 1980.[5] The difference between industry goals and current experience implies that maintaining or improving the railroads' share of total intercity traffic will be a major challenge.

This lag in capital investment is a contributing factor in the average age of capital equipment, which among railroads tends to be older than in other industries. A 1966 survey by McGraw-Hill showed that railroads have 49 percent of their capacity in equipment "over 16 years" old.[6] As can be seen in table 7, which compares the age of capital equipment in 1966 with 1962, "other transportation" has maintained its 1962 distribution of capacity by age. By contrast, in the railroad industry the proportion of capacity more than 16 years old has increased substantially.

The significant rise in the percent of railroad equipment found in the "over 16 years" category in 1966 compared with that of 1962 probably stems from two major causes, in addition to a lagging capital investment program. First, the large amounts of capital equipment purchased between the end of World War II and the Korean conflict entered the "over 16 years" category in the brief period between 1962 and 1966. Second, it is likely that rather large amounts of older capital equipment (relevant particularly to the car fleet) were held in use, rather than retired, during the high demand for railroad service that characterized the period of the early and mid-1960's. It should be borne in mind, however, that the proportion of railroad equipment in the "over 16 years" category might go still higher and yet be within bounds of a "normal" replacement schedule because of the extremely long-lived nature of much railroad equipment (over 25 years).

Table 7. Percentage distribution of age of industrial capacity, spring 1962 and December 1966

Industry	More than 16 years	11–16 years	6–10 years	0–5 years
AS OF SPRING 1962				
Railroads	39	19	23	19
Other transportation and communications	19	15	22	44
All manufacturing	24	16	27	33
AS OF DECEMBER 1966				
Railroads	49	20	13	18
Other transportation and communications	19	16	23	42
All manufacturing	24	19	21	36

SOURCE: McGraw-Hill (Nov. 25, 1966).

In the future, the industry's efforts to modernize will depend, to a great extent, on the amount of funds available from different sources. In earlier periods, the railroads financed capital expenditures primarily from internally generated funds (retained earnings, both undistributed profits and capital consumption allowances). However, debt financing was extensively used after World War II. A continued decline in the rate of return on net investment (original cost of transportation equipment, less depreciation and amortization plus cash and materials) from 2.9 percent in the 1957–67 period to 2.5 percent in 1968 and 1969 has made financing through internal generation of funds increasingly difficult in recent years. Although retained earnings (internally generated funds) still provide over half of the money for capital investment, debt financing has become increasingly important. For example, during the 1957–67 period, debt certificates issued (bonds and equipment trust certificates) amounted to 49 percent of the funds reported for capital expenditures. Equipment trust financing—a special debt form wherein the ownership is retained by the lender until the loan has been repaid in full—is becoming increasingly important and has accounted for over one-third of the $7.7 billion raised through debt financing in the 1957–67 period. (See appendix I-2 for year-by-year figures on methods of debt

[4] *Technological Trends in Major American Industries,* U.S. Department of Labor, Bulletin 1474, 1966, pp. 196–97.

[5] *American Railroad Industry: A Prospectus,* America's Sound Transportation Review Organization, Association of American Railroads, Washington, D.C., June 1970.

[6] "How Modern is American Industry?" McGraw-Hill, Nov. 25, 1966, table 1. More recent data being compiled was not available while this report was being prepared.

financing.) Stock issued during the 1957–67 period amounted to only about 0.5 percent of the reported capital expenditures.

Research and development

The need for greater efficiency in the face of rigorous intermodal competition has led to increased emphasis on research and development expenditures in the railroad and in its supply industries. Research and development (R&D) in this industry is a continuous process which has led to numerous changes in equipment, methods, and materials, many of which are discussed in chapter II.

Surveys on research and development expenditures carried out by *Railway Age* in 1960 and 1966, provide some information on the growth of such expenditures by railroad companies. The relationship between these company expenditures and those of the Association of American Railroads for R&D can be seen in table 8.

This relationship exists because company research efforts are generally geared to the problems of individual companies, AAR research to the entire industry's needs. The Association has traditionally worked on problems that relate to industry-wide technical standards and equipment certification. In 1969, the President of the AAR pledged a change in the Association's research effort leading to both a separation of the testing and research programs, and also increases in the amount of money to be spent in both categories.

Research performed by suppliers complements the individual companies and the AAR's. For example, a company may define a particularly vexing problem to a supplier, asking him to develop and build some type of special equipment, within specified costs. According to the *Railway Age* survey, 32 suppliers spent almost $33 million in 1965 for R & D and the anticipated 1966 figure was close to $30 million.

Table 8. Research and development related to railroad industry[1], selected years 1960–66

Year	Industry		Suppliers
	Companies	AAR	
1960	$6,000,000	$1,000,000	$35,000,000 (est.)
1961	5,400,000 (77)	N.A.	15,000,000 (132)
1965	42,000,000 (22)	N.A.	32,900,000 (32)
1966	48,000,000 (22)	1,272,800	29,800,000 (32)

[1] Parenthetical numbers indicate companies covered by survey.
SOURCE: Railway Age, Apr. 18, 1966.

The U.S. Department of Transportation (DOT) now has the major responsibility for government-sponsored research in the field of railroad transportation. Formerly, this activity was divided with the Department of Housing and Urban Development (for mass transit). One major DOT demonstration project is now taking place in the northeast corridor to test customer response to fast, comfortable rail transportation between New York City and Washington, D.C. During the initial operation minimum time for non-stop "Metroliner" service was 2 hours and 30 minutes. During the first 6 months of operation—through mid-July 1969—all rail passenger service in the corridor increased 11 percent. The number of passengers traveling the full distance between the 2 cities had risen by 72 percent, mainly "Metroliner" passengers. The new trains were filled to 76 percent capacity, a level 50 percent higher than that for conventional trains; passenger traffic on regular trains has also increased slightly. Computerized ticket sales were instituted in 1969 to decrease the need to wait in line for ticket purchase.

Another major Federally sponsored demonstration project is the New York-Boston "Turbotrain," put into operation in April 1969. The three-car trainset, making one round trip between the two cities, and stopping at four intervening locations, is scheduled to make the trip each way in 3 hours and 39 minutes. Thus far, the service provided has been limited.

Chapter II. Technological Change in the 1960's and 1970's

This chapter presents information on the major technological and procedural changes that have been taking place in almost all operating departments of the railroads in the past decade. These innovations include (1) equipment subjected to a major change, (2) a completely new piece of equipment, or (3) a series of minor changes in a particular operation. The common denominator of these items is the significant implication for the industry's labor force. Effects of these changes on employment and occupations are discussed in detail later in chapters IV and V.

Background

Technological changes in the railroad industry have been introduced in response to pressure from competition by other modes of transportation and from rising wage rates, fuel, and material prices. Changes have been a part of overall efforts to cut costs and to provide better services. While many changes have been accepted, the process has been gradual, extending over a long period of time. The factors preventing the immediate acceptance of the diesel locomotive illustrate well the economic constraints slowing many technological advances. For example, when the diesel locomotive was introduced, it could not be immediately adopted because many of the steam locomotives still had years of useful life, while a substantial investment was required to dieselize completely. In addition, rail traffic's decline in the postwar period reduced the number of locomotives needed. Also, capacity to produce the new locomotives was limited. In addition, some railroad managements, especially of lines hauling extensive quantities of coal, were not easily convinced that the diesel was advantageous. As a result, the changeover from steam to diesel locomotives took about 20 years to accomplish; by 1958, virtually every locomotive was diesel-powered. The diffusion of Centralized Traffic Control (CTC) has, likewise, taken place over decades and is still not complete.[7]

A brief description, with present and estimated status in the last half of the 1970's, of 10 types of technological changes is presented in table 9, followed by a detailed discussion of those changes.

Motive power developments

The number of locomotives in use has been declining, largely because the newer ones are capable of delivering more tractive effort than the ones they replaced. In 1967 there were 27,687 locomotives, 99 percent diesels. Approximately 25 percent of these were "second generation," introduced in 1961, and represented a much improved locomotive compared to the first diesel used throughout the industry. Ten years earlier, there had been 30,248 locomotives in service 90 percent diesel-electrics and the remainder steam locomotives. Chart 1, shows the decline in the number of steam locomotives and the growth of diesels at 5-year intervals for the period 1947–67.

The introduction of the second-generation diesel in 1961 reduced unit maintenance requirements. Second-generation diesels required 57 percent fewer unit man-hours for annual maintenance and inspection than did earlier diesels; first generation diesels had also, previously, reduced unit man-hour requirements substantially below the steam locomotives (see chapter V). Among the important improvements included in the second-generation units are sealed, pressurized engine compartments that exclude dirt and moisture; solid state components in electrical systems to improve reliability; alternating current traction generators to replace more complex

[7] For an earlier discussion of diffusion of innovations, see "Regularization of Capital Investment in Railroads," by K.T. Healy in *Regularization of Business Investment*—A Conference, National Bureau of Economic Research, Princeton University Press, 1954, pp. 162–184. Also see *The Transportation Industries,* 1889–1946, Harold Barger, National Bureau of Economic Research, New York, 1951, pp. 100–111 and "Productivity, Hours and Compensation of Railroad Labor," by Witt Bowden, *Monthly Labor Review,* December 1933, pp. 1275–1288 for a discussion of technological improvements between 1916 and 1932.

Table 9. Technological change in railroads, 1957–67 and outlook, 1975–80

Types of innovation	Description and impact	1957 status	1967 status	Outlook
Motive Power Developments	More powerful units; solid state electronics improve electrical systems; higher tractive power per unit; greater overall reliability reduces maintenance.	Class I locomotives totaled 30,248; 90 percent diesel.	Class I locomotives totaled 27,687; 99 percent diesel. Twenty-five percent were second generation models.	Class I locomotives may total about 26,000 diesels; about two-thirds expected to be second generation models by 1975.
Freight Car Improvement	Special cars developed for commodity groups; better bearings; higher capacity with reduced car weight to capacity ratio. Design and material improvements reduce loading and maintenance requirements.	Total fleet contained 2.1 million cars of which 36 percent were general box cars. 13.5 percent of fleet privately owned.	Total fleet contained 1.8 million cars of which 32 percent were general boxcars. Nonrail ownership 17 percent of total.	Total fleet requirements of 1.7 million cars in 1975. Private ownership expected to increase with continuing emphasis on expensive, special purpose cars. Shippers' pressure for cars, rather than capacity, may slow increase in average car capacity.
Facility Relocation and Improvements	Repair station consolidation, including spot shop development, accompanied dieselization, resulting in greater efficiency. Car and locomotive washing and interior cleaning mechanized. Bad order car ratio reduced.	Concept being introduced.	Widespread use.	Further consolidation and use of spot shops expected for both locomotives and cars.
Piggyback and Unit Trains	Trains comprised of trailers or containers of general merchandise loaded on flatcars move on expedited schedules. Unit trains carry a single bulk commodity between two terminals. They are a vital link in production processes	Piggyback trains carried 250,000 carloads. No significant use of unit trains.	Piggyback increased to over 5 times 1957 levels. Widespread use of unit trains for many commodities.	Continued growth of piggyback, but at a decreased rate. 1½–2 million carloading expected in 1975. Greater use of unit trains likely.

Table 9. Technological change in railroads, 1957–67 and outlook, 1975–80—Continued

Types of innovation	Description and impact	1957 status	1967 status	Outlook
	and their movement is on a strict time schedule.			
Automatic Classification Yards	Large yards in which cars are sorted and switched by destinations have digital and analog computers to control car speeds and to aid in switching. Small yards equipped with automatic features now feasible. Increased car utilization, customer service and manpower savings result.	About 20 major yards in service.	More than 50 major classification yards in operation. Three small yards used automatic equipment.	About 12 more major classification yards may be equipped with "automatic" features by 1975. Some additional small yards by 1975.
Computers	Both digital and analog computers in use. Computers have provided information processing and switching capacity that permits management better control of operations.	Limited numbers of analogs in use in classification yards. Digital computers, introduced in 1955, scarce.	Widespread use of analog computers. In January 1967 there were 192 digital computers installed.	The sharp increase to 252 digital computers on January 1, 1969 supports expectation that all Class I roads will be using computers by 1975.
Centralized Traffic Control (CTC)	Control of train movement over 50–100 mile or more stretches of track from a central location. A model of the track is operated by one man who pushes buttons or switches to keep trains moving in accordance with their priorities. Capacity of track is expanded and manpower savings result.	32,000 miles of track were under CTC, out of 269,000 miles of main track operated.	49,000 miles of track were under CTC, out of 254,000 miles of main track operated.	Extension of amount of track under control of a single center expected. This may take form of regional, multiroad complex or coverage of greater percentage of a single road's track.

Table 9. Technological change in railroads, 1957–67 and outlook, 1975–80—Continued

Types of innovation	Description and impact	1957 status	1967 status	Outlook
Miscellaneous Signaling and Communication	These developments enhance equipment utilization, promote safety and decrease maintenance costs.			
(a) Detectors	Detectors—mechanical or infra-red devices—locate and report dangerous conditions in equipment along the right of way. Several types developed for different purposes.	First introduced in mid-1950's.	Over 8,600 detectors were in place.	Detectors will increase. Rising train speed increases importance of detecting dangerous conditions early.
(b) Microwave	High capacity radio carrier wave currently being used by railroads to supplement or supplant wire message carriers.	Federal Communications Commission authorized use in 1957.	22,000 route miles in 1966.	About 50,000 route miles expected. Rapid growth tied to development of total information systems.
(c) Automatic Car Identification (ACI)	Reflecting labels picked up by transmitter, decoded and sent to central operations. Equipment location and progress easily recorded.	Non-existent.	Under development.	Standard version adopted 1969. By 1970, all cars in interchange service to be labeled for ACI, but all roads will not have operating systems to use. By 1975, universal use expected.
Maintenance of Way Innovations	Single and multi-purpose machines aid in track laying, tie placement and ballast surfacing. Continuous rail that replaces 39′ sections and concrete ties are in use. Off-track machines combined with use of radio increase labor utilization. Track defects detected by electronically	Single purpose machines in limited use. Other innovations not yet in use.	Widespread use of single-purpose machines. Concrete ties in limited use. Seven percent of mainline trackage in continuous rail.	By 1975, use of combination machines and concrete ties is likely to expand; continuous rail will be used extensively.

Table 9. Technological change in railroads, 1957–67 and outlook, 1975–80—Continued

Types of innovation	Description and impact	1957 status	1967 status	Outlook
	equipped cars. M/W scheduling aided by computers to obtain maximum equipment and manpower use.			
Innovations in Passenger Service	Air conditioned, electrically driven cars in Northeast Corridor Experiment. Automat food service on some trains. Computerized ticketing.	A/C cars in use.	Northeast Corridor Experiment to use Metroliners being formulated.	Successful use of Northeast Corridor concept may be extended to other areas. Other long-haul service may vanish.

direct-current units, and improved cooling systems.

These new second-generation diesel locomotives range in horsepower from 2,500–6,000, compared with 1,200–1,500 for earlier diesels. Their tractive power—effective pulling force delivered to the drawbar—is also much higher. In 1967, the average diesel electric unit's tractive power was 65,178 pounds compared to 60,479 pounds 10 years earlier. This increased pulling power has resulted in a 12 percent increase in gross ton-miles hauled per engine over the 1957–67 period.

Six axle-drive units have been a contributing factor to this increased tractive effort per locomotive and may promote still further the trend to high horsepower, single unit engines of over 4,000 horsepower. Six-axle drive units have rapidly gained popularity because they increase ability to utilize high horsepower. First available in 1963, the six-axle drive accounted for 60 percent of all units delivered by 1966. The units are especially good for railroads operating in steep grade territory.

Another motive power development becoming more widespread is the use of a "slave" unit, placed unmanned in the middle of the train. Because of the trend toward higher horsepower units, starting trains with only one unit can be hazardous. Too much power applied rapidly can cause breakage of the drawbar—the connecting link between the train and the engine units. Dispersing these slave units throughout the train reduces the amount of inertia to be overcome by each locomotive unit, reducing the drawbar breakage problem and increasing maximum feasible length of trains.

Still another motive power development is the gas turbine locomotive, introduced in the early 1960's, and being used on a limited basis in the West. They are best used over a long haul with a limited number of stops. Thus, their use is precluded on many railroads which operate over shorter distances, so there is little prospect for wider diffusion by 1975.

In 1966, the industry announced that it was embarking on an "Evenkeel" repowering program keyed to the purchase of 1,500 locomotive units each year for the 1966–75 period. While locomotive purchases totaled 1,419 in 1966, the 1966–70 average was only 1,122. Carrying out of this projected purchase of 1,500 units per year through 1975 appears unlikely in view of the limited amount of capital available and the rising unit cost. Through 1975, an annual average of 1,200 locomotives is likely to be added to the fleet. This means that, after accounting for retirements, the total fleet may number about 26,000—down from nearly 28,000 in 1967. The proportionate share of second-generation diesels in the fleet may reach about 63 percent, up from 25 percent in 1967.

Freight car improvements

The percent of freight cars owned by railroad companies fell during the decade 1957–67. There were over 1.8 million freight cars in operation in 1967, down from 2.1 million in 1957. Of this number, 13.5 percent of all cars were owned by other than railroad companies in 1957, in contrast with about 17 percent by 1967. However, the increase in average car capacity has tended to offset much of the decline in the number of freight cars; in fact, the total capacity of all cars, including those privately owned, increased between 1957 and 1967.

The composition of the car fleet has shifted from general purpose toward special-purpose cars and the average capacity has increased. In 1968, for example, the average new car purchased had a capacity of 81 tons compared to an average of only 57 tons for those being retired. In addition, material and design changes have reduced the weight of the car in relation to its capacity.

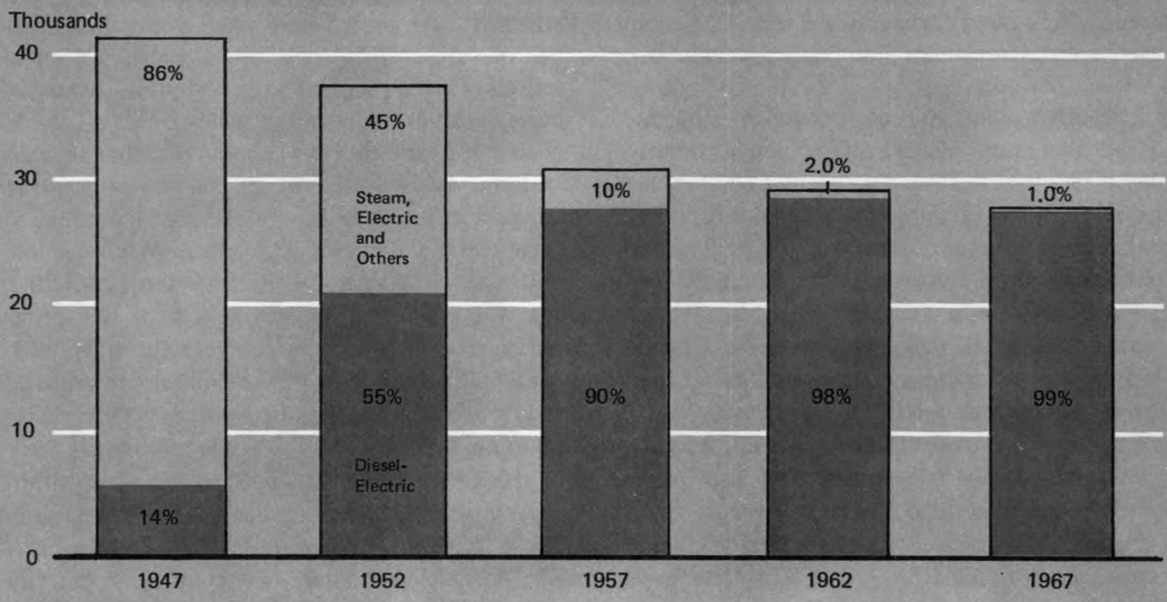
In 1957, box cars had represented 36 percent of all freight cars but, by 1967, this proportion had dropped to 32 percent. (See table 10, Specialized Freight Cars, by Major Class, 1957 and 1967.) On the other hand, the number of specialized cars (box cars especially fitted for a particular kind or class of cargo) rose almost 2½ times (from 54,000 in 1957 to 139,000 in 1967). Declines occurred among general-purpose box cars, stock cars, gondolas and open hopper cars and refrigerator cars.

The number of flat cars in use rose between 1957 and 1967 because of an increase in piggyback traffic and also in the number of automobiles transported by rail. Piggyback traffic grew from less than 1 percent of carloadings in 1957, to 4.3 percent in 1967, and 4.8 percent in 1969. According to the Automobile Manufacturer's Association, auto carriage increased from 538,000 cars in 1959 to 5.4 million in 1969. The dramatic growth in number of autos transported by railroads resulted from the fitting of flat cars with special car carrying racks. As a result, one railroad car was able to carry more autos than one truck, while at the time eliminating the need for a truck driver.

Another improvement, in materials used, has re-

Chart 1.

Number of Locomotives, by Type and Percent of Total



Source: See Appendix II-1.

Table 10. Specialized freight cars, by major class, 1957 and 1967

Major car class	Special features	Average capacity per car (tons) [1]		Ownership—other than railroad		Cargo	Total cars and percentage of fleet	
		1957	1967	1957	1967		1957	1967
I. Box	Increased capacity cars, with special interior fittings like stanchions to support plywood, cushioned underframes, conveyors, etc.	48.9	54.5	0.3%	0.3%	General service bulk freight. Agricultural and manufactured products.	747,838 (36.4%)	578,426 (31.7%)
Conveyor Produce Cars	Conveyor belt inside to load & unload cargo.					Potatoes, apples, other produce		
All-door Box Car	Much greater door space than conventional box car.					Lumber, bulky products.		
"Big Boy" Boxcar	Extra-large box car.					Designed for tobacco.		
"Hello Dolly" Box Car	Contains built-in dolly.					Unitized lumber & plywood; canned goods, pipe and rolled floor coverings.		
II. Flat	Multi-purpose cargo tiedown attachments, compatible with several container types.	52.7	61.6	2.0	28.6	Piggyback containers, autos, lumber.	93,538 (4.6)	143,335 (7.9)
Bulkhead Cars	Flat car with "walls" on the ends.					Lumber, plywood, gypsum.		
Auto Rack Cars	Special drive-on racks.				(2)	Assembled automobiles, 15 per car.		(2)

Table 10. Specialized freight cars, by major class, 1957 and 1967—Continued

Major car class	Special features	Average capacity per car (tons) [1]		Ownership—other than railroad		Cargo	Total cars and percentage of fleet	
		1957	1967	1957	1967		1957	1967
Piggyback Cars	New "all-purpose" cars hold both trailers and containers.					Trucks and containers of general freight.		
III. Stock		39.7	40.3	1.9	2.0	Live animals.	36,415 (1.8)	17,040 (0.9)
IV. Gondola and Hopper	Larger cars with commodity related variations.	60.4	71.3	1.0	4.0	Coal, grain, other bulk solids.	884,563 (43.1)	786,664 (43.2)
Covered Hoppers				([3])	([3])	Commodities like salt, grain, coal.	([4])	([4])
"Big John" Car	4,000-cubic-foot aluminum covered hopper.					Grain		
Pneumatic-unloading hopper	Eliminates center sill for more usable space.					Dry, flowable material, such as flour, malt, chemicals, plastic pellets.		
Hot Steel Car						Hot steel slabs.		
V. Tank		49.7	55.3	96.1	97.2	Petroleum, chemicals, foods, fertilizers, other dry bulk or liquid ladings.	166,452 (8.1)	175,117 (9.6)
Cryogenic Car						Super-cold ladings (−350°F. and below). Liquefied gases, etc.		
Pressure-Flow "Hopper"	Pneumatic pressure-unloading.					Dry-bulk ladings like cement.		

Table 10. Specialized freight cars, by major class, 1957 and 1967—Continued

Major car class	Special features	Average capacity per car (tons) [1]		Ownership—other than railroad		Cargo	Total care and percentage of fleet	
		1957	1967	1957	1967		1957	1967
Wine car	Holds 2½ times wine of earlier cars (20,000 gal.). Insulated, with up to 3 separate compartments.					Wine		
"Sandwich" Tank Car	Thermos style. Urethane insulated. Maintains temperature without mechaniical cooling.					Fruit juices, liquid sugars & fats, adhesives and chemicals.		
VI. Refrigerator		39.5	61.3	83.3	56.0	Meat and other foods stored at 35°F. or somewhat above.	120,998 (5.9)	117,274 (5.4)
Mechanical "reefers"	Uses motor for cooling instead of ice.							([5])
VII. Other, eg. Coil Car	Opens like clam shell to receive cargo.	69.9	68.5	40.5	33.1	Various special cargoes, e.g., six 32,000-lb. coils of thin steel.	4,507 (0.2)	4,513 (0.2)

[1] Average capacity available for class I only.

[2] Accounted for over ⅓ of all flat cars in 1967. These cars are virtually all privately owned.

[3] Ownership by other than railroads increased from 9 percent of the category in 1957 to 19 percent in 1967.

[4] 60,360 in 1957 and 147,412 in 1967.

[5] About 16 percent of refrigerated cars in 1967.

SOURCE: Interstate Commerce Commission, Association of American Railroads, American Railway Car Institute.

sulted in a steady rise in the net-to-tare ratio—weight of the transported product relative to empty car weight. New materials, notably steel alloys and aluminum, and new interior coverings and fittings, are now being used in car construction. Thus, car material and design changes contribute to an increase in the amount of freight that can be hauled by a given amount of locomotive power. Furthermore, because these new materials are stronger and easily cleaned, maintenance requirements are reduced. Many new covered hopper cars are plastic lined to allow easy, thorough cleaning that facilitates their interchangeable use between hauling of food and other commodities. Interior fitting changes include the use of nailable steel floors in place of wooden floors and receptacles in car walls to hold the telescoping rods which reduce in-transit cargo shifts. Hydraulic cushioning devices have also been introduced for the purpose of reducing claims for loss and damage.

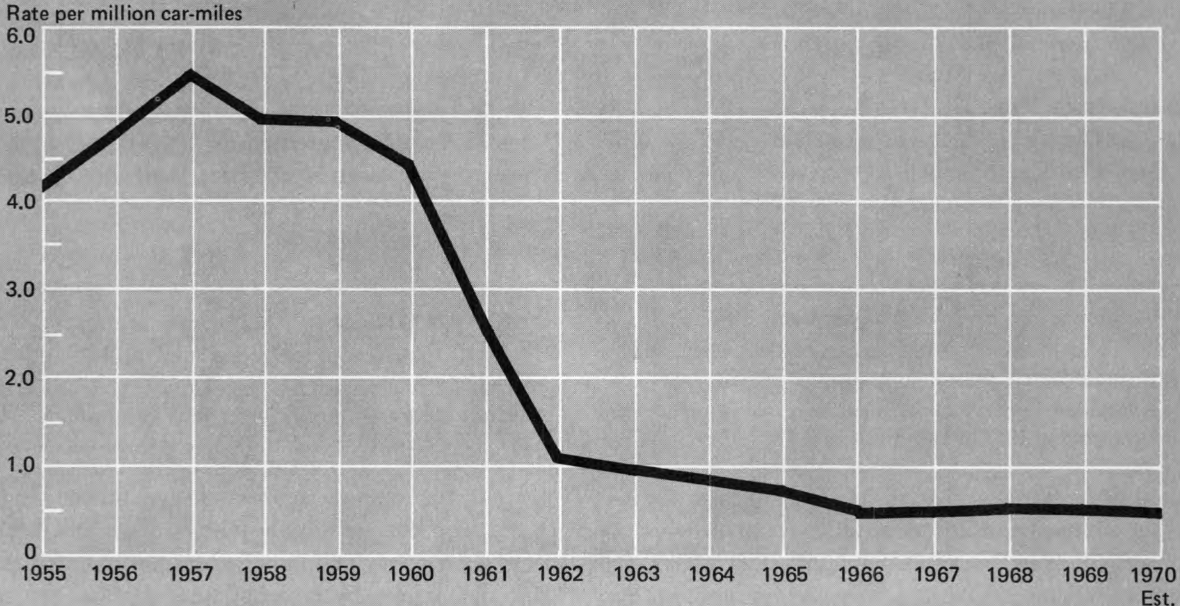
One of the most dramatic improvements in the operation of freight cars has resulted from changes in journal (axle) lubrication procedures and introduction of roller bearings. Before 1957, car wheels and the journals they revolved upon were lubricated by placing rags or "loose waste" in the journal box, to prevent the oil from splashing out and to keep it against the journal. This loose waste had frequently tangled around the axle, however, and caused the very "hotboxes" it was supposed to prevent. Subsequently, journal pads were developed to supersede this use of loose waste. These pads required replacement at 30-month intervals and were more effective in retention of oil or grease than the loose waste. The Association of American Railroads ruled that after August 1, 1957, all new cars purchased must have either journal pads—used with friction bearings—or roller bearings; after January 1, 1961, all cars used in interchange had to have one or the other. According to the Association, about 4 percent of all cars were equipped with roller bearings in 1960, over 20 percent by 1966. By 1975, taking into consideration anticipated car purchases, about half the car fleet should be equipped with roller bearings.

The hotboxes that once resulted from improper axle lubrication were a major cause for car setouts —cars set off on sidings for later repair. Chart 2, Car Setouts Per Million-Car-Miles, 1955–68, dramatically shows how the use of journal pads and roller bearings have reduced lost train time. From the 1957 peak of 5.5 car setouts per-million-car-miles, a decline of almost 90 percent had occurred by 1968. The net result of the reduction in time spent with car setouts for repair has been to increase car utilization.

The diffusion of the innovations relative to freight cars (as described above) is directly related to anticipated new car purchases. The American Railway Car Institute (ARCI)—the major spokesman and data source for car builders—has made estimates of annual new car and total fleet requirements between

Chart 2.

Freight Car Set-Outs Per Million Car-Miles, 1955-70



Source: Association of American Railroads.

1967 and 1975. Based on retirement curves, utilization trends, and demand estimates of various commodity groups, the ARCI foresees retirements averaging 71,000 cars for the period January 1, 1967 through January 1, 1976. Total fleet requirements in 1975, estimated at 1.7 million cars, less the retirements, yields an average annual purchase requirement ranging from 62,000 to 85,000 cars, depending on railroad market share. Average purchases for 1967–70 have been about 69,000 cars annually, or about the level expected by ARCI.

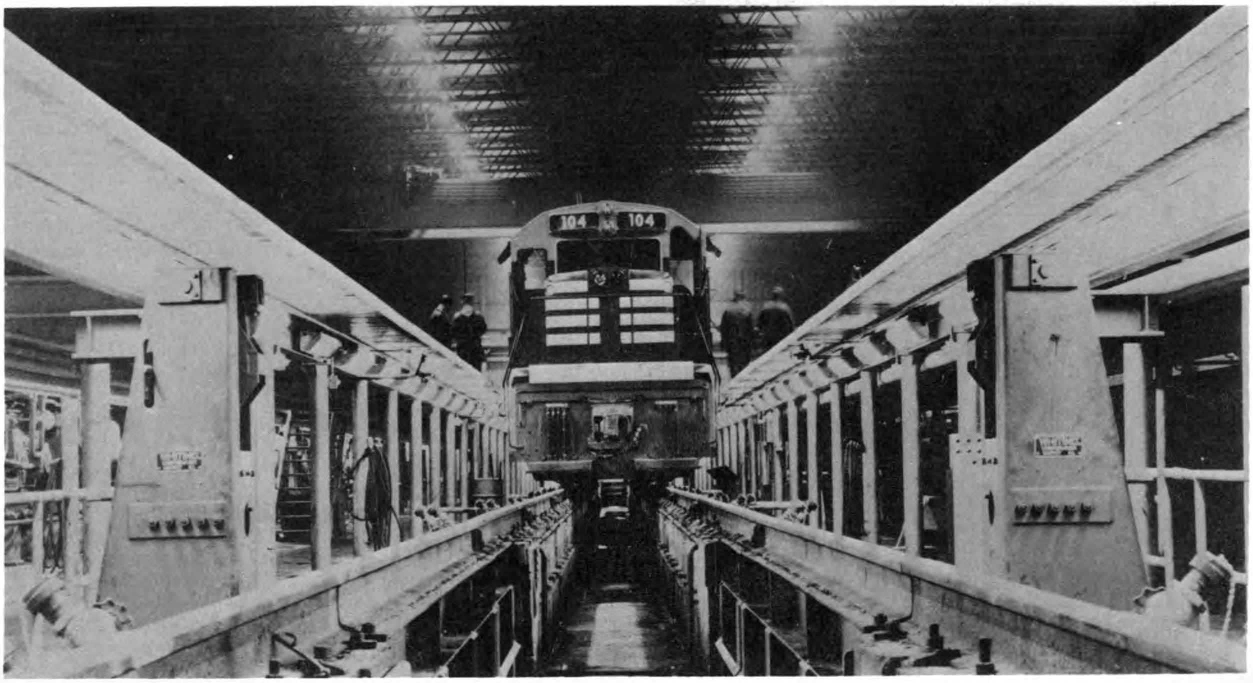
Shop facilities: relocation and improvements

Repair work of rollingstock, both locomotives and cars, has been shifted from locations scattered along the right-of-way to central locations called "spot shops," which use production-line techniques. The locomotive or car is now brought to a central facility which is subdivided into various work stations where specialized equipment is available for any type of repair or inspection required. Thus, time spent in carrying tools to the equipment to be repaired has been eliminated. When disassembly of locomotive or car components is required, the repair of parts is closely coordinated so that equipment is not held in bad order condition because of lack of some minor part. Other changes taking place within spot shops include the strategic location of high-capacity hydraulic jacks and electric hoists. Hose reels, acetylene, and oil are similarly placed, as are revolving part bins that eliminate fumbling for a part or the need to make a trip away from the work station. Heating of new facilities is accomplished with more efficient boilers, having better controls. Car cleaning is done in these locations by using automatic "car wash" techniques. These procedures cut cleaning time by as much as one-half. Large vacuum units are used to clean car interiors.

While the cost of these new spot shop facilities is high, railroads adopting them expect the savings realized to result in a quick payback. For example, one railroad centralized and modernized one of its shop facilities in 1964. Its fully automated wheel shop, which replaced 10 smaller shops, was expected to be fully amortized in 1969. Also, one equipment company reports that spot repair facilities "generally increase labor efficiency 100 percent." [8]

The superiority of spot shops use over older repair methods is widely recognized. Although they are presently widespread, some further adoption of this method can be expected. Further improvements within these facilities, such as the automatic wheel shops mentioned above, are also expected by 1975.

[8] Car and Locomotive Cyclopedia, 1966, Simmons-Boardman, 1966, p. 1182.



View from the "pit," as diesel-electric locomotive undergoes periodic maintenance and overhaul check-up.

Piggyback traffic and unit trains

Piggyback traffic, or trailer-on-flat-car (TOFC), and more recently container-on-flat-car (COFC), services are among the most significant newer transportation developments. Piggybacking is simply the loading of a highway trailer onto a flat car by means of a ramp or mechanical loader. COFC service is less widespread because a mechanical loader is always required; however, the space savings from eliminating wheels on containers makes them relatively more attractive for intramodal shipment between rail, air, and sea transportation. In either TOFC or COFC traffic, goods need to be handled only once, at the shipper's dock. The container can be transshipped through several transportation modes, arriving at the consignee's dock without being subjected to reloading—a prime cause of breakage, delay, and pilferage.

TOFC technology includes use of specially designed flatcars, tunnel, and track reconstruction, and the design of terminal facilities for high volume TOFC loading and unloading. The American Standards Association has established standard container sizes which will permit easier interchange between railroads and other modes of transport. Trailer Train, an organization of 36 railroads, had a pool of 50,000 TOFC cars in 1969. Trains of TOFC-loaded flatcars operate on expedited schedules.

The handling of TOFC is covered by five major plans approved by the ICC. Table 11 describes these plans, including their major characteristics. Plan 2½ is growing very rapidly. Although, in the first half of 1967, it accounted for only 5 percent of all terminations—the final delivery of a trailer from the railroad to a trucker or to the final consignee—it had reached 26 percent in the first half of 1968.

On January 1, 1966, a private survey indicated that there were 1,548 U.S. cities having piggyback facilities.[9] Of these, 1,391 had only trailer ramps; the remaining 157 had mechanical loading or unloading devices. Over 1,000 storage yards for use in conjunction with piggyback operations existed in 1966, with a combined capacity of almost 54,000 units, the survey also indicated. Since 1966, railroads have continued to expand and improve their storage yards.

For the period 1957–68, piggyback traffic has been growing at a rate of about 16.5 percent a year. Since 1955, the first full year of TOFC service, carloadings have risen from 168,150 to over 1.3 million, or 4.7 percent of total loadings in 1968 (see chart 3). Assuming a continuation of this rate of growth, piggyback traffic would reach a level of about 3.9 million carloadings in 1975. However, as shown in chart 3, the rate of increase in this traffic has been moderating in recent years. Also, because of the increasing size of the traffic base and the attendant congestion of facilities to handle TOFC/COFC freight, it appears that the 1957–68 rate of growth cannot be sustained. Thus, it is estimated

[9] *Railway Age,* Oct. 31, 1966, pp. 22ff.

Table 11. ICC approved piggyback plans, unit terminations, and revenues, first 6 months, 1968

Plan number	Terminations of trailers and containers: Percent of total[1] — Terminations	Revenue	Characteristics: Ownership of van and flatcars	Payment	Loader & unloader	Mover to and from tracks
I	15%	8%	Motor carrier	At motor rates. Motor carrier collects from shipper and pays railroad pro-rata share.	Motor carrier	Motor carrier
II	39%	43%	Railroad	At rates competitive with other modes.	Railroad	Shipper
II-1/2	26%	27%	Railroad	Same as plan II.	Shipper	Shipper
III	10%	7%	Shipper owns van; RR owns flatcars.	Based on approximate cost of highway operation between points served.	Railroad	Shipper
IV	7%	12%	Shipper	Rail rates for loaded or empty cars. Allows for expense of flatcar ownership.	Shipper	Shipper
V	4%	3%	Variable	Based on through-route and joint-rate coordination of rail and motor carriers.	Variable (interchange of modes)	Variable

[1] Percentages do not add to 100 due to rounding.
SOURCE: Interstate Commerce Commission.

that a lower level of around 1½–2 million carloadings may be possible by 1975.

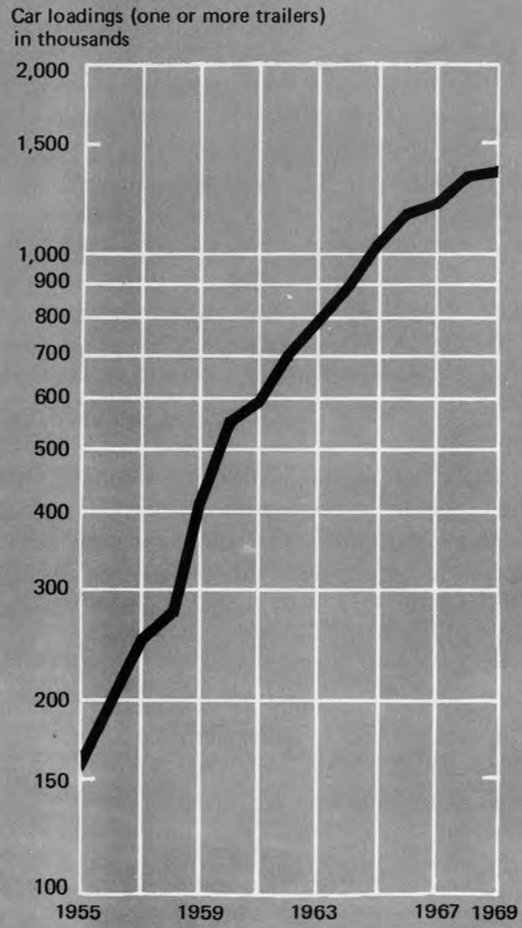
The unit train, like TOFC, is a high-priority train that hauls a single commodity. It may haul any one of a number of different kinds of bulk commodities such as coal, bauxite, hot asphalt, steel slabs, and various kinds of grains, in from 70 to 120 hopper cars. Unit trains usually travel from a single destination to their terminals on a continuous basis, although a recent variation would permit the renter to move the train between several points. Railroads transport about three-fourths of America's coal; in 1969, about 21 percent of the total 560 million tons produced moved by unit train. Several railroads and electric power companies have negotiated long-term contracts which often run for 20 years. They provide for the movement of millions of tons of coal annually by unit train.

The major reason for the growth in the use of unit trains since 1962 is the decreased cost per ton carried, compared to previous methods used. These savings result because unit trains bypass switchyards and are subject to quick turnaround. Although high in initial cost, these trains yield a rapid return on the capital invested. According to one expert in the field, unit trains return 16 percent net income on revenue compared with only 8 percent for conventional cars.[10]

By 1975, it is likely that unit trains will be used even more extensively than today because of the formulation of special rates for various commodities. One such target for special rates is the approximately 55 million tons of coal—about 10 percent of total production in 1969—moved annually by rail-water combination. The development of new rates that may divert this traffic to all rail movement is being investigated.

Chart 3.

Piggyback Freight Carriage, 1955-1969



Source: See Appendix II-2.

Automatic classification yards

Classification yards are the center of railroad activity; thus, yards can be a major contributor to productivity. In 1970, according to the AAR, the average serviceable car spent about 11 percent of its time, either loaded or empty, moving in a train. The remainder of the time it spent in classification yards, or standing idle because of seasonal lulls, or waiting to be loaded or unloaded. The experience of many railroads indicates that automatic classification yards bring about increased car utilization. Other benefits stemming from the automatic classification yards are improved customer service through reduced transit time; consolidation of work from outlying locations with accompanying manpower savings; and prevention of claims from loss and damage.

The case of one railroad provides a good example of the benefits to be derived from automatic classification yards. The railroad recently completed an automatic yard at a cost of $75 million. This replaced

[10] *Unit Train Operations,* Railway Systems and Management Association, Chicago, 1967, p. 22.

A 200-car unit train moves coal directly from mine to customer site.

8 smaller yards and is the first in the industry to employ a digital computer for car classification.[11] Another road built a new yard that replaced six old ones, reduced car throughput (receive, classify, and dispatch) time by 5–12 hours. Annual return on investment, according to the railroad, was calculated at 25 percent.

Technological changes in classification yards, other than miscellaneous improvements (such as closed circuit television, and use of radios and weighing-in-motion), are divided into three major elements:

1. The change from flat yards to hump yards. This simply introduces a slight incline into the switch yard so that, instead of having to provide all the power to send a car from the point at which it was cut from the train, the switch engine need only reach the top of the hump at a relatively slow speed and gravity provides the momentum needed to keep the car going into the desired classification track. The engine need no longer go forward and backward, but simply travels slowly forward toward the hump.
2. The installation of mechanical retarders located along the track. Operated by electro-pneumatic or hydraulic power, they "squeeze" the wheels of cars passing through them, thus slowing the car to the desired speed. While retarders were used in some yards before World War II, their adoption was speeded during the war because of manpower shortages. These retarders, initially manually operated, are now controlled by computers. These computers calculate braking requirements according to car weight, and the speed of the car.
3. Shifting of the switching operation from the yard to a console operator in the tower. Where previously a man in the yard had to throw the switch for each car or group of cars, the tower console operator now merely operates switches on the console before him. He has a list of cars being switched and activates switches according to destinations.

The diffusion of automatic classification yards is shown in table 12. The first of these yards appeared in 1949, and by 1967, construction had been started on 52 automatic classification yards. In early 1967, according to a private survey, 118 freight yards out of about 1,200 major classification yards had some form of automatic control.[12]

Recent advances in technology have now made possible a small-scale adaptation of the automatic yards. These new yards operate efficiently with a lower number of cars classified per day. These so-called "economy yards" first appeared in 1965 and in 1967 there were three yards on which the upgrading had already been accomplished (see table 11).

Total expenditures for automatic classification

[11] "PC's Milestone Yard Dedicated September 25," *Traffic World*, Sept. 28, 1968, p. 50.

[12] "Railroads on the Automation Track," *Electronics*, Jan. 9, 1967, pp. 168–70.

yards are not available. However, based on average expenditures per yard of about $9 million, total expenditure estimates are in the area of one-half billion dollars. Because of the high capital investment required, ownership is concentrated in large companies. All 52 major yards are owned by 22 class I railroads; 28 of them are owned by only 8 railroads, each of which owns 3 or more yards.

By 1975, there are prospects for limited further application of large automatic classification yards in the United States. One major supplier of equipment estimates that 12 additional yards may be installed by that time. The smaller automatic yard has much further to go to reach complete diffusion. Some 300–400 smaller yards have traffic patterns of density suitable for yard upgrading, but it is difficult to estimate how many will be converted by 1975.

Computers

The computer, in combination with microwave data transmission, allows data to be transmitted for accurate control of car movement. By establishing car locations quickly, computers allow shippers to find out where their goods are, enroute, and the railroads to utilize vacant cars more fully. Reports can be routinely issued on either a periodic or a request basis, so that management can fully perceive existing problems or forestall potential ones. Previously, information on problem areas, potential or actual, could be lost in the large volume of papers generated by freight transactions.

The impact of the computer on railroads has been pervasive. Computers aid in locating and switching cars, in scheduling trains and in making motive power assignments to trains. They are used also in controlling inventory and in scheduling road maintenance and equipment use.

Advanced applications include simulation of classification yards or other operating areas of the railroad. Simulation obtains information on the potential effects of changes in operating procedures and physical configuration without spending the real-time and money required in actually trying new procedures or constructing new facilities. Construction projects are subjected to sophisticated control techniques, such as critical path method scheduling that may result in time savings and can eliminate bottle-

Retarder operator controls the speed of coasting freight cars in classification yard.

Table 12. U.S. Automatic Classification Yards

Yard	Year started	Car capacity per day	Cost (millions)
1. Moline, Ill. (Silvis)	1949	4,372	$ 3.3
2. Kansas City, Kans. (Armourdale)	1949	4,980	1.5
3. Kansas City, Kans. (Argentina)	1949	7,173	[1]
4. Chicago, Ill. (Markham)	1950	9,827	3.0
5. Pueblo, Colo.	1950	2,163	[1]
6. Knoxville, Tenn. (Sevier)	1951	4,500	4.0
7. Birmingham, Ala. (Norris)	1952	5,400	10.0
8. Gary, Ind. (Kirk)	1952	[1]	4.9
9. Milwaukee, Wis. (Airline)	1952	1,799	3.0
10. Roseville, Calif.	1952	[1]	[1]
11. Chicago, Ill. (Bensenville)	1953	7,497	5.2
12. Nashville, Tenn. (Radnor)	1954	7,905	14.0
13. Hamlet, N. C.	1954	5,030	8.0
14. Houston, Tex. (Englewood)	1954	7,719	7.6
15. Chattanooga, Tenn. (Citico)	1955	6,300	12.0
16. Pasco, Wash.	1955	4,700	5.5
17. Portsmouth, Ohio	1955	10,300	[1]
18. Pittsburgh, Pa.	1955	828	4.5
19. Minot, N. Dak. (Gavin)	1956	3,237	6.0
20. St. Paul, Minn.	1956	3,245	4.9
21. Eugene, Ore.	1956	5,063	2.0
22. Pittsburgh, Pa. (Conway)	1957	12,000	35.0
23. Atlanta, Ga. (Inman)	1957	7,800	15.0
24. Buffalo, N. Y. (Frontier)	1957	6,100	10.5
25. Atlanta, Ga. (Tilford)	1957	2,141	11.0
26. Chicago, Ill. (Corwith)	1958	5,871	20.0
27. Elkhart, Ind. (Young)	1958	7,873	14.0
28. Birmingham, Ala. (Boyles)	1958	6,151	10.0
29. Youngstown, Ohio (Gateway)	1958	5,848	7.5
30. Chicago, Ill. (Cicero)	1958	5,777	6.5
31. Pine Bluff, Ark.	1958	2,820	4.5
32. Kansas City, Mo. (Paul J. Neff)	1959	7,156	12.8
33. Russell, Ky. (Fitzpatrick)	1959	1,861	5.5
34. Potomac Yard	1959	[1]	2.5
35. Indianapolis, Ind. (Big Four)	1960	4,480	14.0
36. Cumberland, Md.	1960	2,976	10.0
37. North Little Rock, Ark.	1961	4,654	8.4
38. East Buffalo, N. Y.	1961	3,000	7.5
39. Roanoke, Va.	1961	[1]	[1]
40. McGehee, Ark.	1962	2,608	[1]
41. Chicago, Ill. (59th Street)	1965	[1]	[1]
42. Selkirk, N. Y. (Perlman Yd.)	1966	[1]	29.0
43. Kansas City, Mo.	1967	[1]	9.0
44. Decoursey, Ky.	[1]	5,000	11.5
45. Pocatello, Ida.	[1]	4,812	[1]

Table 12. U.S. Automatic Classification Yards—Continued

Yard	Year started	Car capacity per day	Cost (millions)
46. North Platte, Nebr.	(1)	3,900	(1)
47. Grande Jct., Colo. (East)	(1)	(1)	(1)
48. Riverdale, Ill. (Blue Island)	(1)	(1)	(1)
49. Detroit, Mich.	(1)	(1)	(1)
50. Memphis, Tenn. (Tennessee)	(1)	(1)	(1)
51. Tulsa, Okla. (Cherokee)	(1)	(1)	(1)
52. East St. Louis	(1)	(1)	(1)
SMALL AUTOMATIC YARDS			
53. Bellevue, Ohio	1965	(1)	(1)
54. Grandview, Ohio	(1)	(1)	(1)
55. Richmond, California	(1)	(1)	(1)
56. Beaumont, Texas	(1)	(1)	(1)

[1] Data not available.

SOURCE: *Trains*, January 1961; Association of American Railroads.

necks in completing projects and save large sums of money.

Computers were introduced into the railroads in 1955. By January 31, 1969, according to the Association of American Railroads, there were a total of 252 computers installed or 6.8 percent more than the number installed one year earlier.[13]

Leading railroads have adopted use of computers at about the same time as major companies in other industries. For example, according to a McGraw-Hill survey, in early 1965, 4 percent of all railroad respondents had owned computers for 7 years or more—the same as the average for either all manufacturing or all businesses (see table 13). However, diffusion throughout the railroad industry has tended to be generally slower than in other industries. The survey indicated that 91 percent of railroad respondents that had computers had used them for less than 3 years, compared with 71 percent for all manufacturing.

Computers have shifted the basis for decision-making from precedent and experience to a more objective one based on quantified data. By 1975, railroad use of computers will be more widespread and intensive. In this connection, the Association of American Railroads notes that . . . "computers will be a necessity for all class I railroads and most of the smaller railroads."

[13] Data Systems Division, Association of American Railroads, July 1969.

Console operators at data processing centers expedite the huge volume of paperwork handled daily by the railroads.

Signaling and communication improvements

Advances in signaling and communication technology are having a continuing impact on all other phases of railroad operations. The components of signaling are becoming more and more a part of a complex, comprehensive, interlocking communication system. These parts include centralized traffic control mechanisms, detectors of many different kinds, microwave carrier capacity, and finally computers to process increasing amounts of information. When the total communication system is completed, it is likely to include continuous hotbox monitoring, regional centralized traffic control, automatic car identification and interroad information exchange on car location anywhere in the United States.

Centralized traffic control (CTC) is the activation, by remote control, of signals and switches over long stretches of track. A single operator controls and monitors the train movement from a central unit. The control panel is equipped with an electronically animated track model of the controlled track sections. By watching the model, the control board operator, or dispatcher, is able to view the track for occupancy. With push buttons and levers, he activates the signals and switches to control traffic flow. This dispatcher determines train priority for track use, rerouting of trains, and use of track for passing and sidings; he also controls the distance between trains. He uses the track model as a decision-making tool, since track occupancy and the positions of signals and switches for main tracks and sidings are immediately evident.

Before the advent of CTC, trains were operated by use of time tables and written train orders only (without signals and/or switches), with manual signaling by flagmen, and by block signaling, both manual and automatic. This "block signaling" concept, introduced before 1872, is still basic to the system in use today. It uses wayside towers for control of signals and switches, and as relay stations for information. The Interstate Commerce Commission classifies CTC as a part of "automatic block signaling" and includes both track and road miles of CTC in this total.

CTC is used to expedite rail traffic over the fewest possible miles of track, without the use of written train orders. Recent additions to basic CTC systems have helped to promote faster rail traffic. Added circuits allow signals to clear automatically without the control board operator's intervening. Direct voice communication between the CTC board operator and the signalmen along the line, as well as with the train and engine service employees, increases the system's efficiency. Thus, dragging equipment and hotbox indications can be immediately reported to operating personnel for correction when detectors are installed as a part of the CTC system because of this radio link.

Centralized traffic control was first introduced on the railroads in 1927; at that time, it accounted for only 40 out of a total of 260,000 miles of main track operated. During the period 1957–68, track miles under centralized traffic control rose from slightly over 32,000 to nearly 50,000. In 1957, CTC represented about 12 percent of total main track operated; by 1968, this proportion had increased to approximately 20 percent (see table 14 for mileage). Moreover, the rapid growth in track mileage under CTC systems since 1957 took place while the total miles of main track operated were declining. Undoubtedly, CTC has contributed greatly to the ability of the railroads to handle the increasing volume of traffic of recent years by providing better track utilization. For example, installing CTC on a single track line may increase its capacity up to 80 percent of the capacity of a double track, but at a lower cost.

According to the Association of American Railroads, some form of centralized traffic control is likely to become more common on all rail lines in the years ahead. By 1975, the number of track miles under centralized traffic control is likely to be extended further, because of the increasing use of computer programing of train operations to include dispatching and scheduling. Computerization is also likely to expand the miles of track that can be controlled by one CTC center and also may make possible inclusion of entire roads into a single system.

Table 13. The age of operating computers, railroads and other industries, 1965

Industry	Percent of companies indicating—		
	Less than 3 years	3–6 years	7 years and over
All manufacturing	71	25	4
Mining	79	16	5
Railroads	91	5	4
Other transportation and communications	71	25	4
Electric utilities	57	39	4
Commercial	68	27	5
All business [1]	70	26	4

[1] Excludes gas utilities.

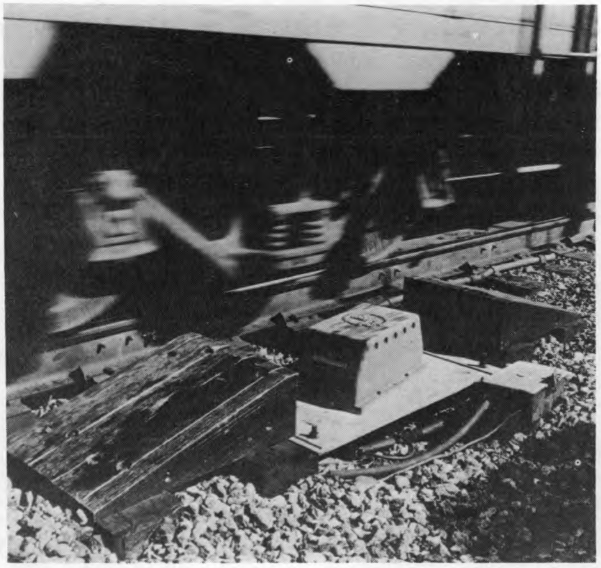
SOURCE: McGraw-Hill Publishing Company.

Detection devices. A hotbox or hot journal (axle) involves the overheated condition of friction journals or roller bearings, caused by inadequate lubrication. If a hotbox is not discovered early, the temperature of the journal or bearing may rise to a critical level, so that the wheel end of the journal may burn off and cause a derailment of the car.

Hotbox detectors are designed to measure temperature changes of journals and/or roller bearings on passing railroad cars. Ideally, these detectors are mounted alongside the track at about 30-mile intervals—usually in areas of CTC track. They scan the journal box or the hubs of the car wheels and relay the journal temperature of each wheel to CTC offices or other central locations where this information is recorded on tape. Should an overheated journal be indicated, an alarm brings this fact to the attention of the recorder monitor. He, in turn, informs the train engineer by signal or direct station-to-train telephone.

The use of detectors replaces the old "sight and smell" method of hotbox detection—a method that has become less reliable with adoption of improved technologies. Better journal lubricants and substitution of journal pads for loose waste have greatly reduced the visible smoke and flames generally resulting from a journal's overheating and ignition. Also, visual inspection is virtually impossible, because of faster moving trains and the increased use of roller bearings.

The savings and other benefits that stem from the



Detectors mounted along the track automatically warn of improper or dangerous equipment conditions.

Table 14. Track miles controlled by block signal and CTC systems[1], selected years, 1952–68

Year	Total miles of main track operated	Track miles of block signal system: Total	Automatic	Manual	Track miles of centralized traffic control
1957	269,300	139,594	110,689	28,905	32,033
1961	263,222	131,177	107,563	23,614	38,264
1968	227,897	123,007	116,612	14,411	48,984
	Average Annual Percent Change				
1957–61	−0.6	−1.6	−0.7	−4.9	4.6
1961–68	−2.1	−.9	1.2	−6.8	3.6

[1] Coverage is for all U.S. railroads.

SOURCE: Report of the Section of Railroad Safety, Bureau of Railroad Safety and Service of the ICC for year concerned.

installation of hotbox detectors have more than offset the cost of their installation and maintenance, even in the shortrun. According to one manufacturer, for each potential hotbox detected the cost of replacing the axle—up to $300—is saved. However, the overriding factor for adopting hotbox detectors is to prevent car derailments and other serious wrecks which may result in equipment loss and personal injury.

Hotbox detectors were introduced in the mid-1950's, but the first available accumulated total of installation is for 1958, when 97 detectors were already installed. In 1967 alone, 21 roads installed 132 detectors. In addition to wayside installation, many roads are installing detectors at classification yard entrances. It is expected that the installation of wayside detectors will become increasingly more diffused, leading to continuous monitoring of the journal temperatures, possibly by 1975.

In addition to hotbox detectors, railroads are installing other new detector devices in increasing numbers each year. With the advent of faster freight and passenger speeds, there is an increasing emphasis on safety and a growing need for new detectors of all types. These increased from about 5,000 automatic devices in 1957 (including hotbox detectors) to more than 8,000 in 1967 (see table 15). They include "presence" detectors which are placed in areas where falling rocks or other debris may be found on the track, clearance or high-wide load detectors, high-water detectors, and smoke detectors.

Microwave. Railroads are increasingly adopting microwave, a radio frequency above 890 megacycles per second, to provide the wider bandwidth necessary for the growing volume of data, voice, and message traffic. Route mileage of railroad micro-

Table 15. Miscellaneous detectors installed, by year, 1960–1967

Year	Dragging equipment	Broken wheel	Presence [1]	Other	Cumulative total, all detectors [2]
1960	17	15	....	79	5,505
1961	37	15	....	19	5,691
1962	22	1	....	1	5,788
1963	67	12	700	3	6,611
1964	26	28	331	....	7,164
1965	19	11	266	18	7,611
1966	123	31	312	5	8,303
1967	70	31	210	3	[3] 8,617

[1] No specific yearly data available before 1963.

[2] Includes hotbox detectors.

[3] Estimated.

SOURCE: **Railway Age,** July 17, 1967; 1967, Railway Signaling and Communications, January 1968.

wave has increased from less than 200 miles used on an experimental basis in 1952 to more than 22,000 miles in 1966. A 1966 survey indicates an annual rise of 25 percent in voice traffic and 8 percent in message volume; data transmission, however, is increasing about 40 percent per year. In 1957, the Federal Communication Commission (FCC) for the first time formally assigned a band of frequencies for private railroad microwave. Both leased common carrier and private, road-owned lines are used. Many roads are using microwave to completely supplant existing pole-lines.

Adoption of microwave offers substantial cost savings that result from the avoidance of pole line installation, particularly where the terrain is difficult and requires many extra miles of circuits to span. Also, savings occur with increased transmission reliability (especially in extreme weather), lower maintenance costs and greater usage possibilities. The General Supervisor of Communications for one railroad reports a reliability of 99.99658 percent, with only 15.81 minutes of downtime per year.

Facsimile transmission (as of waybills) and VHF radio are two of the key uses of railroad microwave. One railway system, for instance, is using a combination of computer and data processing techniques, with microwave and long distance xerography, to provide real-time transmission, primarily of waybills. This waybill contains data needed for operational control—train consist, commodity weight, and consignee. Centralized, operational control is dependent on transmitting advance knowledge of crew, car, and motive power requirements, as well as of cost data—all information contained in the waybill or able to be computed from its entries. Now in use on several roads, facsimile transmission is expected to become one of the principal uses of railroad microwave. VHF radio is being increasingly used in yard and road operations and in maintenance-of-way work, as well as in dispatching from wayside to train, because the line communication system is not adequate to meet the demand. Industry estimates of 35,000 route miles of private railroad microwave by 1970 and 50,000 route miles by 1975 are based on rising requirements for current, accurate information.

Automatic Car Identification. Automatic car identification (ACI) is a system that uses wayside scanners to locate cars carrying specially printed labels. ACI is also helpful in scheduling cars for inspection and for servicing. A label with the car initial and description is placed on the exterior of the car, caboose, locomotive, trailer, or container. As the car passes, wayside scanners "read" and transmit the data from the label to decoders which provide the user with all types of information about the car's location, type, current load status, future availability, priority status (in scheduling) and its weight (net, gross, load). (See appendix II-3 for descriptions of various applications of ACI.)

In the mid-1960's the need for an industry-wide ACI system was recognized by the Association of American Railroads. A standard system was adopted for industry-wide use beginning in the spring of 1969. According to AAR rules, all cars and locomotives to be interchanged among the various railroad systems must be equipped with ACI labels by January 1, 1970. In the fall of 1969, it was reported that roughly half the car fleet were labeled and no railroad had less than 30 percent of its cars labeled; also, about 50 ACI scanners were in service. Scanners will be located at interchange points and supply information to both railroads, thus enhancing better scheduling coordination. Transit time and the amount of clerical work will be reduced substantially. Also, with a continuous information flow, the railroad industry is likely to improve customer service and, in turn, its position in the competitive shipping market.

Maintenance of way changes

The term "maintenance of way" refers to the installation and upkeep of railroad track, rail bed, and associated structures. For some years following World War II, maintenance of way work was done by men who relied largely upon sheer brawn and handtools. Gradually, these handtools were supplemented with pneumatic powered tools and then replaced by single-purpose machines. These machines were designed for specific operations such as pulling and driving spikes, unscrewing bolts, packing ballast, and hoisting heavy materials like ties and rails into place.

In the late 1950's and early 1960's, these single-purpose, manually-operated machines spread throughout the industry. Concurrently, manufacturers also developed off-track vehicles which could travel along the tracks for work purposes but could also get off the track quickly when trains approached. Sophisticated combination machines that could raise and align the track, and level and tamp the ballast in the road bed in a single operation were also introduced. Still other machines were developed that could pick up, clean and return ballast to the roadbed; remove old ties and insert new ones; or clean switch yards quickly.

A 1969 survey revealed that the degree of mechanization of the various operations involved in maintenance of way ranged from 20 to 100 percent. (See table 16.)

In addition, improved materials and techniques are also contributing to a reduction in maintenance labor requirements. Of major importance is the adoption of continuous rail and the imminent spread of the concrete tie. In 1967, over 7 percent of main-line track was continuous-welded rail that was laid in quarter-mile sections with extensive use of machinery. This type of rail eliminates joints at the rail-end and saves a significant amount of labor once required to lift, cut off and relay short 39-foot pieces of conventional rail. Concrete ties, which tend to have longer useful lives than wooden ones, are currently in experimental use on several roads and their more widespread use is expected in the future. Other developments, such as two-way radio, have contributed greatly to increasing work capacity of the labor force. Radio communication permits the work force to maximize work time before clearing the track in advance of oncoming trains. In addition, improved paints, paint application methods, and the use of prestressed concrete for bridge construction reduce maintenance labor requirements. The future adoption of "weathering" steel for construction purposes may also reduce manpower requirements for surface maintenance.

Routine maintenance and "clean up" around the classification yard is also being speeded up by prefabrication of track panels and retarder units. This reduces the time and labor required to repair tracks and transfers repair work indoors where it can be done more efficiently. In both yard and line-of-track work, snow removal attachments for some maintenance of way equipment and also specialized portable snow removal equipment are replacing manual removal of snow. Routine maintenance is also aided by the use of herbicides which are mechanically applied in yards and along the track.

Table 16. Degree of maintenance of way mechanization, by operation, 1969

Operation	Percent of mechanization
Transportation of gangs	65
Track surface and lining (mainline)	81
Rail laying, cropping, transposing—	
Jointed rail:	
Unloading and distribution	68
Installation	78
Pickup	73
Transposing	75
Welded rail:	
Unloading and distribution	76
Installation	100
Pickup	55
Transposing	95
Normal handling	100
Ballast unloading and distribution	65
Snow removal	37
Tie renewal:	
Unloading and distribution	51
Installation	86
Disposal	21
Vegetation control:	
Spraying	67
Cutting	52
Road crossing maintenance	45
Track inspection and field testing	90
Right of way fences	20
Cleaning ditches and drains	65
Track and yard cleaning	45

SOURCE: Roadmasters and Maintenance of Way Association, Chicago, 1969.

In 1957, 151,453 men were maintaining the 345,832 miles of track operated, compared to 76,546 men maintaining 322,855 miles of track in 1967.[14] The 50 percent decrease in the employment of workers maintaining approximately the same miles of track implies a significant increase in productivity. However, these statistics include an unknown number of miles of track used on which little or no maintenance is performed. The subject of deferred maintenance in the railroad industry is a controversial one. Observers of the industry and trade specialists have been studying this problem for some time. According to one of these sources, for the past several years maintenance has been pro-

[14] In both years, the amount of track operated under trackage right agreements is excluded as a means of avoiding duplication. The exclusion will also eliminate some track which is jointly owned. Coverage is for class I railroads only.

ceeding at only about 60 percent of the rate required to effect a complete rail renewal within 50 years. Within the industry, some spokesmen maintain that many roads are not financially able to keep abreast of their scheduled maintenance of way requirements.

The outlook for further mechanization in the period through 1975 is not clear, but some trends are discernible. Increasingly, there are indications of a continuing emphasis on maintenance of way equipment acquisition and activity. For example, when capital expenditures were reduced by 22 percent, from a 1966 high of $1.9 billion, total expenditures for roadway and structures were reduced only 6 percent. Again in 1968, when total capital expenditures were reduced still further—by 23 percent—the reduction in total expenditures for roadway and structures was only 2.2 percent.

Passenger service

Positive efforts to improve passenger service have been hampered for several reasons. From the customer's point of view, coach ticket costs on railroads are frequently only slightly below air fare, while additional time is required to go by rail. When overnight travel is involved, sleeping accommodations bring the cost above air fare. From the railroads' point of view, passenger trains are costly to run. For example, in 1967 expenses related solely to passenger and allied services (including rents and taxes) exceeded total passenger service revenues by $138 million. Because of a lack of profits from passenger service, old equipment dating from the late 1940's and early 1950's, in general, has not been replaced. This older equipment is difficult to maintain and makes travel by railroad undesirable for many persons. In addition, the problem has been compounded as train service has been cut to minimize cash drains.

There have been only a few changes in long-haul passenger service technology. One such change is the Northeast Corridor Experiment in which customer response to frequently scheduled, well maintained trains is tested. To achieve these goals, new lightweight, high-speed cars have been developed and stretches of welded track installed. Also, computerized ticket machines have been introduced to expedite the process of purchasing tickets. Further innovations in passenger service may follow at the conclusion of the current experiment if it proves to be successful.

Currently, attempts are being made in the U.S. Congress to improve railroad passenger service. For example, the Railroad Passenger Service Act of 1970 established the National Railroad Passenger Corporation (NRPC) in the fall of 1970. A semipublic corporation, the NRPC has 8 directors who serve on a 15-man board that has the responsibility for operating most of the nation's intercity passenger trains effective May 1, 1971. Amtrack is attempting to eliminate underutilized and unprofitable passenger trains to the greatest extent possible, while still maintaining a network of passenger routes among selected cities. The implications of these developments for passenger traffic and for employment are outlined in chapters V and VI.

Chapter III. Productivity and Other Measures of Technological Change

Several quantitative measures are presented in this section that are illustrative of technological progress. These include output per man-hour, and a variety of capital related measures such as the capital output ratio.

Output per man-hour

Relating changes in output to changes in man-hours (i.e., productivity) is a useful although partial indicator of the pace of technological change. The change in the ratio reflects the changes in quality and quantity of capital equipment, capital investment, new materials, new approaches to marketing as well as the procedural changes and many other management measures that contribute to more effective freight and passenger transportation. Measures of output per man-hour reflect also changes in occupational mix, skill levels, training, and education of the work force. Furthermore, the measure for the industry reflects shifts in the importance of railroads with different degrees of operating efficiency and the long-term practice of shifting some railroad operations to outside firms as discussed in the chapter on employment.

Output per man-hour (productivity) increased more rapidly between 1957 and 1969 than in the previous decade, although productivity in the industry was already growing more rapidly than that of the total nonfarm economy. Many factors contributed to this increase, including the new technology mentioned earlier, increased levels of capital expenditures, and cost-cutting in services caused by financial stringency.

The average annual rate of increase in output per man-hour for all employees in the railroad industry was 5.2 percent between 1947–70, (chart 4), almost twice the 2.7 percent increase for the total nonfarm economy. Between 1957 and 1970, output per man-hour of all employees in the railroad industry increased at an average annual rate of 6.0 percent.

Besides those already discussed, another factor contributing to the increase in productivity in the later period was the noticeable growth in output.[15] For example, the average annual rate of change in output between 1957 and 1970 was 2.2 percent, compared with a decline of 0.4 percent between 1947 and 1957.[16]

Levels of output in revenue traffic units (RTU's) per man-hour vary widely among the railroads because of differences in equipment, managerial, and employee skills, size of railroad, and the type of traffic carried—the latter influenced greatly by the geographic districts [17] in 1965, based on the number sents data on railroads which were selected as the "best" railroad in each of the three ICC-designated geographic districts [17] in 1965 based on the number of revenue traffic units produced per all employee man-hour in 1965. The railroads considered for analysis were restricted to those having a labor input in excess of 20 million man-hours annually. The "best" railroads were chosen from among 22, at the top of their geographic districts—West, South, East—when ranked according to productivity.[18]

Those "best" railroads were studied to see if their

[15] See appendix III-1 for study concerning relationship between output and output per man-hour growth.

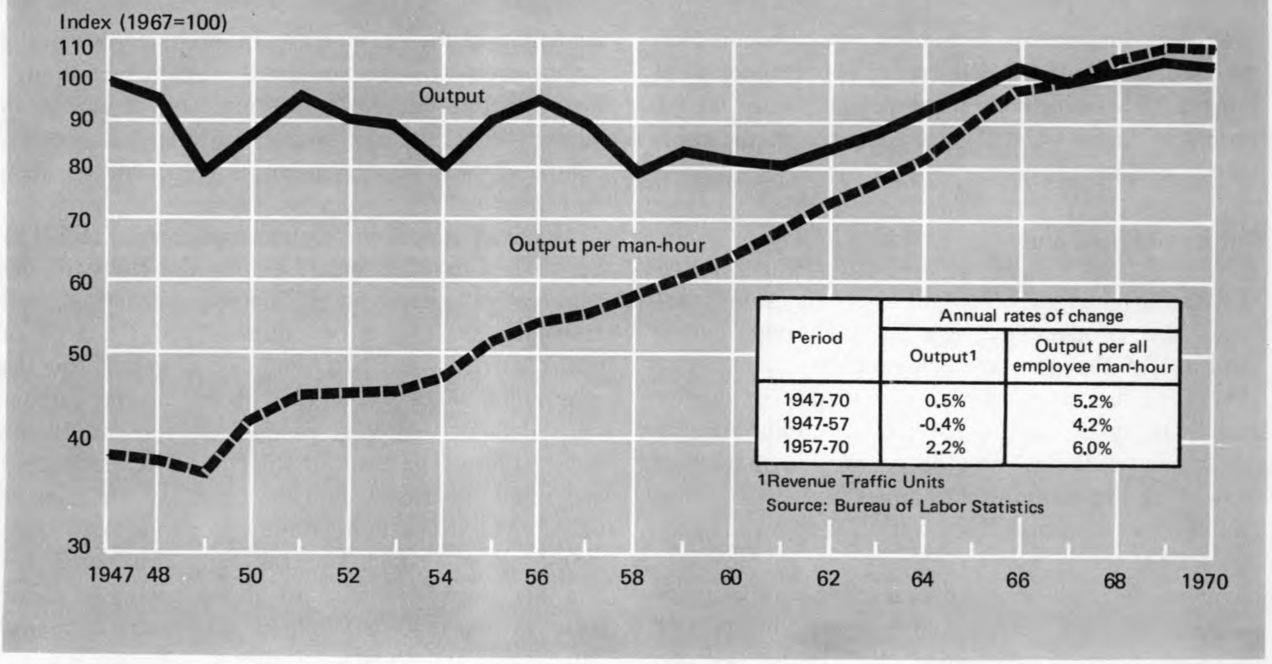
[16] This output measure is based on revenue traffic units (RTU's), a weighted combination of revenue freight ton-miles (one ton of freight hauled one mile) and revenue passenger miles (one passenger carried one mile). (See appendix III-3.) Also see U.S. Department of Labor, "Indexes of Output Per Man-Hour, Selected Industries, 1939 and 1947–70," BLS Bulletin 1692, Government Printing Office, 1971, Washington, D.C.

[17] A district is a geographical grouping, used by the Interstate Commerce Commission, to which railroads have been assigned for statistical purposes.

[18] Although a particular railroad may be the "best" in its geographic district, there may be other plants in other districts that exceed its level of productivity. For example, in 1965, five out of seven railroads in the Southern district and two out of 10 in the Western district, had higher levels of output per man-hour than the "best" railroad in the Eastern district. For more detail on choice of railroads and methodology, see appendices III-5 and 6.

Chart 4.

Railroads: Output and Output Per Man-Hour, 1947-70



productivity growth patterns could be used as predictors for the entire industry. Even though subsequent analysis indicated that the approach was no better than one which uses conventional trend analysis, it showed a wide range in productivity levels (output per man-hour) both among the "best" railroads and between each of them and the industry average. (See table 17.) Also, analysis of the "best" railroads revealed that the time required for the industry as a whole to achieve the average "best" plant level of productivity has shortened—from about 42 months to roughly 35 months—a situation that would persist if the industry meets its capital expenditure goals. This shortened lag results from the more recent higher average rate of changes in productivity (output per man-hour). The weighted "best" railroad average productivity was about 23 percent above the industry for the 1956–66 period. During the early 1960's, when all railroads generally were increasing their productivity, the average for

Table 17. Output (RTU's) per man-hour: Ratios for "best" railroads in a district and industry average, 1956–66

Year	Ratio of "best" railroads to industry average				Industry average (RTU's/Mhr.)[1]
	Railroad "A", southern district	Railroad "B", eastern district	Railroad "C", western district	"Best" railroad, average	
1956	1.38	1.03	1.03	1.17	314.9
1957	1.41	1.00	1.07	1.19	320.3
1958	1.36	1.06	1.08	1.19	336.1
1959	1.38	1.03	1.11	1.19	357.3
1960	1.37	1.01	1.12	1.18	372.3
1961	1.40	.99	1.18	1.20	398.2
1962	1.38	1.03	1.23	1.22	423.5
1963	1.39	1.07	1.28	1.25	450.1
1964	1.38	1.09	1.32	1.27	476.6
1965	1.30	1.10	1.32	1.24	526.0
1966	1.28	1.04	1.30	1.21	563.3

[1] The industry average differs slightly from the published BLS series due to omission of switching and terminal company data.

SOURCE: Bureau of Labor Statistics and Interstate Commerce Commission.

all of the "best" ones considered together increased their margin over the industry. These roads increased their traffic more than the industry average, indicating a business shift toward more efficient plants.

Capital and output per unit of capital

The trend in output relative to the trend in value of road and equipment owned by U.S. railroads is an indicator of changes in the productivity of capital. Although for productivity analysis, the flow of capital services rather than physical stock is the preferred measure, the data for this measure are not available.[19] In 1958 dollars, the value of road and equipment owned by all U.S. railroads remained virtually unchanged between 1948 and 1967—about $52 billion in each year. (See table 18.) During the 20-year period, the BLS index of output for class I railroads (RTU's) rose about 4 percent from 114.2 to 118.8.

Railroad employment during the same period decreased drastically with the result that the value of road and equipment per employee increased from $34,000 to about $75,000 per employee. However, despite the change in this ratio, and the changing quality of the equipment used, as described earlier, the output relative to the value of road and equipment changed little. This resulted in large measure from the nature of the industry which requires a fleet of rollingstock that is in a non-earning status much of the time.

Output and material inputs [20]

Still another measure that is helpful in assessing industry changes taking place is the trend in output (BLS revenue traffic) relative to the input (including fuel, materials, and services), exclusive of capital and labor discussed elsewhere. For the whole period of 1947–68, output increased by less than one percent while the value of supplies consumed decreased on a constant dollar basis by 39 percent. (See appendix III-8.)

One of the outstanding reductions that occurred was in the amount of fuel required per gross ton-mile of train movement. Fuel is among the more important inputs, excluding capital and labor, and the amount required to move a gross ton-mile has declined by 80 percent in the 1948–66 period, as shown in chart 5. (See appendix III-9, 10.) Although a major portion of this savings is due to the transition from steam to diesels, quality improvements in the fuels, themselves, may also have been a factor. Although small increments may be realized as fuel savings in the future, the most likely further economies resulting from motive power changes will be from reduced maintenance man-hour requirements. (See discussion on redieselization in chapter II.)

Table 18. Value of road and equipment, number of employees, all U.S. railroads, selected years, 1948–67 [1]

Year	Road and equipment (constant 1958 dollars, billions)	All railroad employees (000's)	Road and equipment per employee (000's of $)
1948	51.9	1,517	34.2
1952	53.6	1,400	38.3
1957	53.3	1,121	47.5
1962	51.0	796	64.1
1967	52.1	698	74.6
	Average Annual Percent of Change		
1948–57	0.3	−3.3	3.7
1957–67	−.2	−4.7	4.6

[1] See Appendix III-7.

SOURCE: Office of Business Economics, Bureau of Labor Statistics, Interstate Commerce Commission.

Selected equipment utilization measures

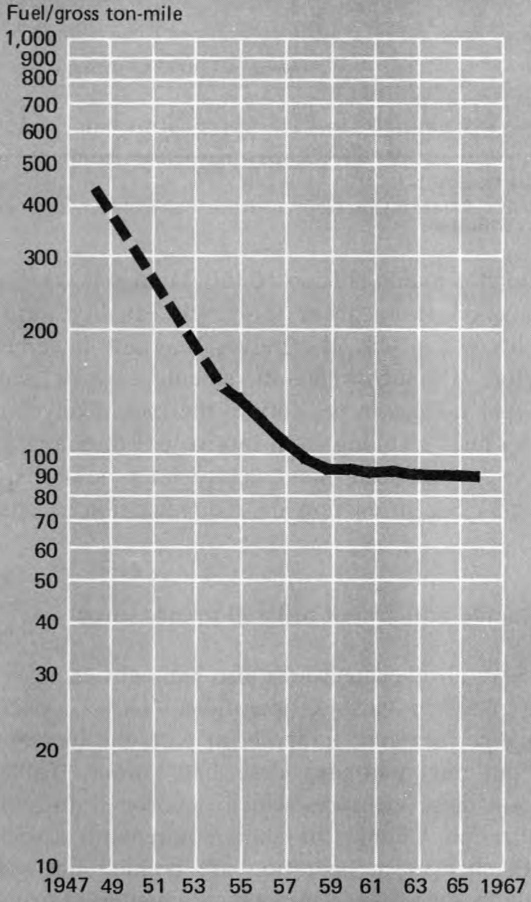
Several other measures also highlight changes taking place in various operations. These aspects of train performance underlie, in part, the increases in output per man-hour described earlier. Table 19 shows these measures which describe train and car utilization. Changes in labor requirements associated with changes in operation are pointed out specifically in subsequent employment chapters. For example, the same changes in car construction that permit greater average speed also reduce the requirements for maintenance men; similarly, a car's higher capacity frequently lends itself to mechanized loading and adversely affects persons employed as freight handlers. In general, as unit sizes increase

[19] A flow measure reflects differences in usage and efficiency of existing capital capacity and how these differences affect varying levels of output. See paper prepared for the National Commission on Productivity which includes a discussion on this subject by Jerome A. Mark, Assistant Commissioner for Productivity and Technology, BLS, pp. 21–22.

[20] These inputs include fuel, rail, and ties as well as other materials and supplies needed to carry on day-to-day business operations.

Chart 5.

Fuel Requirements Per Gross Ton-Mile in Class I, Linehaul Railroads (Index 1957-59=100)



Source: See Appendix Table III-7.

and transit times decrease, unit labor requirements are reduced.

The first group of measures (line numbers one through four) pertain to train operation and demonstrate the increases that have occurred in the 1957–68 period. Taken together, they show that the average freight train has been increased in length from 68.6 to 70.1 cars; in product carried from 1,424 to 1,768 tons; in speed from 18.8 to 20.4 miles per hour. This combination of increased length, load and speed has resulted in the average train's carrying more freight per train hour—34.5 percent more in 1968 than in 1957. Increased locomotive power, tractive effort, and better bearings have permitted the railroads to use these heavier, longer trains while centralized traffic control has reduced train delays and contributed to increased average train speed.

The second group of measures (line numbers 5–8) relate to the use of cars. In the 1957–68 period, the average daily distance traveled was increased from 47.0 to 53.9 miles; the average freight carload increased from 43.8 to 51.8 tons, while the average capacity increased from 54.5 to 64.3 tons. Taken together, these increases in distance traveled, carload weight, and car capacity have resulted in an increase of almost 40 percent in the ton-miles produced per freight car day.

Another measure related to freight car utilization is the ratio of annual revenue and nonrevenue ton-miles carried to annual capacity available. As shown below in table 20, utilization of railroad-owned and leased cars increased 14.8 percent between 1955 and 1968, from 7,040 ton-miles to 8,079 ton-miles per ton of capacity. The increase in utilization may be due, in part, to the exclusion of private cars.

Changes in car material and construction, combined with better classification yards and higher

Table 19. Freight equipment utilization, 1957 and 1968

Line number	Occupations	1957	1968	Percent change 1957–68
1	Cars per average freight train	68.6	70.1	+ 2.2
2	Average freight train load (tons)	1,424.0	1,768.0	+24.2
3	Average freight train speed	18.8	20.4	+ 8.5
4	Net ton-miles per train hour	26,833.0	36,091.0	+34.5
5	Average daily car mileage	47.0	53.9	+14.7
6	Average freight carload (tons)	43.8	51.8	+18.3
7	Average freight car capacity (tons)	54.5	64.3	+18.0
8	Ton-miles per freight car-day	975.0	1,361.0	+39.6

SOURCE: Yearbook of Railroad Facts, 1969 and 1970 editions, Association of American Railroads.

Table 20. Revenue and nonrevenue ton-miles per ton of capacity, class I railroads, selected years, 1955–68

Year	Total revenue and nonrevenue ton miles (billions)	Aggregate capacity of freight cars in service [1] (millions of tons)	Revenue and nonrevenue ton miles per ton of capacity
1955	642.2	91.2	7,040
1959	588.2	92.3	6,375
1963	632.9	85.9	7,364
1966	749.6	91.4	8,197
1968	755.7	93.5	8,079

[1] Cars in service of class I railroads, owned and leased at close of year.
SOURCE: Interstate Commerce Commission.

train speeds, are largely responsible for better car utilization by the railroads. Since car purchases account for about 55 percent of average annual railroad capital expenditures, slight improvements in car utilization can have great significance for the railroads' overall capital spending program. A small gain in utilization effectively increases the car fleet size, thus freeing capital for other areas.

The technological advances that seem to promise the greatest return on investment for the future are those that increase car utilization by increasing train speed and daily car mileage. Areas of capital expenditures that would facilitate these developments are improvements in right-of-way and track and structure, as well as communication and signaling —particularly automatic car identification. As car utilization is increased, without enlargement of the fleet, the railroads' return on investment may be enhanced, attacting more capital to the industry and permitting it to preserve its market share of intercity freight.

Chapter IV. Employment Trends

This chapter reviews trends of the industry's employment profile, which serve as a basis for estimating future employment levels. It also provides information on the regional distribution of employment, the age of workers, and the employment of women and Negroes. Projected employment levels, which take into account the specific impact of technological changes, are presented in chapter V.

Employment trends

In 1969, employment of class I railroads stood at 578,277 workers, down about 26 percent from 1960, and 57 percent from 1947 (see table 21). During this same period, the trend in employment for production workers followed a similar pattern, although declining slightly as a proportion of total employment.[21]

At the same time that employment in the industry has been declining, the unemployment rate has been lower than for the economy as a whole. In 1969, the unemployment rate for railroad and railway express workers was 1.6 percent; for all workers, it was 3.5 percent. This better-than-average record reflects, in part, the relative success of the efforts of the industry and unions to provide adjustment measures, as described in chapter VI.

Employment Shifts. In addition to primary employment changes brought about directly in the industry work force by technology, changes in employment have also resulted from the long-standing practice of shifting employment to outside firms which supply equipment to the industry. For example, a growing proportion of the freight car fleet is privately owned (14.3 percent in 1960 and 17.1 percent in 1967); this has contributed to a drop in manpower requirements in the "maintenance of equipment and stores" category. Similarly, "piggybacking" has shifted work previously done by railroad workers to freight forwarders and regular trucking firms. Also, the exchange of one diesel locomotive unit for another through purchase, a practice known as "unit exchange," has cut down on engine rebuilding in railroad shops. The leasing of equipment that is related to technological changes in the railroad industry—communication and computer systems, for example—generates employment in other industries which manufacture and service such equipment.

Characteristics of the railroad workforce

Distribution of Employment. In early 1967, nearly two-fifths of all railroad employment was concentrated in 23 Standard Metropolitan Statistical Areas (SMSA's), compared with about one-third in 1957. (See appendix IV-1.) [22] The shift of railroad employees from locations mainly on the rural railroad rights-of-way to urban communities resulted, in part, from the consolidation of railroad car classification yards and rolling stock maintenance facilities. Changes in communication technology have also contributed to this shift to urban centers.

Chicago, Illinois, the leading SMSA in terms of railroad employment (48,600 employees) is the hub of railroad traffic; it serves as the point for transshipment of eastern manufactured goods to the west and south, as well as eastbound agricultural products. In addition, it serves as a terminal point for goods leaving the country via the Great Lakes route. St. Louis, Missouri-Illinois and Kansas City, Missouri-Kansas, with 15,600 and 10,800 employees respectively, are both gathering points for agricultural products. New York City, N.Y. (19,900 em-

[21] See appendix III-3 and 4 for data.

[22] Except in New England, an SMSA is a county or group of contiguous counties which contains at least one central city of 50,000 inhabitants or more. In addition to the county, or counties, containing such a city, or cities, contiguous counties are included in a standard metropolitan area if according to certain criteria they are essentially metropolitan in character and sufficiently integrated with the central city. In New England, "Metropolitan State Economic Area" is a county or group of counties which is characterized by a distinctive combination of social and economic characteristics.

Table 21. Railroad (class I) employment and traffic, selected years, 1947–69

Year	Total employment (in thousands)	Revenue ton miles (in billions)	Revenue passenger-miles (in billions)
1947	1,352.0	654.7	45.9
1952	1,226.2	614.8	34.0
1953	1,206.5	605.8	31.7
1954	1,064.6	549.3	29.3
1955	1,057.2	623.6	28.5
1956	1,042.6	647.1	28.2
1957	984.8	618.2	25.9
1958	840.8	551.7	23.3
1959	815.2	575.5	22.0
1960	780.5	572.3	21.3
1961	717.5	563.4	20.3
1962	700.2	592.9	19.9
1963	679.3	621.7	18.5
1964	665.0	658.6	18.2
1965	640.1	697.9	17.4
1966	624.9	738.4	17.1
1967	602.6	719.5	15.2
1968	590.5	744.5	13.1
1969	578.3	767.2	12.2

SOURCE: Association of American Railroads and Interstate Commerce Commission.

ployees), Philadelphia, Pennsylvania (15,200), Los Angeles, California (13,800), and San Francisco, California (11,500), are all overseas terminal points. New York is also a distribution point for east coast commodity shipments, with San Francisco serving as a major import-export center for trade with the Orient. Pittsburgh, Pennsylvania (13,900) is a city where activity centers around processing raw materials into primary metals—bulky, heavy products which are best transported by rail. (See appendix IV-1 for railroad employment in major SMSA's and appendix table IV-2 for definitions of these areas in 1957 and 1967.)

Women Employed by Railroads. In 1966, the railroads employed 58,000 women, about 6 percent of total railroad employment, according to data compiled by the Railroad Retirement Board. Their employment reached a high point during World War II when they accounted for 9.2 percent of total railroad employment, reflecting the general increased labor force participation by women during that time.

Year	*Employees in service during year (000's)*	*Women (000's)*	*Female employment as percent of all employees*
1944	2,903	268	9.2
1947	2,470	140	5.7
1957	1,510	92	6.1
1966	944	58	6.1

SOURCE: Annual Report, Railroad Retirement Board.

Soon after the end of World War II, men began replacing women in many of the more strenuous railroad occupations and some women returned to their traditional clerical and service occupations. By 1966, they accounted for 66 percent of workers in the "clerks and other office employee" category.

While technological and procedural changes have had an impact on office employment, the decline in these occupations (discussed fully in chapter V) has been less rapid than that of the total railroad industry. The increasing use of data by the industry may cause this employment sector to remain fairly stable, thus causing an expansion in the proportionate share of jobs held by women in the 1970's.

Age. The age distribution of an industry's employment supplies important clues about present and future job opportunities. The railroad industry's workforce had a median age of 46.4 years in 1967, up from 44.4 years in 1957. (See table 22 for distribution of employment by age.) Between 1967 and 1975, it is estimated that 235,000 railroad employees will reach age 65, providing an increasing number of potential job vacancies. These cover workers at all skill levels and in jobs requiring varying levels of education to enter. For example, the largest single number of potential retirees will be among shop craftsmen; the next largest, among clerks and other office employees; and the third largest among supervisors and professional workers (see table 23). Relatively large numbers of retirees will also be found among miscellaneous maintenance of way workers.

Table 22. Age distribution of railroad employees, 1957 and 1967

Age (On birthday in given year)	Percentage distribution	
	1957	1967
Total [1]	100.0	100.0
34 and under	29.6	26.9
35–44	21.7	19.7
45–54	21.6	25.3
55–64	20.5	22.3
65 and over	6.4	5.6

[1] Includes employees whose age was not reported.
SOURCE: U.S. Railroad Retirement Board.

Employment of Negroes and Spanish-Surnamed Americans. Negroes and persons with Spanish surnames made up a relatively small proportion of total railroad employment in 1966, according to a survey of 788-establishments conducted by the U.S. Equal

Table 23. Estimated retirements, by occupation, 1967–75

Occupational category	Number	Percent
Total	235,000	100.0
Office employees:		
Executives, officials, and staff assistants	6,496	2.8
Supervisors and professionals	21,012	9.0
Station agents and telegraphers	7,897	3.4
Clerks and other office employees	26,983	11.5
Train and engine service employees:		
Engineers	15,642	6.6
Conductors	13,741	5.8
Firemen and hostlers	5,320	2.3
Brakemen, baggagemen, and switchtenders	12,990	5.5
Gang foremen	13,642	5.8
Maintenance employees:		
Way and structures craftsmen	7,470	3.2
Shop craftsmen	35,802	15.2
Way and structures helpers and apprentices	799	.3
Shop helpers and apprentices	5,023	2.1
Other maintenance-of-way employees	17,961	7.6
Other shop and stores employees	10,544	4.5
Station and platform employees	10,842	4.6
All other employees	22,836	9.7

SOURCE: U.S. Department of Labor, Bureau of Labor Statistics, based on Railroad Retirement Board data.

Employment Opportunity Commission (EEOC).[23] In 1966, there were 54,250 Negroes employed in these establishments and 16,703 persons with Spanish surnames; both groups were heavily concentrated in blue collar jobs, often as operatives or laborers. (See table 24). About one-fifth of the Negro railroad workers were employed as service workers. Spanish surnamed Americans comprised 6.9 percent of white collar jobs, with 2.6 percent for Negroes. Among the Spanish surnamed Americans, slightly over half the women were in white collar employment (office and clerical) compared with 6.2 percent of the males. Among Negroes, 9.1 percent of the women employed on railroads were in white collar jobs and only 2.3 percent of the men.

Relatively more Negroes are employed in the railroad industry than in industry as a whole—9.4 percent compared with 8.2 percent in 1966, according to the EEOC study. Negro workers, who comprise a high proportion of workers in low skill occupational categories, will continue to be in demand because of increased maintenance of way work, much of which has been deferred for years and because of the large number of older workers in these job categories. (See table 23.) In general, Negro workers with appropriate education and training are likely to have better prospects in the future for higher level work because of the growing trend toward hiring Negroes for such jobs and for upgrading their skills.[24]

[23] Equal Opportunity Report No. 1, Part II, Job Patterns for Minorities and Women in Private Industry, 1966, U.S. Equal Employment Opportunity Commission, Washington, D.C., 1968.

[24] "Where do Railroads Stand on EEO?" Tom Shedd, Modern Railroads, February 1969, pp. 40–42; Part II, pp. 44, 45.

Table 24. Railroad employment of minority groups, 1966

Employee category	Total employment	Total white collar employment	Total blue collar employment	Blue collar occupations: Craftsmen	Operatives	Laborers	Total service workers
All Employees (SIC 40)							
Male	648,136	151,547	476,068	225,388	156,189	94,491	20,521
Occupational distribution	100.0	23.4	73.5	34.8	24.1	14.6	3.2
Female	34,992	30,958	3,231	599	372	2,260	803
Occupational distribution	100.0	88.5	9.2	1.7	1.1	6.5	2.3
Total (788 establishments)	683,128	182,505	479,299	225,987	156,561	96,751	21,324
Occupational distribution	100.0	26.7	70.2	33.1	22.9	14.2	3.1
Spanish Surnamed American							
Male	16,458	1,017	15,281	4,656	2,366	8,259	160
Occupational distribution	100.0	6.2	92.8	28.3	14.4	50.2	1.0
Percent of total	2.5	.7	3.2	2.1	1.5	8.7	.8
Female	245	129	101	0	6	95	15
Occupational distribution	100.0	52.7	41.2	.0	2.4	38.8	6.1
Percent of total	.7	.4	3.1	.0	1.6	4.2	1.9
Total	16,703	1,146	15,382	4,656	2,372	8,354	175
Occupational distribution	100.0	6.9	92.1	27.9	14.2	50.0	1.0
Percent of total	2.4	.6	3.2	2.1	1.5	8.6	.8
Negro							
Male	52,478	1,224	40,937	4,888	7,948	28,101	10,317
Occupational distribution	100.0	2.3	78.0	9.3	15.1	53.5	19.7
Percent of total	8.1	.8	8.6	2.2	5.1	29.7	50.3
Female	1,772	162	1,415	69	56	1,290	195
Occupational distribution	100.0	9.1	79.9	3.9	3.2	72.8	11.0
Percent of total	5.1	.5	43.8	11.5	15.1	57.1	24.3
Total	54,250	1,386	42,352	4,957	8,004	29,391	10,512
Occupational distribution	100.0	2.6	78.1	9.1	14.8	54.2	19.4
Percent of total	7.9	.8	8.8	2.2	5.1	30.4	49.3

SOURCE: U.S. Equal Employment Opportunity Commission.

Chapter V. Employment Outlook and Impact of Technological Change on Occupational Structure

This chapter provides an estimate for class I railroad employment as well as the underlying assumptions about output (traffic) and technological change. It also relates future changes in employment in specific occupational categories to the major technological changes that have affected them in the past.

Employment outlook

The outlook for an upturn in railroad employment by 1975 is not promising. Technological and other changes which have influenced output and productivity, and in turn employment trends in recent years, are likely to persist and to become even more pervasive in the years ahead. Thus, the most optimistic estimate of class I railroad employment in 1975 is that it may total 540,000 persons, compared with about 600,000 in 1967.[25] Even though this estimate points to a continued decline in class I railroad employment, many job opportunities will continue to arise because of the growing need to replace workers who die or retire. Also, because of changing job requirements in this industry, which stem from the technological changes and other's cited earlier, a growing need for workers with higher levels of education and skill is likely.

Any employment estimate for class I railroads must take into consideration trends in output (freight and passenger traffic) as well as overall productivity changes. The trends in output per all employee man-hour, (productivity) have been discussed previously in chapter III. In estimating future trends in productivity, it was assumed that the most recent rate of growth would continue through 1975.[26]

Trends in freight traffic. Between 1947 and 1967, the average annual increase in revenue ton-miles was 0.5 percent but since 1961, freight traffic has been rising at an average annual rate of 3.6 percent. Projections of future growth in revenue ton-miles assume, as a minimum, the continuation of this trend between 1961–67. This conclusion arises both from the great increase in all intercity freight traffic (revenue ton miles of 1.7 trillion in 1967, compared with 1.3 trillion in 1961) since the 1960–61 dip in economic activity, and also from the ability of the railroads to maintain their competitive position vis-a-vis other transportation modes. The impact of the Vietnam buildup on the amount of railroad freight traffic carried is difficult to measure; however, total railroad carloadings have increased slightly since 1964. Between 1964 and 1965, carloadings rose by 0.3 percent; the following year (1966) carloadings increased by 1.8 percent. The cessation of hostilities in Vietnam will have some effect on the growth of railroad traffic, but apparently the overall reduction is unlikely to alter the 1961–67 trend greatly because of the underlying strength of the American economy.

Should the 1961–67 trend persist through 1975, revenue ton-miles may total 954 billion, up one-third from the 1967 level. A somewhat higher level, about 985 billion revenue ton-miles is possible, however, if the stable relationship continues between this output measure and constant dollar Gross National Product (GNP) which has been growing at the long-term rate of 4 percent yearly.

Trends in passenger traffic. The long-term rate of decline in revenue passenger miles has been modi-

[25] This estimate of 1975 class I railroad employment is consistent with the estimate of 570,000 workers employed in all railroad transportation published earlier in *Tomorrow's Manpower Needs,* Supplement Number 2, U.S. Department of Labor, Bureau of Labor Statistics, 1970. The Bureau of Labor Statistics employment projections utilize regression analysis and take account of information from the Bureau's economic growth model and its industry-occupational matrix.

[26] An alternate productivity projection based on regression analysis was developed by the Bureau. The method is discussed in appendix III-1.

fied slightly since 1961; at this time it slowed to an average annual rate of 4.7 percent. By comparison, this rate of change between 1947 and 1967 was −5.4 percent; during the early part of this 20-year period, a dramatic shift had occurred from railroad to air passenger travel, particularly among sleeping and parlor car patrons. Coach traffic had also declined between 1947 and 1957, but at a considerably slower pace. During this period, the sleeping and parlor car traffic decreased at an average annual rate of 11.1 percent—over twice as fast as the rate for coach traffic. The major factor modifying the drop in revenue passenger miles has been commuter traffic, which has averaged about 4 billion passenger miles a year since 1960. This, together with a possible increase in corridor-type traffic (see Research and Development section of chapter I) and the operation of intercity passenger trains by Amtrak, may slow the rate of decline in passenger traffic.

Changes in Occupational Structure, 1957 and 1967. Each of the seven summary reporting occupational categories, as defined by the Interstate Commerce Commission registered declines in employment, although the relative proportion of specialized and high level manpower in the industry tended to grow (see table 25). The classes of occupations most adversely affected by the drop in employment between 1957 and 1967 generally were those occupations that required little formal education, training, or experience to enter, such as the helper or laborer job classifications concerned with either maintenance of way and structures, maintenance of equipment and stores, or transportation. Those occupations which experienced declines faster than the average annual industry rate of 4.7 percent between 1957–67 are listed in table 26.

Employment in certain occupations increased during the 1957–67 period. Among these were chief claim agents or investigators (ICC 22) in the professional and clerical major occupational group and portable equipment operators (ICC 35) and gang foremen (ICC 38, 39) in the maintenance of way and structures group. In addition, while employment in skilled trades declined in absolute numbers, this decline was substantially below the industry average annual rate.

Technology and occupational trends

To get more detailed information about specific occupational categories, as distinct from the broad trends in employment described earlier, technological, managerial, marketing and other changes that have affected employment of class I railroad workers were examined independently for their impact on workers in particular occupations.[27] Each of the 128 ICC categories was reviewed to ascertain the kinds of work done by persons reported in a particular category and an evaluation was then made of the relationship between the various technological changes and job content. To facilitate analysis, some innovations that affected the same classes of occupations were grouped together. Also, when more than one technological change affected a single occupation, that occupation was included with the change that had the greatest impact on employment. For

[27] It was not possible, however, to assess fully the probable impact on productivity and employment of any substantial increase in the rate of abandonment of unprofitable lines. At the time this report was being prepared, abandonment of unprofitable lines was a subject being discussed in the industry but the positions of the various interested parties had not been determined.

Table 25. Changes in class I railroad employment, by major occupational group, 1957–67

ICC reporting title (major occupational group)	Employment				
	1957		1967		Average annual percent change 1957–67
	Number	Percent	Number	Percent	
Total	986,001	100.0	610,191	100.0	−4.7
Executives, officials and staff assistants	16,264	1.7	15,501	2.5	−.5
Professional, clerical, and general	190,046	19.3	131,360	21.5	−3.7
Maintenance of way and structures	170,766	17.3	90,462	14.8	−6.2
Maintenance of equipment and stores	246,358	25.0	138,488	22.7	−5.6
Transportation (other than train, engine, and yard)	115,293	11.7	57,020	9.3	−6.8
Transportation (yardmasters, switch tenders, and hostlers)	14,199	1.4	9,828	1.6	−3.6
Transportation (train and engine)	233,075	23.6	167,532	27.5	−3.3

SOURCE: Interstate Commerce Commission.

Table 26. Occupational categories with greatest employment decreases, 1957–67

ICC line no.	Title	Employment 1957	Employment 1967	1957–67, percentage decrease
	Total	187,553	61,039	67
	Class I, linehaul employment	986,001	610,191	38
65	Helper apprentices (M. of E. and stores)	1,023	215	79
23	Miscellaneous trades workers (other than plumbers)	791	183	77
62	Molders	163	39	76
92	Truckers (stations, warehouses, and platforms)	10,425	2,499	76
103	Crossing and bridge flagmen and gatemen	6,983	1,806	74
64	Skilled trades helpers (M. of E. and stores)	37,002	9,752	74
37	Pumping equipment operators	258	74	71
91	Callers, loaders, scalers, sealers, and perishable-freight inspectors	12,099	3,675	70
74	Stationary firemen, oilers, coal passers, and water tenders	1,563	479	69
32	Bridge and building painters	1,858	639	66
42	Section men	69,264	24,277	65
104	Foremen (laundry) and laundry workers	419	149	64
107	Switch tenders	2,655	950	64
49	Signalman and signal maintainer helpers	2,291	833	64
128	Yard firemen and helpers	20,160	7,447	63
43	Maintenance of way laborers (other than track and roadway) and gardeners and farmers	1,972	738	63
72	General laborers (stores and ice, reclamation, and timber-treating plants)	11,202	4,211	62
96	Chefs and cooks (restaurants or dining cars)	3,060	1,232	60
86	Baggage agents and assistants	364	151	59
95	Stewards, restaurant and lodging-house managers, and dining-car supervisors	1,203	507	58
115	Road passenger baggagemen	2,798	1,183	58

SOURCE: Interstate Commerce Commission.

each grouping of innovations, the occupations affected and the total number of workers employed was determined for the year 1957 and then compared with employment levels in 1967. Then, taking into account past and expected trends in the diffusion of the technological change and their impact on past employment, estimates for the various occupations were obtained for the year 1975. Table 27 summarizes employment related to the major groups of innovations for 1957 and 1967, and provides an estimate of the probable impact of these changes on employment by 1975. Using this method to estimate class I railroad employment implies that this total will reach 540,000 by 1975.

Altogether, 10 technological innovation groupings were selected as having a major impact on class I railroad employment. These are described in chapter II and include redieselization; improved cars; facility relocation and improvements; unit trains and "piggyback;" automatic classification yards; computers; centralized traffic control; detectors, microwave and automatic car identification; maintenance of way; and passenger service changes and improvements. In this chapter, the innovation groupings are analyzed for their manpower implications.

Redieselization

In 1967, there were 78,033 railroad employees working in 16 occupations that had been significantly affected by redieselization (purchase of new and greatly improved diesels). This employment represents a drop of 47 percent since 1957.[28] The average annual decline in employment for the group was 6.2 percent, substantially above the 4.7 percent average for the total of the industry's class I railroads. Table 28 shows the occupations that comprise the group and employment changes since 1957.

Among those occupations with the greatest rates of decline in employment were molders (ICC 62) who have all but disappeared from the industry. They accounted for 39 workers in 1967, and it is likely that this occupation will vanish by 1975 as workers die or retire.

Employment in two other occupations in the group also declined rapidly. Skilled trades helpers (ICC 64) and helper apprentices (ICC 65) totaled 9,967 in 1967, down from 38,025 in 1957. This decline of 74 percent is closely associated with decreased unit maintenance man-hours for new locomotive series. As an example of the sharp drop in man-hour requirements, table 29 sets forth requirements for locomotives introduced at different times, representing first- and second-generation diesels and improvements in each stage of development. It can be seen from the table that unit man-hour requirements for maintenance of second-generation diesels

[28] See *Railroad Shopcraft Factfinding Study,* U.S. Department of Labor, 1968, for a detailed analysis of year-to-year trends in these occupations.

Table 27. Employment by innovation group, 1957, 1967, and outlook for 1975

Innovation grouping	Number of occupations affected	Employment: Number 1957	Employment: Number 1967	Employment: Number Estimated 1975	Average annual percent change 1957–67	Average annual percent change 1967–75
Total	128	986,001	610,191	538,900	−1.9	−1.6
Redieselization	16	147,941	78,033	66,000	−6.2	−2.1
Improved cars	10	110,845	66,428	51,000	−5.0	−3.3
Facility relocation and improvements	5	16,543	6,757	3,900	−8.6	−6.6
Unit trains and piggyback [1]	9					
Automatic classification yards	10	127,233	90,173	85,000	−3.4	−0.7
Computers	8	137,804	95,713	93,000	−3.6	−0.4
Centralized traffic control	10	48,880	29,257	26,000	−5.0	−1.5
Detectors, microwave, and automatic car identification	5	21,924	13,764	10,000	−4.6	−3.9
Maintenance of way	17	151,453	76,546	72,000	−6.6	−0.8
Passenger service changes and improvements	15	60,964	30,385	17,700	−6.7	−6.5
All other	32	162,414	123,135	116,000	−2.7	− .7

[1] Occupational categories whose employment was affected by the introduction of this innovation, are included in the above three changes because they had a greater impact on employment.

SOURCE: Interstate Commerce Commission, BLS.

are less than 40 percent of those for diesels of the first series.

In 1975, manpower requirements in these 16 categories of jobs affected will be substantially lower due to expected diffusion of second generation diesels. Man-hour requirements for diesel maintenance in these 16 occupations will be reduced, although workers in these occupations will also be required to work on other equipment, both rolling stock and stationary. It is estimated that employment in the 16 occupations will be reduced by about 12,000 jobs, and will total 66,000 in 1975.

Improved cars

In 1967, there were 66,428 employees working in 10 occupations that had been significantly affected by changes in the design and construction of new railroad cars. In addition, the almost complete disappearance of less-than-carload freight traffic also accounted for employment declines in most of these occupations. The 1967 employment in these occupations is 40 percent below the 1957 level. The average annual decline in employment for the group was 5.0 percent, slightly above the 4.7 percent average

Table 28.` Employment and occupational changes related to redieselization, 1957–67

Occupations (ICC classification numbers)	Employment: 1957 Number	Employment: 1957 Percent	Employment: 1967 Number	Employment: 1967 Percent	Average annual percen change, 1957–67
Total	147,941	100.0	78,033	100.0	− 6.2
General, assistant general, and department foremen (50)	7,762	5.2	6,231	8.0	− 2.2
General and assistant general foremen (stores) (51)	295	.2	207	.3	− 3.5
Equipment, shop, electrical, material and supplies inspectors (52)	1,388	.9	804	1.0	− 5.3
Gang foremen and gang leaders (skilled labor) (53)	7,389	5.0	5,454	7.0	− 3.0
Blacksmiths (54)	2,963	2.0	1,539	2.0	− 6.4
Boilermakers (55)	3,558	2.4	1,681	2.2	− 7.2
Electrical workers (A) (58)	15,199	10.3	10,983	14.1	− 3.2
Machinists (61)	29,977	20.3	18,612	23.9	− 4.7
Molders (62)	163	.1	39	.1	−13.3
Sheet-metal workers (63)	8,854	6.0	5,800	7.4	− 4.1
Skilled trades helpers (M. of E. and stores) (64)	37,002	25.0	9,752	12.5	−12.5
Helper apprentices (M. of E. and stores) (65)	1,023	.7	215	.3	−14.5
Regular apprentices (M. of E. and stores) (66)	6,090	4.1	3,553	4.6	− 5.2
Gang foremen (shops, enginehouses, and power plants) (68)	646	.4	329	.4	− 6.5
Classified laborers (shops, enginehouses, and power plants) (70)	11,302	7.6	5,490	7.0	− 7.0
General laborers (shops, enginehouses, and power plants) (71)	14,330	9.7	7,344	9.4	− 6.5

SOURCE: Interstate Commerce Commission, BLS.

Table 29. Estimated maintenance man-hours for selected diesel locomotive series[1]

Work performed	First generation		Second generation	
	Series 1 introduced 1941	Series 2 introduced 1947	Series 3 introduced 1961	Series 4 introduced 1965
Total	1,541	1,301	548	499
ICC Inspection man-hours (annual)	270	270	270	270
Scheduled Maintenance (annual)	1,271	1,031	278	299
Total Maintenance & ICC Inspection Man-hours for 4-year cycle	7,283	6,154	2,619	2,286
Average annual unit man-hours	1,820	1,538	655	572

[1] Excludes truck maintenance man-hours which amount to about 1½ man-hours per 1,000 unit miles. In 1966, the average daily mileage for freight locomotive units was 232, according to the Association of American Railroads.

SOURCE: General Motors Electromotive Division.

for all occupations in the industry's class I railroads. Table 30 shows the 10 occupations that comprise the group and employment changes in them since 1957.

Among those occupations with the greatest rates of decline were truckers (ICC 92) and callers, loaders, scalers, sealers, and perishable-freight inspectors (ICC 91). Employment in these two occupations was substantially affected by changes in the design of railroad cars that permitted the use of more mechanized loading equipment. In 1957, workers in these occupations accounted for about 20 percent of the employment associated with the loading of freight cars; by 1967, the proportion had declined to less than 10 percent. Carmen (ICC 56 and 57), who are responsible for the maintenance of freight and passenger cars, have also been reduced in numbers, but their average rate of decline has been less rapid than for the industry as a whole. Their employment has been affected by the increasing use of large size freight cars. Also, modern freight cars are constructed of lighter weight, more durable materials and use improved bearings—factors that contribute to reduced car maintenance requirements.

In 1975, overall employment in this group of occupations will be about one-fourth lower than in 1967 and may total 51,000 workers. This conclusion assumes a continuation of recent trends in employment among carmen, truckers and callers, loaders, scalers, sealers, and perishable-freight inspectors who, together, accounted for 84 percent of the employment in this group of occupations in 1967.

Shop facilities: relocation and improvements

In 1967, there were 6,757 employees working in five occupations that had been significantly affected by facility relocation and improvements; in 1957, employment in these occupations had totaled 16,543 workers. The average annual decline in employment for the group was 8.6 percent, substantially higher than the class I railroad industry average rate of 4.7 percent. Table 31 shows the occupations that comprise the group and employment changes since 1957.

This innovation grouping includes technological changes that have had a very significant impact on employment. It excludes automatic classification yards, but covers improvements within maintenance

Table 30. Employment and occupational changes related to improved cars, 1957–67

Occupations (ICC classification numbers)	Employment				
	1957		1967		Average annual percent change, 1957–67
	Number	Percent	Number	Percent	
Total	110,845	100.0	66,428	100.0	− 5.0
Motor vehicle and motor car operators (24)	6,453	5.8	5,745	8.6	− 1.2
Carmen (A and B) (56)	16,434	14.8	12,436	18.7	− 2.7
Carmen (C and D) (57)	56,107	50.6	37,142	55.9	− 4.0
General foremen (freight stations, warehouses, grain elevators and docks) (88)	362	.3	187	.3	− 6.4
Assistant general foremen (freight stations, warehouses, grain elevators, and docks) (89)	194	.2	89	.1	− 7.5
Gang foremen (freight stations, warehouse, grain elevators and dock labor) (90)	2,647	2.4	1,208	1.8	− 7.6
Callers, loaders, scalers, sealers, and perishable-freight inspectors (91)	12,099	10.9	3,675	5.5	−11.3
Truckers (stations, warehouses, and platforms) (92)	10,425	9.4	2,499	3.8	−13.3
Laborers (coal and ore docks and grain elevators) (93)	1,620	1.5	760	1.1	− 7.3
Common laborers (stations, warehouses, platforms, and grain elevators) (94)	4,504	4.1	2,687	4.0	− 5.0

SOURCE: Interstate Commerce Commission, BLS.

Table 31. Employment and occupational changes related to facility relocation and improvements, 1957–67

Occupations (ICC classification numbers)	Employment				
	1957		1967		Average annual percent change 1957–67
	Number	Percent	Number	Percent	
Total	16,543	100.0	6,757	100.0	−8.6
Electrical workers (B) (59)	1,998	12.1	1,221	18.1	−4.8
Electrical workers (C) (60)	397	2.4	200	3.0	−6.6
General laborers (stores and ice reclamation, and timber-treating plants) (72)	11,202	67.7	4,211	62.3	−9.3
Stationary engineers (steam) (73)	1,383	8.4	646	9.6	−7.3
Stationary firemen, oilers, coal passers, and water tenders (74)	1,563	9.4	479	7.1	−11.2

SOURCE: Interstate Commerce Commission, BLS.

facilities and in adjacent service operations. Employment in each of the occupations affected by facility relocation and improvements declined more rapidly than the industry average. Two affected occupations —general laborer (ICC 72) and stationary firemen (ICC 74)—were among those that led the industry in terms of average annual rates of decline in employment.

First in importance in reducing labor requirements has been consolidation of maintenance facilities stemming largely from the widespread industry adoption of the diesel engine. The development of more efficient boilers and controls has also had an adverse impact on the employment levels of stationary engineers and their helpers. Other technological improvements have affected employment of laborers: wheel maintenance is now performed by sophisticated machines; large vacuum units are being used to clean car interiors; and mechanized washing facilities are available for the exterior cleaning of cars and locomotives.

Altogether, employment in these five occupations in 1967 was 59 percent below the number employed in 1957. Although facility consolidation is an industry practice which has already become widespread, continuing declines in employment among laborers is anticipated but at a lower average annual rate than that of the period, 1957 to 1967. By 1975, it is likely that overall employment in this group of occupations will decline further to 3,900 workers, largely because of employment trends in the general laborer category (ICC 72).

Unit trains and piggyback traffic

Altogether, employment in 9 ICC occupational categories has been affected by the development of unit trains and piggyback traffic; in 8 of these occupational categories (motor vehicle and motor car operators, ICC 24, is the exception), the adoption of these innovations has led to greater-than-average declines in employment between 1957 and 1967. Following is a list of these occupational categories, each of which has already been discussed under the appropriate technological development that has had the greatest impact on its employment.

ICC Line	*Occupational Category*
24	Motor vehicle and motor car operators
60	Electrical workers (C)
88	General foremen (freight stations, warehouses, grain elevators, and docks)
89	Assistant general foremen (freight stations, warehouses, grain elevators, and docks)
90	Gang foremen (freight station, warehouses, grain elevators, and dock labor)
91	Callers, loaders, scalers, sealers, and perishable freight inspectors
92	Truckers (stations, warehouses, and platforms)
93	Laborers (coal and ore docks and grain elevators)
94	Common laborers (stations, warehouses, platforms, and grain elevators)

In both unit and piggyback trains, manpower savings have resulted from the reduction in loading, unloading, and switching operations. Unit trains bypass switchyards completey and piggyback trains are unloaded by simply driving the trailers away from the switchyards. Some low-skilled railroad jobs associated with loading, unloading, and switching operations have been diverted to other industries as a result of these innovations. However, new jobs have also been created in the railroad industry. These job titles include those of the director of piggyback pricing or marketing, his assistants, and his related clerical staff. All of these new jobs are included among professional and clerical (white collar) occupations while the occupations that have declined in employment have been blue-collar ones.

Yardworker directs the loading of a piggyback trailer onto a waiting flatcar.

Automatic classification yards

In 1967, there were 90,173 railroad employees working in 10 occupational categories (about 14 percent of all class I railroad workers) that had been significantly affected by the establishment of automatic classification yards. This employment represents a total drop of 29 percent since 1957, when this innovation was still relatively new. The average annual decline in employment for the group of occupations was 3.4 percent, significantly less than the 4.7 percent average for the industry's class I railroads. Table 32 shows the occupations that comprise the group and employment changes since 1957.

Among those occupations with the greatest rates of decline in employment were yard firemen and helpers (ICC 128) and switchtenders (ICC 107). Employment for yard firemen and helpers also declined because of dieselization and the subsequent compulsory arbitration award called for by the Presidential Railroad Commission established in 1963. Both switchtenders and yard firemen and helpers were among the 21 occupational categories in the industry (out of 128) that declined the most between 1957 and 1967.

New technology associated with the establishment of automatic classification yards has changed the job content in several occupations. Yardmasters and their assistants (ICC 105 and 106), for example, now rely heavily on computers for accurate information about the location and scheduling of cars—when they are due, where each is bound, and which are being switched. Data available to the yardmaster through computer printouts allow him to supervise the movement of scheduled inbound and outbound traffic. Also, the yardmaster relies on the use of radio transmission to provide current information to yard personnel. In automatic classification yards, switches are no longer thrown manually by switch tenders; instead, retarder and remote control switch operators, located in towers overlooking freight yard operations, switch cars by flicking switches located on a console. The duties of the yard brakemen (ICC 120) have also been modified somewhat. In some yards, they still manually uncouple cars and signal to the switchtender when track switches must be thrown; in others, regulation of car speed has been taken over by computers which control mechanical retarders. Also, the brakeman uses radio to communicate with the yard conductor from whom he receives his instructions.

The 1975 employment outlook for workers in this

Table 32. Employment and occupational changes related to use of automatic classification yards, 1957–67

Occupations (ICC classification numbers)	Employment				
	1957		1967		Average annual percent change 1957–67
	Number	Percent	Number	Percent	
Total	127,233	100.0	90,173	100.0	−3.4
Yardmasters (105)	5,129	4.0	4,803	5.3	−.7
Assistant yardmasters (106)	1,213	1.0	688	.8	−5.5
Switchtenders (107)	2,655	2.1	950	1.1	−9.7
Outside hostlers (108)	1,767	1.4	1,352	1.5	−2.6
Inside hostlers (109)	2,319	1.8	1,272	1.4	−5.8
Outside hostlers helpers (110)	1,116	.9	763	.8	−3.8
Yard conductors and yard foremen (119)	21,411	16.8	18,729	20.8	−1.3
Yard brakemen and yard helpers (120)	53,293	41.9	38,590	42.8	−3.2
Yard engineers and motormen (124)	18,170	14.3	15,579	17.3	−1.6
Yard firemen and helpers (128)	20,160	15.8	7,447	8.3	−9.5

SOURCE: Interstate Commerce Commission, BLS.

group of occupations related to automatic classification yards is one of relative stability. Current employment (1967) is likely to diminish only slightly by 1975, accounting for about 85,000 workers in this group of occupations. This slight change in overall employment is related to the diffusion of small automatic classification yards and the construction of a few more large ones.

Computers

In 1967 there were 95,713 employees working in 8 occupations that had been significantly affected by computers. This employment represents a drop of 31 percent since 1957. The average annual decline in employment for the group of occupations between 1957 and 1967 was 3.6 percent, compared to a 4.7 percent decline in all class I railroad employment during the same period. Table 33 shows the occupations that comprise the group and employment changes since 1957.

Among the occupations with the greatest rates of decline in employment were clerks (ICC 7), the telephone switchboard operators and office assistants (ICC 14), and messenger and office boys (ICC 15). Employment in the last two occupations declined at a much greater average annual rate than overall employment of occupations related to the utilization of computers. In fact, their numbers have been so depleted that the further introduction of new telephone switching techniques and greater use of computer terminals for information dissemination is not likely to have much effect on employment levels in these occupations. However, the major groups of clerks (ICC 6 and 7) may be reduced somewhat further as additional computer systems are modified to permit direct shipper and consignee access to car location files, rather than relying on clerks to query the system for these users.

The introduction of computers in the railroad industry provides a good example of the employment and occupational changes associated with technological change. In this industry, as in others, the impact of the growing use of computer technology has been to reduce employment most heavily in occupations requiring lower levels of skill and in jobs that are repetitive. At the same time, higher level jobs have been growing in importance, increasing their relative share of overall employment. For example, in the railroad industry, employment among professional and subprofessional assistants (ICC 3), chief clerks (ICC 4 and ICC 5) and clerks and clerical specialists (ICC 6) declined at a rate substantially below the average for class I railroad employment between 1957 and 1967. At the same time, employment in these occupational categories increased as a proportion of all workers employed in occupations associated with introduction of computers.

The introduction of computers has also meant the introduction of job titles previously unheard of in the industry.[29] These new job titles are shown in table 34.

In 1975, employment in this group of occupations may total 93,000, only slightly below the 1967 level shown on table 33. This estimate takes into consideration the increasing requirement for high-level white-collar workers (noted above) and is based

[29] These job titles were reported to the Interstate Commerce Commission under its 128 line reporting system. Since these are new job titles, they were subsumed into the existing classification. The greatest number of new job titles were reported in categories 1–8 (mainly in occupations related to computers) while the remainder were distributed among the other occupational categories.

Table 33. Employment and occupational changes related to use of computers, 1957–67

Occupations (ICC classification numbers)	Employment				
	1957		1967		Average annual percent change 1957–67
	Number	Percent	Number	Percent	
Total	137,804	100.0	95,713	100.0	−3.6
Professional and subprofessional assistants (3)	8,325	6.0	7,373	7.7	−1.2
Supervisory or chief clerks (major departments) (4)	2,769	2.0	2,342	2.4	−1.7
Chief clerks (minor departments) and assistant chief clerks and supervising cashiers (5)	11,416	8.3	9,407	9.8	−2.0
Clerks and clerical specialists (A) (6)	11,265	8.2	9,132	9.5	−2.1
Clerks (B and C) (7)	90.013	65.3	58,562	61.2	−4.2
Mechanical device operators (office) (8)	8,233	6.0	6,026	6.3	−3.1
Telephone switchboard operators and office assistants (14)	3,434	2.5	1,775	1.9	−6.4
Messengers and office boys (15)	2,349	1.7	1,096	1.1	−7.3

SOURCE: Interstate Commerce Commission, BLS.

Table 34. New railroad job titles associated with use of computers

ICC Line and occupational category	New job titles reported
Division officers, assistants and staff assistants (ICC 2)	Supervisor of Computer Centers; Supervisor of Data Coordination; Transportation Analyst
Professional and subprofessional assistants (ICC)	Assistant Computer Engineer; Assistant Manager, Applied Research; Assistant Quality Control Engineer; Communication Valuation Engineer; Electronic Engineer.
Supervisory or chief clerks (major departments) (ICC 4)	Assistant Chief Cost Analyst; Assistant Cost Analyst; Auditor; Machine Accounting; Manager, Electronic Data Processing Center; Supervisor, Methods and Cost Control Engineers Systems.
Chief clerks (minor departments), assistant chief clerks and supervising cashiers (ICC 5).	Chairman, EDPM Committee; Accounting Chief of Keypunch; Chief System Analyst; Tape Room Supervisor.
Clerks and clerical specialists (A) (ICC 6)	Automation Analyst; Cost and Methods Engineer; Junior Economist; Methods Analyst; System and Methods Analyst.
Clerks (B and C) (ICC 7)	Manifest Clerk IBM Operator; Tape Librarian.
Mechanical Device Operator (Office) (ICC 8)	IBM Clerk; Accounting Machine Operator; Alpha-Numeric Keypunch Operator; Assistant Computer Programer; Assistant IBM Operator; Clerk, Machine Operator; Lead Computer Programmer; Console Operator.

SOURCE: Interstate Commerce Commission, BLS.

upon employment and occupational trends found in a few railroad companies that have led the industry in computer applications.

Centralized traffic control

In 1967, there were 29,257 employees working in 10 occupational categories that had been significantly affected by the installation of centralized traffic control. This employment represents a drop of 39 percent since 1957. The average annual decline in employment for the group between 1957 and 1967 was 5.0 percent, compared with a decline of 4.7 percent among all class I railroad workers. During this period, the number of miles of track under centralized traffic control increased from 32,000 in 1957, to 46,000 in 1967. Table 35 shows the 10 occupational categories included in the group and employment changes since 1957.

Among those occupations with the greatest rates of decline in employment were assistant signalmen and assistant signal maintainers (ICC 48), signalmen and signal maintainer helpers (ICC 49), clerk-telegraphers and clerk-telephoners (ICC 82), telegraphers, telephoners and towermen (ICC 83), crossing and bridge flagmen and gatemen (ICC 103) and train dispatchers (ICC 76). On the other hand, in two occupational categories—general and assistant general foreman and inspectors (ICC 44) and gang foremen, signal and telegraph skilled trades labor (ICC 45)—employment declines were slight between 1957 and 1967.

Telegraphers and telephoners, in the past, had received train orders from dispatchers while towermen operated the controls for automatic and manual block-signaling devices. With the adoption of CTC, many towermen, telegraphers and telephoners were shifted from work locations along the line of track to work stations where, with the use of a console, several stretches of track could be controlled. The effect on employment in these occupations can be illustrated from the example of one railroad which installed approximately 150 miles of track regulated by CTC. This change eliminated the need for 6 towers along the right of way and the 24 signal operators (towermen) who were employed in these towers—one operator per tower for each of 3 shifts plus one relief man at each tower.[30]

Signalmen and signal maintainers are skilled workers who can readily find employment in other industries. Employment in this occupational category declined relatively more slowly than overall industry employment. Competition from other industries for men with these skills has been a factor in the decline of employment. Attrition of this occupational category also accounts for the recent upturn in employment in the related helper and apprentice categories (ICC 48, 49) which had a substantial net decline between 1957 and 1967.

Clerk-telegraphers and telephoners (ICC 82) convey train orders received from dispatchers to various destinations along the right-of-way. With the adoption of CTC, this activity is becoming less common, reducing the need for some clerk-telegraphers and telephoners who have been transferred to other clerical duties such as car distribution. In addition, the transmission of messages using Morse Code has been virtually superseded by voice and facsimile

[30] *Railway Age,* June 19, 1961. Also, Interview, Baltimore and Ohio Railroad, May 25, 1966.

Table 35. Employment and occupational changes related to centralized traffic control, 1957–67

Occupations (ICC classification numbers)	Employment				
	1957		1967		Average annual percent change 1957–67
	Number	Percent	Number	Percent	
Total	48,880	100.0	29,257	100.0	−5.0
General and assistant general foremen, and inspectors (signal, telegraph, and electrical transmission) (44)	1,585	3.2	1,520	5.2	−.4
Gang foremen (signal and telegraph skilled trades labor) (45)	1,684	3.5	1,479	5.1	−1.3
Signalmen and signal maintainers (46)	8,664	17.7	6,786	23.2	−2.4
Assistant signalmen and assistant signal maintainers (48)	2,254	4.6	1,166	4.0	−6.4
Signalman and signal maintainer helpers (49)	2,291	4.7	833	2.8	−9.6
Chief train dispatchers (75)	1,086	2.2	894	3.1	−2.0
Train dispatchers (76)	2,949	6.0	2,219	7.6	−2.8
Clerk-telegraphers and clerk-telephoners (82)	8,123	16.6	4,440	15.2	−5.8
Telegraphers, telephoners, and towermen (83)	13,261	27.1	8,114	27.7	−4.8
Crossing and bridge flagmen and gatemen (103)	6,983	14.3	1,806	6.2	−12.7

SOURCE: Interstate Commerce Commission, BLS.

transmission—a factor which has contributed greatly to the above-average rate of decline in this occupational category.

Employment among crossing and bridge flagmen and gatemen (ICC 103)—an unskilled occupation—has declined rapidly as a result of the installation of automatically actuated signals. Train dispatchers (ICC 75, 76) have had an employment decline substantially less than that of total employment in the industry. They now have charge of CTC consoles or may operate them and have wide responsibility for safe train movement.

By 1975, total employment in the 10 occupations associated with the installation of centralized traffic control may decline to 26,000 at a rate considerably slower than between 1957 and 1967. The occupational composition may also change: crossing and bridge flagmen and gatemen may disappear and employment levels may continue to drop among telegraphers, telephoners, and towermen; clerk-telegraphers and telephoners; and among train dispatchers. In the case of train dispatchers, moreover, some of the reduction in employment may result from CTC's becoming more widely used on a regional basis. An upturn in employment is likely among both assistant signalmen and assistant signal maintainers and also signalmen and signal maintainer helpers because of the growing need to train skilled signalmen and signal maintainers who are in short supply.

Detectors, microwave and automatic car identification

In 1967, there were 13,764 employees working in five occupations that had been significantly affected by the introduction of such innovations as detectors, microwave, and automatic car identification. This employment represents a drop of 27 percent since 1957. Between 1957—when the Federal Communications Commission first assigned frequencies to the railroads—and 1966, microwave grew to more than 22,000 route miles. The average annual decline in

Table 36. Employment and occupational changes related to detectors, microwave, and automatic car identification, 1957–67

Occupations (ICC classification numbers)	Employment				
	1957		1967		Average annual percent change 1957–67
	Number	Percent	Number	Percent	
Total	21,924	100.0	13,764	100.0	−4.6
Traveling auditors or accountants (13)	1,183	5.4	811	5.9	−3.7
Linemen and groundmen (47)	2,835	12.9	2,132	15.5	−2.8
Station agents (smaller stations—nontelegraphers) (79)	4,119	18.8	2,216	16.1	−6.0
Station agents (telegraphers and telephoners) (80)	12,660	57.7	7,553	54.9	−5.0
Chief telegraphers and telephoners or wire chiefs (81)	1,127	5.1	1,052	7.6	−.7

SOURCE: Interstate Commerce Commission, BLS.

employment for the group of occupations between 1957 and 1967 was 4.6 percent, about equal to the decline of 4.7 percent in total class I railroad employment during the same period. Table 36 shows the occupations that comprise the group and employment changes since 1957.

Station agents (telegraphers and telephoners—ICC 80) and station agents (smaller stations—non-telegraphers—ICC 79) relay train orders and messages and may have other duties such as ticket sales, passenger information, and baggage checking, depending upon the size of the station. The installation of microwave has been a major reason for above-average employment declines among station agents. The increasing use of detectors for determining the condition of journals or roller bearings and to check for equipment that may be dragging or for a broken wheel, smoke, high water, and for many other purposes, has also cut down on the employment of station agents, who formerly visually checked the train for these conditions. The growth of centralized traffic control systems, the decrease in passenger service, the centralizing of freight station accounting and the loss of less-than-carload traffic, are among the additional factors that have contributed to the decline in employment in these occupations.

The adoption of microwave-based communication systems has also contributed to the decline in employment among linemen and groundmen (ICC 47) largely because of reduced line maintenance and need for fewer telegraph poles. The growing use of microwave has had little impact on the employment of chief telegraphers and telephoners or wire chiefs (ICC 81); some workers in this occupational category have, in fact, found the scope of their work activities broadened to include a new job title—supervisor, communications center.

Employment of traveling auditors or accountants (ICC 13) has been adversely affected by the adoption of microwave which has furnished the capacity to centralize recordkeeping. Clerks have also suffered employment declines because of microwave's increased carrying capacity; however, the major impact on their employment has resulted from the widespread adoption of computers.

In 1975, employment in these five occupations may total about 10,000, down 27 percent from 1967 levels. Should this decline take place, the downward trend in employment will probably be reflected mainly among linemen and groundmen and among station agents as microwave becomes more widely established. The installation of detector devices is not likely to have a major impact on the employment of workers who read such devices routinely as a part of their regular duties. Some recorders, for example, are tied in directly with centralized traffic control, while hotbox detectors that are located at trackside are the responsibility of signal maintainers and their helpers. In addition, automatic car identification, as it becomes more operational in the industry, will mainly affect employment levels of clerks and office personnel while employment of traveling auditors or accountants is likely to remain relatively stable.

Signalman checking out signal strength of a microwave station.

Maintenance of way innovations

In 1967, there were 76,546 employees working in 17 occupations that had been significantly affected by improvements and innovations in maintenance of way activities. Current employment represents a drop of 49 percent from 1957. The average annual decline in employment for the group between 1957 and 1967 was 6.6 percent, compared with a 4.7 percent decline among class I railroad employees. Table 37 shows the 17 occupational categories included in the group and employment changes since 1957.

Ten of the occupations associated with maintenance of way changes declined at a faster average annual rate than did class I railroad employment. Moreover, four of these 10 occupations were among the 20 railroad occupations that declined the most between 1957 and 1967. Altogether, six of the occupational categories with above average employment declines had large concentrations of workers: section men (ICC 42); gang or section foremen (ICC 40); extra gang men (ICC 41); bridge and building carpenters (ICC 30); bridge and building gang foremen, skilled labor (ICC 29); and maintenance of way and structures helpers and apprentices (ICC 34). As the occupational titles show, both skilled and unskilled workers were included among the declining occupational categories. In the case of skilled workers, the declines have slowed down since 1964 while in the case of unskilled workers, employment declines have continued, although at a slower rate than in the late 1950's.

Between 1957 and 1967, employment increases occurred among workers in three occupational categories related to maintenance of way work: portable equipment operators (ICC 35) because of the shift from pick and shovel work to the use of pneumatic handtools and multipurpose machines; gang foremen (extra gang and work train laborers, ICC 38) because of the growing reliance upon supervision as more complex equipment is used to satisfy grade, curvature and ballast specifications; and gang foremen (bridge and building, signal and telegraph laborers, ICC 39) who are relatively few in number.

The relatively stable occupations associated with maintenance of way work in the 1957–67 period were roadmasters, general foremen, and assistants (ICC 27); masons, bricklayers, plasterers and plumbers (ICC 33); and maintenance of way and scale inspectors (ICC 28).

Total employment in maintenance-of-way activities is difficult to estimate. Much of this kind of work is performed by workers in low skilled occupations whose employment tends to fluctuate with increases and decreases in maintenance of way expenditures, as does employment of the skilled workers they assist. According to one expert, estimates of maintenance requirements of rail installations assume an "average service life for rail of over 100 years" [31] even though many railroad officials believe track life is much shorter. In 1968, record expenditures of over $400 million were earmarked for

[31] See, "Derailment Problems Tackled by Railroads," by Vera Herschberg, *Journal of Commerce,* Mar. 12, 1969.

Table 37. Employment and occupational changes related to maintenance of way innovations, 1957–67

Occupations (ICC classification numbers)	Employment				
	1957		1967		Average annual percent change 1957–67
	Number	Percent	Number	Percent	
Total	151,453	100.0	76,546	100.0	−6.6
Roadmasters, general foremen, and assistants (27)	3,374	2.2	3,206	4.2	−.5
Maintenance of way and scale inspectors (28)	993	.7	817	1.1	−2.0
Bridge and building gang foremen (skilled labor) (29)	3.547	2.3	2.278	3.0	−4.3
Bridge and building carpenters (30)	10,464	6.9	5,214	6.8	−6.7
Bridge and building ironworkers (31)	785	.5	404	.5	−6.5
Bridge and building painters (32)	1,858	1.2	639	.8	−10.2
Masons, bricklayers, plasterers, and plumbers (33)	2,788	1.8	2,726	3.6	−.2
Maintenance of way and structures helpers and apprentices (34)	5,627	3.7	2,444	3.2	−8.0
Portable equipment operators (35)	6,897	4.6	8,891	11.6	+2.6
Portable equipment operators helpers (36)	581	.4	322	.4	−5.7
Pumping equipment operators (37)	258	.2	74	.1	−11.7
Gang foremen (extra gang and work-train laborers) (38)	2,881	1.9	3,309	4.3	+1.4
Gang foremen (bridge and building, signal and telegraph laborers) (39)	128	.1	149	.2	+1.5
Gang or section foremen (40)	16,949	11.2	7,486	9.8	−7.8
Extra gang men (41)	23,087	15.2	13,622	17.8	−5.1
Section men (42)	69,264	45.7	24,227	31.7	−10.0
Maintenance of way (other than track and roadway) and gardeners and farmers (43)	1,972	1.3	738	1.0	−9.3

SOURCE: Interstate Commerce Commission, BLS.

Men are still an important element in maintenance of way activities despite introduction of mechanization.

maintenance of way requirements; this was heralded by many in the industry as evidence of a new awareness of the need to stop deferring such maintenance work. If current high levels of maintenance of way expenditures continue, employment in this group of occupations may drop only slightly to 72,000 by 1975 (about 6 percent below 1967 levels). Should this occur, there will be numerous opportunities for relatively unskilled workers and the skilled craftsmen they assist—particularly in view of the high average age and years of service in these categories.

Passenger service changes

In 1967, there were 30,385 employees working in 15 occupations that had been significantly affected by changes and improvements in passenger service, a drop of about 50 percent since 1957. The average annual decline in employment for the group of occupations between 1957 and 1967 was 6.7 percent, compared with a decline of 4.7 percent among all class I railroad workers. Table 38 shows the 15 occupational categories included in the group and employment changes since 1957.

Eleven of the occupations associated with changes and improvements in passenger service declined at a faster average annual rate than did class I railroad employment, as a whole. One of these occupations—parlor and sleeping car conductor (ICC 100)—disappeared altogether.

Overall employment in this group of occupations is likely to continue to decline rapidly, and may reach 17,700 by 1975. Developments such as the introduction of the Penn-Central Metroliner and other high-speed trains that operate in corridors are not likely to contribute greatly to employment of workers whose jobs are related to passenger traffic. These high-speed trains carry traffic that is much less labor-intensive than the regular passenger train traffic they offset. Over the long run, should the Metro concept be extended to other corridors and account for the bulk of passenger traffic and should the operation of intercity passenger trains by Amtrak be successful, employment levels may stabilize or even rise among some workers. These include coach cleaners (ICC 67); road passenger engineers and motormen (ICC 121); road passenger brakemen and flagmen (ICC 116); train attendants (ICC 101); road passenger conductors (ICC 111); assistant road passenger conductors and ticket collectors (ICC 112).

Table 38. Employment and occupational changes related to passenger service, 1957–67

Occupations (ICC classification numbers)	Employment				
	1957		1967		Average annual percent change 1957–67
	Number	Percent	Number	Percent	
Total	60,964	100.0	30,385	100.0	−6.7
Coach cleaners (67)	8,093	13.3	3,464	11.4	−8.2
Supervising baggage agents (85)	95	.2	72	.2	−2.7
Baggage agents and assistants (86)	364	.6	151	.5	−8.4
Baggage, parcel room, and station attendants (87)	8,208	13.5	4,425	14.6	−6.0
Stewards, restaurant & lodging-house managers, & dining-car supervisors (95)	1,203	2.0	507	1.7	−8.3
Chefs and cooks (restaurants or dining cars) (96)	3,060	5.0	1,232	4.1	−8.7
Waiters, camp cooks, kitchen helpers, etc. (97)	7,028	11.5	2,995	9.9	−8.2
Parlor and sleeping car conductor (100)	6	.0	0	.0	
Train attendants (101)	3,403	5.6	2,111	6.9	−4.7
Road passenger conductors (111)	5,341	8.8	2,926	9.6	−5.8
Assistant road passenger conductors and ticket collectors (112)	2,851	4.7	1,975	6.5	−3.6
Road passenger baggagemen (115)	2,798	4.6	1,183	3.9	−8.3
Road passenger brakemen and flagmen (116)	6,269	10.1	2,963	9.8	−7.2
Road passenger and engineers and motormen (121)	6,434	10.6	3,489	11.5	−5.9
Road passenger firemen and helpers (125)	5,811	9.5	2,892	9.5	−6.7

SOURCE: Interstate Commerce Commission, BLS.

Other employment and occupational changes not related to a specific innovation

Thirty-two additional occupational categories (out of the 128 classified for reporting purposes by the ICC) were also affected by technological or procedural changes. However, shifts in their employment could not be readily traced to a single innovation or to a combination of technological changes, as with all other occupations. Altogether, these 32 occupations accounted for 123,135 workers in 1967, compared with 162,414 in 1957. As a group, they declined at an average annual rate of 2.7 percent between 1957 and 1967, considerably slower than total class I railroad employment. (See table 39).

Employment in 11 of the 32 occupations amounted to 99,829 workers in 1967, compared to 123,729 workers in 1957, a decline of 2.2 percent a year during the period 1957–67. Each of the 11 occupations accounted for at least 5,000 employees in 1967 and as a group accounted for 81 percent of all workers in the residual group.

Employment of road freight firemen and helpers (ICC 126) declined at an average annual rate of 7.2 percent between 1957 and 1967, sustaining the most rapid rate of decline of any of these 11 occupational categories. The main reason for this decline was the initial changeover from steam to diesel engines, which resulted in the elimination of the "firing" job of the fireman. Subsequently, the arbitration award of 1963 permitted the railroads to start cutting employment in this category. In view of the strong bid by unions to reinstate firemen since expiration of the award, it is impossible to project employment for this occupation.

Employment of stenographers and typists (ICC 10) has declined at an average annual rate of 5.2 percent during the 1957–67 period. In addition to their regular work, stenographers and typists also perform routine clerical work which has been taken over by computers or affected by changes in communications. This portion of their work is likely to be further diminished as more railroads develop total information systems.

Each of the occupational categories discussed below declined well below the average annual change in class I railroad employment between 1957 and 1967. Also, employment in some of these occupations began to rise in the latter part of the period. These included road freight brakemen and flagmen, local and way freight (ICC 118); rail freight engineers and motormen, through freight (ICC 122); and road freight conductors, through freight (ICC 113).

Employment of traffic and various other agents and investigators (ICC 19) declined at an average annual rate of 2.8 percent between 1957 and 1967. This decline is likely to continue to 1975 since many of these workers are performing tasks related to passenger traffic.

Employment of road freight brakemen and flagmen in local and way freight service (ICC 118) has declined at an average annual rate of 1.5 percent for the 1957–67 period. Despite a slight upturn in employment starting in 1965, a decrease in employment by 1975 is likely to result from the growing use of newly developed automatic coupler devices which eliminate the need for manual air hose connections.

Table 39. Employment and occupational changes, not related to specific innovations, 1957–67

Occupations (ICC classification numbers)	Employment				
	1957		1967		Average annual percent change 1957–67
	Number	Percent	Number	Percent	
Total	162,414	100.0	123,135	100.0	−2.7
Executives, general officers, and assistants (1)	7,276	4.5	6,595	5.4	−1.0
Division officers, assistants, and staff assistants (2)	8,988	5.5	8,906	7.2	−.1
Stenographers and typists (10)	12,944	8.0	7,578	6.2	−5.2
Traffic and various other agents, inspectors, and investigators (19)	10,681	6.6	8,039	6.5	−2.8
Road freight conductors (through freight) (113)	9,286	5.7	8,303	6.7	−1.1
Road freight conductors (local and way freight) (114)	6,244	3.8	6,085	4.9	−.3
Road freight brakemen and flagmen (through freight) (117)	23,282	14.3	19,591	15.9	−1.1
Road freight brakemen and flagmen (local and way freight) (118)	14,712	9.1	12,616	10.2	−1.5
Road freight engineers and motormen (through freight) (122)	11,456	7.1	9,941	8.1	−1.4
Road freight engineers and motormen (local and way freight) (123)	6,478	4.0	6,333	5.1	−.2
Road freight firemen and helpers (through freight) (126)	12,382	7.6	5,842	4.7	−7.2
All other occupations (21 occupations)	38,685	23.8	23,306	18.9	−4.9

SOURCE: Interstate Commerce Commission, BLS.

Employment of road freight engineers and motormen, through freight (ICC 122), declined at an average annual rate of 1.4 percent between 1957 and 1967. Although employment in the group is allied closely with freight traffic, which has been rising since 1960, this link will become less direct with the increasing use of more powerful locomotives to pull longer and heavier trains. Thus, despite increased freight traffic, employment in this occupational category in 1975 is expected to be about the same as today.

Road freight conductors' employment on through freight trains (ICC 113) declined at an average annual rate of 1.1 percent between 1957 and 1967. As in the case of road freight engineers and motormen, through freight (ICC 122) noted above, employment in this occupational category is closely related to traffic. Like road freight engineers and motormen, their employment is likely to be much the same in 1975 as now, despite increased traffic.

Employment of road freight brakemen and flagmen (ICC 117) declined at the same average annual rate as the conductors'—1.1 percent—between 1957 and 1967. Like that in the two occupations discussed above, employment of workers in this occupational category is also affected by length of trains and amount of traffic carried. Current disputes concerning the manning scale for freight make employment estimates difficult. However, should the United Transportation Union (UTU), which represents many of these employees, continue to be successful in obtaining one conductor and two brakemen crews for most trains and should the expected rise in overall freight traffic materialize, a slight increase in the number of these employees by 1975 may be in prospect.

Employment levels in the executive, general officer, and assistant category (ICC 1) declined at an average annual rate of 1.0 percent between 1957 and 1967. Many new jobs related to changed technology or innovations in marketing have been reported in this category in recent years. These include assistant manager, property taxes; assistant manager, rail-highway sales; director of piggyback pricing; and director of computer systems. The diffusion and adoption of various new technologies and marketing methods points to a growing need for the higher level manpower represented in this occupational category. There appears to be every indication that the slight decline in employment noted in the 1957–67 period will be reversed by 1975.

In local and way freight service, employment of road freight conductors (ICC 114) and road freight engineers and motormen (ICC 123) declined at average annual rates of 0.3 percent and 0.2 percent respectively, during the 1957–67 period. Each category increased substantially as freight increased in the 1960's and because of this factor, it is likely that their employment will increase still further in the 1970's.

Employment of division officers, assistants, and staff assistants (ICC 2) declined during the 1957–67 period, at an average annual rate of 0.1 percent. The average annual rate of decline might have been higher, however, except for the fact that employment in this group benefited from the adoption of new technology.[32] Since 1964, employment in this category has increased by almost 1,000 persons; in all likelihood, a steady growth in employment may be expected through 1975.

[32] See the section dealing with employment effects of computers which discusses new job titles created in this reporting category.

Chapter VI. Adjustments to Technological Change, Working Conditions and Earnings

Widespread technological change is responsible for changes in working conditions and industrial relations and has contributed to worker adjustment problems. This chapter examines these innovations from the viewpoint of their impact on working conditions and of employee adjustments to technological change, largely as expressed in collective bargaining agreements.

Collective bargaining and adjustments to technological change

Although collective bargaining provisions specifically relating to technological change have become prominent in the 1960's in the railroad industry, they follow the pattern of a contract—the "Agreement of May 1936, Washington, D.C."—originally designed to protect employees of merged carriers.[33] The nationwide pact, signed by most of the major U.S. railroads and all the standard railroad labor unions represented by the Railway Labor Executive Association, provided comprehensive protection against loss of job or earnings resulting from mergers and consolidations. It included provisions for advance notice of a merger; moving expenses and reimbursement for losses on home sales by relocated employees; an allowance which maintained the former wage rates of downgraded employees for several years; and, for separated workers, a severance allowance payable over a period of time or as a lump sum. The "Washington Agreement," however, did not apply to displacement or job loss caused by technological changes, or to reorganization within one railroad; neither did subsequent ICC regulations. Therefore, as these types of situations arose and had a greater effect on railroad workers during the 1950's and early 1960's, the growing demand for job protection became the subject of collective bargaining negotiations. Subsequently, some principles and provisions of the "Washington Agreement" were applied as well, to meet problems stemming from technological change, being incorporated into a few nationwide union-management contracts. For example, a 1964 nationwide contract covering some 140,000 nonoperating, shopcraft employees, extended protections such as moving allowances, income maintenance provisions and severance pay.[34] Also, in early 1965, a national contract embodying job guarantees, limitations on job subcontracts, and income protection devices was negotiated for about 255,000 nonoperating, nonshopcraft employees.[35] In 1970, the first agreement with such provisions for operating employees was negotiated on a pilot basis between the United Transportation Union and the Illinois Central Railroad.

Nonoperating railroad employees, totaling about 360,000 people, are organized into about 25 separate unions. (See appendix V-1).[36] A merger in early 1969 reduced the number of unions covering operating personnel—about 170,000 workers—from five to two: The United Transportation Union (UTU) and the Brotherhood of Locomotive Engi-

[33] See "Adjusting to Technology on the Railroads," *Monthly Labor Review,* November 1969, pp. 36–42.

[34] The Shopcraft Agreement of Sept. 25, 1964, signed by the Eastern, Western, and Southeastern Carriers' Conference Committee and the Railway Employees Department, AFL–CIO.

[35] The Nonshopcraft Agreement dated Feb. 7, 1965, between the National Railway Labor Conference and the Eastern, Western, and Southeastern Carriers' Conference Committee and the following unions: Brotherhood of Railway and Steamship Clerks, Freight Handlers, Express and Station Employees; Brotherhood of Maintenance of Way Employees; Order of Railroad Telegraphers; Brotherhood of Railroad Signalmen; Hotel and Restaurant Employees and Bartenders International Union.

[36] Some of these major unions are the Brotherhood of Maintenance of Way Employee (BMWE), Brotherhood of Railway, Airline and Steamship Clerks, Freight Handlers, Express and Station Employees (BRASC), and the International Association of Machinists and Aerospace Workers (IAM).

neers (BLE, Independent).[37] Declining railroad employment and the resulting decline in union membership has encouraged the smaller unions to merge to strengthen their bargaining power.

The existing adjustment techniques for technological change that apply to nonoperating employees include: Advance notice of change; various guarantees of job security, including crew size regulations and transfer and retraining rights and benefits; limitations on subcontracting and provisions for shorter work periods, income maintenance plans, and unemployment and retirement benefits. A discussion of each technique follows.

Adjustment techniques

Advance Notice. Usually, the carriers notify the union or unions affected at least 1 to 3 months in advance of a planned change which will eliminate positions. During this period, the parties may negotiate the individual conditions of each change in a separate ad hoc agreement. The definition of "change" is just beginning to extend beyond transfer and consolidation of seniority rosters to include any change in job function or in work methods. For example, when jobs are to be "abolished" the two nationwide nonoperating employee agreements mentioned earlier require advance notice. Notice must be given to the union 60 days in advance of a job abolition caused by technological, organizational, or other operational change, including "contracting-out" of work. If the change requires some employees to relocate, 90 days' notice must be provided. After the required notice is given, the parties negotiate an "implementing agreement" which deals with such specific adjustments as the realignment of seniority rosters, job content, or rates of pay. If a dispute develops over these implementing steps, the problem is referred to a special committee for adjustment.

Job Security. Guarantee of job security is becoming the pattern in railroad union agreements. Such provisions specify that no employee will be severed from the payroll except for disciplinary reasons. Some contracts, moreover, "stabilize" the work force in each craft by setting a maximum annual rate at which employment may decline. In both types of seniority clauses, employment levels are reduced only through attrition. This means that jobs are abolished only because of the workers' death or retirement, or as workers quit or leave their jobs for other reasons. Where the carrier has agreed to "stabilize" the work force, it must hire new workers if losses through attrition exceed an agreed-upon number. Agreement with these provisions, however, often do not apply when layoffs are necessitated by declining business or when employees have less than a specified amount of service, or when employees are seasonal. Moreover, these contracts usually contain special provisions for temporary layoff during emergency weather conditions.

Some of the first agreements with employment stabilization provisions based on attrition were negotiated by the Order of Railroad Telegraphers and the Brotherhood of Railway and Steamship Clerks in the late 1950's and early 1960's, when the railroads initially began installing electronic data processing equipment and improved communications systems. Some other agreements having job guarantees written into them included two in 1965: the first, the national nonoperating, nonshopcraft employees' contract covering 255,000 workers and the second, the agreement between the trainsmen and 23 eastern carriers, covering 80,000 workers. In addition, the arbitration award in 1963, affecting about 33,400 firemen, which resolved the dispute over using firemen on freight diesels, provided various job guarantees. (Also, see the section on "Severance" provisions permitted by this award.) The problem of manning of locomotives has been one of national importance since the diesels were first introduced in 1934.[38]

Crew Size Regulation. Additional job security in the industry is provided when union contracts and state laws require each train to operate with a minimum size of crew or specify the crew's occupational composition. As of early 1969, five States—Arkansas,

[37] In early 1969, the railway conductors and brakemen, locomotive firemen and enginemen, trainmen, and switchmen merged their separate unions into a new organization, the United Transportation Union (UTU). Also by early 1969, the Brotherhood of Railway and Airline Clerks, a nonoperating union, completed its merger with other nonoperating craft unions including railway patrolmen, telegraphers, and business machine technicians and other unions covering similar occupations outside the railroad industry.

[38] See *U.S. Emergency Board,* Steelton and Highspire Railroad Company, 1944 (I. L. Sharfman, Chairman), U.S. Government Printing Office, Washington, D.C., 1945.

Indiana, New York, Ohio, and Wisconsin—still had "crew consist" laws on the books compared to 14 States in the early 1960's. Over the years, as the trainmen were successful in negotiating agreements regulating crew size, they no longer opposed the repeal of State full crew laws. "Crew consist" laws or contract provisions may remain in effect for many years after an innovation has reduced labor requirements, or altered duties, skills, or occupational needs. An example of such a situation was the national "rule" (contract) negotiated in 1937, requiring the use of a fireman on all freight, yard, and passenger locomotives. On steam locomotives, which represented virtually all locomotives in operation that year, firemen stoked the furnaces and tended the boiler to produce power. This duty was eliminated, however, on diesel-electric locomotives, which by 1958 had nearly replaced all steam locomotives. It was only in 1963, after negotiations by the carriers and unions, that a study by a Presidential Commission and a Congressional investigation culminated in legislation calling for arbitration of the dispute [39]. At that time, the existing rule was modified, permitting carriers to remove firemen's positions on about 90 percent of all freight locomotives.

The manning of train crews continues to be a major industrial relations problem. For example, one recent dispute involved an attempt to restore trainmen helper jobs (also eliminated by the carriers as a result of the 1963 arbitration award). The efforts of the union to restore these jobs have been relatively successful but negotiations continue on this issue.[40]

Transfer rights. In the past, transfers of workers among the various railroad craft unions have occurred relatively infrequently, mainly because the railroad work force is organized according to craft. Seniority rights are usually accrued on the basis of length of service in a particular craft as well as in a seniority or geographic district. Thus, a worker who transfers into another craft or geographic district may lose some or all of his seniority, depending upon the contract provisions.

All class I railroads and the labor unions with which they bargain have been encouraged by the Railroad Retirement Board to develop a job placement system; it operates like a clearinghouse and provides transfer opportunities for employees who are threatened with layoff from their present jobs. Placement may be made both in and out of the industry. When layoff is imminent, usually because of abandonment of facilities, unemployment claims agents employed by the railroads seek out roads that are hiring workers and attempt to arrange transfers. Frequently, these transfers are within the agent's carrier system. Where the available jobs are semiskilled or unskilled, craft restrictions do not apply, and transfers may cut across departmental or district seniority lines. However, in the case of skilled shopcraft workers, the transfers have been made within the same craft. Altogether, during the 11-month period July 1, 1968 to May 30, 1969, a total of 6,153 placements were made; slightly over three-fifths were arranged within the railroad industry, itself.

Geographical transfers have been common in the railroad industry throughout its history. In connection with railroad mergers and consolidations, the "Washington Agreement" provided moving allowances, including a salary maintenance or "displacement" allowance, which assured the person being transferred that his earnings would not fall below their current level for 5 years. The national contracts signed in 1964 and 1965 covered nonoperating employees, provided for the payment of moving allowances, patterned after the provisions of the "Washington Agreement," in cases of transfer resulting from road reorganization or from technological change. Expenses for moving household effects and travel are usually covered, but losses incurred from the sale of a house are not always covered. There is also great variation among the contracts about the number of days for which pay will be received and the conditions under which moving allowances will be paid. The National Contract for operating employees, unlike that for non-operating employees, does not provide for payment of moving allowances in cases of job transfer.

Training. Use of training or retraining measures, as a means of adjusting to technological change, has differed widely among railroad occupations. The occupational structure of the industry, ranging as it

[39] Public law 88–108, Aug. 28, 1963. See "The 1963 Railroad Arbitration Act," *Monthly Labor Review*, October 1963, Volume 86, No. 10, pp. 1187–1188.

[40] The 1965 trainmen agreement with 23 eastern carriers fixed future crews at one conductor and 2 brakemen (or switchmen or helpers). By the fall of 1968, it was estimated that roughly two-thirds of the railroad industry was operating under contracts requiring these 3-man crews.

does from the relatively unskilled worker who performs maintenance-of-way tasks to the highly skilled craftsman and professional and technical worker, requires the services of persons with varying levels of education and training. At the lower end of the occupational spectrum, most jobs can be learned in a short time and are usually interchangeable. Therefore, there is no great problem in training or retraining. At the middle and upper level occupations, the case is quite different. The skilled crafts, for example, require the completion of several years of formal apprenticeship training to enter. This fact, along with the seniority provisions of union agreements, prevents crossing over from one skilled craft to another.

Railroads themselves have been providing training to help some workers meet new demands. Railroad clerks and the telegraphers have been most affected by the introduction of computer technology and their contracts with the carriers have provided for training workers with seniority to meet the requirements of changed jobs, as in the agreement between the Southern Pacific Company (Pacific Lines) and the Brotherhood of Railway Clerks,[41] effective April 1, 1963.

Many of the carriers have training programs, outside of collective agreements, which are directed toward improving and updating worker skills. Training may be given on the job or be provided through correspondence or other schools in the community. Railroad workers—particularly those in the skilled crafts and in some maintenance-of-way occupations —often learn about new and changed equipment directly from the equipment manufacturer or the supplier.

Railroad unions, in turn, have also attempted to set up training programs to help their members qualify for available job opportunities in the railroad industry. The Brotherhood of Locomotive Firemen and Enginemen, an AFL–CIO affiliate, developed an apprenticeship program for locomotive engineers approved by the U.S. Department of Labor in January 1966. Most of the carriers have rejected the program, maintaining that retraining is not a bargainable issue. This dispute is still before the Federal Courts.

[41] Merged with Brotherhood of Railway, Airline and Steamship Clerks, Freight Handlers, Express and Station Employees in early 1969.

Limitations on Subcontracting. The issue of "contracting out" work is particularly important to the shopcraft unions because diesel engine repair and rebuilding are frequently accomplished in this way. Some maintenance-of-way tasks and the installation of new signal equipment are also subject to this practice.

Restrictions on subcontracting to avoid job loss are sometimes explicitly stated in the union contract. When they are not so stated, such limitations have been inferred from the clauses which defined the scope of the agreement and its coverage. For the most part, however, the subcontracting policy that has evolved in this industry can be found in the various arbitration awards of the National Railroad Adjustment Board. Contracting out is generally permissible if the carrier does not have adequate equipment or properly trained men for special jobs, or if there is an emergency time limit, with the following stipulations: (1) The carrier must justify subcontracting; (2) laid-off employees must be used before outsiders are hired; and (3) proposed subcontracting must first be discussed with the union(s) affected.

Displacement Allowances. Nearly all nonoperating employees are now covered by contractual displacement allowance provisions modeled after those found in the "Washington Agreement," which provides a guaranteed wage to displaced workers if they accept transfers to other jobs. The displacement allowance guarantees an average of the previous year's earnings for a period of 5 years for the firemen and for shopcraft workers; it is paid indefinitely to nonshopcraft, nonsupervisory employees.

In 1964, the shopcraft unions negotiated an agreement which extended the provisions of the "Washington Agreement" to displacements resulting from technological change, as well as from other causes. The national contract of February 1965 for nonshopcraft, nonoperating employees provides a similar allowance to all these employees (other than seasonal) who had completed 2 years of service prior to October 1964 and were willing to accept a transfer (see footnote 35 for unions concerned). The arbitration award covering the issue of firemen's employment on diesels extended the displacement allowances of the "Washington Agreement" to firemen, with more than 2 but less than 10 years of service, who were offered "another comparable job."

Manpower adjustment provisions found in collective bargaining agreements may represent sizable cash benefits to the workers affected, as demonstrated in the findings of BLS research into situations resulting from mergers and consolidations covered by the "Washington Agreement." [42] For example, in a 1957 case involving the payment of displacement allowances, $375,374 was paid over a period of 40 months to 200 operating employees. Two-thirds of this sum was paid in the form of partial benefits which averaged $132 a month per worker; full benefits averaged $447 a month per worker. In another case involving 37 employees, an average of $765 was paid in displacement allowances to employees who lost their jobs, and $1,486 in moving allowances per worker who transferred. In addition, the carrier provided affected employees with free trips to their new location to look for homes and familiarize themselves with their new surroundings.

Severance or Dismissal Allowances—The "Washington Agreement" provides either a continuing allowance or a lump sum payment to employees who lose their jobs as a result of merger. The continuing allowance amounts monthly to 60 percent of the employee's last 12 months' average pays. It is granted for periods ranging from 6 months to 5 years, depending on length of service. Payments the worker receives from the Railroad Unemployment Insurance Fund are subtracted from the allowance. The lump-sum payment is higher, but an employee who chooses this alternative severs all ties; he must resign his rights to recall, to maintenance of fringe benefits, and to all other rights which continue while on a temporary layoff status.

In the early 1960's, contracts between individual crafts and roads began to extend these "Washington Agreement" allowances to layoff or severance resulting from technological change. The agreements of national nonoperating shopcraft and nonshopcraft employees also extend these provisions to technological change and a wide variety of situations reducing the work force. In the 1963 arbitration award which resolved the firemen-on-diesels issue, provision was made for lump-sum severance payments based on seniority. It is estimated that between 1964 and 1968, some $35 million in severance payments were made to firemen whose jobs were eliminated. Altogether, some 17,000 firemen jobs disappeared by the end of 1968; some firemen, however, were able to move into jobs as engineers.

Although not specifically related to technological innovations, the law that created the National Railroad Passenger Corporation (Amtrak, see page 72) provides that the Secretary of Labor has the ultimate responsibility for protecting employees "against a worsening of their position with respect to their employment." With the law becoming effective on May 1, 1971, the carriers and the rail unions failed to negotiate a mutually acceptable job protection plan, and Amtrak submitted its plan to the Secretary who certified it as "fair and equitable."

The Amtrak plan, which the rail unions may challenge in the courts, requires railroads to provide full wages and benefits, up to 6 years on a monthly basis, to workers displaced by Amtrak's planned cutting of the Nation's 300 passenger trains to 114. Estimates of the number of workers to be affected ranged from 12,000 to 25,000. Any income a worker earned from other jobs would be subtracted from these payments. He would be covered for up to 6 years and would qualify for any pay increases during the "protective" period, while still eligible to be recalled to work. The worker would also have the option of receiving lump sums of up to 1 year's salary, instead of the monthly payments.

Unemployment Benefits. Railroad workers are covered by a Federal unemployment insurance system which operates only within the railroad industry, is financed by employer contributions, and provides uniform benefits throughout the United States. Benefits are paid equal to 60 percent of the last daily rate of pay of the unemployed worker, up to a maximum daily benefit of $12.70. Nearly all beneficiaries are awarded the maximum benefit of $12.70 a day. Unemployed workers receive benefits for twenty-six 5-day weeks. For workers with many years of railroad service, there are additional weeks of benefits: 14 for workers with 10 to 14 years of service or 26 for workers with 15 or more years of service. Special provisions allow a worker who has frequently-recurring spells of unemployment to qualify repeatedly for benefits, each time he becomes unemployed.

Unlike the several State unemployment compensation programs, the Railroad Unemployment Insurance (RUI) system does not vary in terms of

[42] "Studies Relating to Railroad Operating Employees," Appendix Volume III to the Report of the Presidential Commission, Washington, D.C., Feb. 1962, pp. 136–171.

coverage, benefit amount and duration, qualification requirements, and the proportion of weekly income replaced. Also, the railroad program is more liberal than the State programs in two other respects: disqualification provisions and compensation for intermitten days of unemployment.

Retirement. Retirement is yet another way in which the work force may adjust to technological change. In 1966, for example, 5.6 percent of all railroad workers were 65 years old or older compared with 3.6 percent of all nonfarm workers. At the present time, only about one-third of all railroad workers elect to retire at age 65, and few union agreements have mandatory retirement provisions, although early retirement is possible. In the benefit year, 1967–68, some 40,000 persons retired. The average age of those retiring for reasons other than disability was 66.5 years. Between 1963 and 1967 (the latest year for which this information is available) an average of 99,000 persons have retired each year, a figure far in excess of the net decline in employment each year since 1963.

Railroad employees are covered by a compulsory pension system, the National Railroad Retirement System, which is administered by the Federal Government, but financed by a tax on employee earnings and on payrolls. Pension benefits, starting at age 65, are determined by length of service and amount of earnings. Legislation enacted in 1966 provides for the payment of an additional annuity at age 65 to persons entitled to an age or disability annuity who have completed 25 or more years of service and who have a current connection with the railroad industry. Beginning with 1971, employees forfeit the supplemental annuity if they work in the railroad industry beyond a specified closing date. This closing date for the years after 1973 is the end of the calendar month following the month in which the employee reaches age 65, with somewhat higher ages applicable for the years 1971 through 1973.

Early retirement, on a reduced annuity, is possible at age 62 for employees with 10 years or more of railroad employment. All employees with 30 years of railroad service can retire at age 60, though the amount of the pension is reduced for men who exercise this option. In fiscal year 1967–68, about 16 percent of all those who retired because of age (rather than for disability) did so early and on a reduced annuity; their average age was 63.2 years.

Earnings and Working Conditions. The introduction of technological change in the railroad industry has affected working conditions and frequently has resulted in adjustments in wage rates. Wage rates and working conditions, including hours of work and overtime provisions, are covered in the labor-management agreements that apply to most of the workers in the industry. Their basic work schedules differ, depending on the kinds of work they do. For example, the basic workweek of the great majority of workers employed at terminals—in railroad yards, stations and offices—is 40 hours of five 8-hour days; overtime is usually paid after 8 hours of work a day.

However, train and engine crew members are paid according to different rules, in terms of their movement over the road. They must either cover a specified number of miles, or else have worked a certain number of hours, before receiving extra pay. Workers in occupations that directly serve passenger needs work a stipulated number of hours each month before receiving premium pay for overtime work. Also, irregular work schedules are common among railroad workers who do not have regular assignments but are called in when their services are needed. Train service must be provided 24 hours a day and, thus, railroad workers must often work nights, weekends, and on holidays. This accounts for the higher-than-average workweek in this industry compared with all manufacturing industries. (See table 40.)

The basic wage formula for operating employees takes into consideration minimum daily guarantees, mileage pay, graduated rates, special allowances which are higher than standard rates and mileage limitation rules. The pay system for nonoperating employees is much simpler and is primarily on a time basis, hourly, daily, or monthly.

Average hourly earnings (including premium pay) of class I railroad workers are higher than those paid to workers in manufacturing generally. In 1968, for example, class I railroad workers earned an estimated $3.39 an hour, on the average, compared with an estimated average hourly rate of $3.01 for workers in all manufacturing industries. This relationship has persisted since 1957, through the spread between average hourly earnings in class I railroads and in all manufacturing has ranged widely, from a low of 21 cents an hour in 1957 to an estimated high of 38 cents an hour in 1968 (see

Table 40. Hours and earnings of workers in manufacturing and class I railroads, 1947, 1957, and 1960–68

Year	Class I railroads [1]			All manufacturing [2]		
	Average hourly earnings	Average weekly earnings	Average weekly hours	Average hourly earnings	Average weekly earnings	Average weekly hours
1947	$1.19	$55.03	46.4	$1.22	$49.17	40.4
1957	2.26	94.24	41.7	2.05	81.59	39.8
1960	2.61	108.84	41.7	2.26	89.72	39.7
1961	2.67	112.94	42.3	2.32	92.34	39.8
1962	2.72	115.87	42.6	2.39	96.56	40.4
1963	2.76	118.40	42.9	2.46	99.63	40.5
1964	2.80	121.80	43.5	2.53	102.97	40.7
1965	3.00	130.80	43.6	2.61	107.53	41.2
1966	3.09	135.65	43.9	2.72	112.34	41.3
1967	3.24	139.97	43.2	2.83	114.90	40.6
1968	[3] 3.39	[3] 149.16	[3] 44.0	3.01	122.51	40.7

[1] Excludes executives, officials, and staff assistants (ICC group I).
[2] Applies to production workers only.
[3] 8–month averages.
SOURCE: Bureau of Labor Statistics and Interstate Commerce Commission.

Table 41. Average straight time pay, by occupational group, class I railroads, 1957 and 1967

Occupational group	Average straight times rates [1]			Percent of total employees	
	1957	1967	Percent change 1957–67	1957	1967
Executives, officials, and staff assistants	$4.512	$6.648	47.3	1.65	2.54
Professional, clerical, and general	2.300	3.364	46.3	19.27	21.53
Maintenance of way and structures	2.002	2.976	48.7	17.32	14.82
Maintenance of equipment and stores	2.222	3.196	43.8	24.99	22.70
Transportation (other than train, engine and yard)	2.123	3.113	46.6	11.69	9.34
Transportation (yardmasters, switch tenders, and hostlers)	2.631	3.698	40.6	1.44	1.61
Transportation (train and engine service)	2.385	3.220	35.0	23.64	27.46
All employees (excluding switching and terminal companies)	2.288	3.302	44.3	100.0	100.0

[1] Includes "straight time paid for" in train and engine service, and "time actually worked and paid for at straight time rates" in other services.
SOURCE: Interstate Commerce Commission.

Table 42. Employee compensation, class I railroads, 1965

Compensation practice	All employees		
	Percent of compensation	Per hour: Paid for	Per hour: Working time
Total expenditures	100.0	$3.71	$4.04
Gross payments to workers	87.8	3.26	3.55
Straight time pay	78.5	2.91	3.17
Overtime, weekend, and holiday work	2.0	.07	.08
Pay for leave time [1]	6.9	.26	.28
Vacations	5.0	.19	.20
Holidays	1.5	.06	.06
Sick leave	.4	.01	.01
Terminal payments	.3	.01	.01
Expenditures in addition to payroll	12.2	.45	.49
Legally required insurance programs	8.0	.30	.32
Retirement income and protection	5.0	.19	.20
Unemployment insurance	2.3	.09	.09
Occupational injury and illness	.7	.03	.03
Private welfare plans [2]	4.2	.16	.17
Life, accident, and health insurance	3.3	.12	.13
Pension and retirement plans	.9	.03	.04

[1] Includes military, jury, funeral, and personal leave, not presented separately.
[2] Includes savings and thrift plans, not presented separately.
NOTE: Due to rounding, sums of individual items may not equal totals.
SOURCE: Bureau of Labor Statistics.

table 40.)

Average straight time rates in class I railroads rose by nearly 45 percent between 1957 and 1967, as can be seen in table 41. This rate of increase was exceeded in every major occupational group except in Transportation (train and engine service), Transportation (yardmasters, switchtenders, and hostlers), and in Maintenance of equipment and stores.[43]

Straight time pay for time worked is the major component of employer expenditures for the compensation of employees. To arrive at total compensation, it is necessary to include employer payments for overtime and other premium payments, payments for leave time (vacations, holidays, sick leave, and other leave), terminal (severance) payments and expenditures for legally required insurance programs and private welfare plans operated for the benefit of employees. In 1965, average compensation of all class I railroad workers amounted to $4.04 per working hour,[44] $3.17 of which was straight time pay, and 87 cents pay supplements. (See table 42.) By 1967, the BLS estimated total straight time pay per hour of working time in class I railroads had risen to $3.51, and supplements to straight time pay to $1.00 a working hour.[45] Total compensation rose by about 11 percent in the 2-year period, from $4.04 to $4.51 an hour. Straight time pay increased because of pay raises that were negotiated while the level of supplemental expenditures grew because of higher employer payments for railroad retirements, health and welfare benefits, premium pay, and vacations.

[43] Wage statistics which provide information for the years 1957 and 1967 and from which average straight time rates may be computed for the detailed occupations that comprise the major occupational group are available from the Interstate Commerce Commission A-300 Reports, Wage Statistics of class I railroads in the United States.

[44] Hours paid for consist of aggregate hours worked, paid leave hours, rest periods, coffee breaks, machine downtime, and other nonleave hours paid for but not worked, for which employers made direct payments to workers during the year. Excluded are hour equivalents for which pay was received though actual hours were not involved; for example, hours paid for because of additional mileage or because of extra work during regular working hours. Working time excludes paid leave hours. Unless otherwise noted, all rates are expressed as per hour of working time.

[45] See "Employment Compensation and Payroll Hours, Railroads, 1965," Report 335-3, U.S. Department of Labor, Bureau of Labor Statistics. Also, see "Pay and Fringe Benefits of Railroad Employees," by Robert E. Pope, in *Monthly Labor Review*, Sept. 1968, Vol. 91, No. 9, pp. 45-48.

Appendix I Tables

1. Railroads and other transportation, new plant and equipment expenditures, 1945–70

[billions of dollars]

Year	Total expenditures			
	Railroads		All other transportation	
	Amount	As a percent of all industries	Amount	As a percent of all industries
1945	.55	6.3	.57	6.6
1946	.58	3.9	.92	6.2
1947	.91	4.7	1.30	6.7
1948	1.37	6.4	1.27	6.0
1949	1.42	7.5	.88	4.6
1950	1.18	.8	1.19	5.9
1951	1.58	6.2	1.47	5.8
1952	1.50	5.7	1.47	5.6
1953	1.42	5.0	1.53	5.4
1954	.93	3.4	1.46	5.4
1955	1.02	3.5	1.56	5.3
1956	1.37	3.8	1.66	4.6
1957	1.58	4.2	1.71	4.5
1958	.86	2.7	1.43	4.5
1959	1.02	3.0	2.11	6.3
1960	1.16	3.2	1.96	5.3
1961	.82	2.3	1.96	5.5
1962	1.02	2.7	2.17	5.7
1963	1.26	3.1	1.98	4.9
1964	1.66	3.5	2.52	5.4
1965	1.99	3.7	2.90	5.3
1966	2.37	3.7	3.38	5.3
1967	1.86	2.8	3.77	5.8
1968	1.45	2.1	4.15	6.1
1969 p	1.83	2.4	4.20	5.6
1970 e	1.94	2.4	3.96	4.8

P—Preliminary.

E—U.S. Dept. of Commerce and SEC. estimate.

SOURCE: Securities and Exchange Commission (SEC).

2. Class I Railroads, methods of financing, by year, 1957–67

[thousands of dollars]

Year	Debt issues [1]				Stock issued	Total debt plus stock
	Conditional contracts & deferred payments	Corporate equipment obligations (par value)	Other	Total		
Total......	3,463,175	2,553,008	1,693,253	7,709,436	771,985	8,481,421
1957.............	279,938	359,501	61,207	700,646	14,912	715,558
1958.............	113,884	175,180	225,014	514,078	30,393	544,471
1959.............	138,451	170,505	176,583	485,539	144,544	630,083
1960.............	150,807	180,193	241,824	572,824	60,765	633,589
1961.............	107,705	118,215	191,069	416,989	145,783	562,772
1962.............	178,896	135,980	60,377	375,253	10,923	386,176
1963.............	211,022	240,900	183,506	635,428	40,884	676,312
1964.............	435,302	318,976	184,598	938,876	78,389	1,017,265
1965.............	545,079	258,345	218,227	1,021,651	79,656	1,101,307
1966.............	798,286	341,968	50,457	1,190,711	44,319	1,235,030
1967.............	503,805	253,245	100,391	857,441	121,417	978,858

[1] Does not include any new debt issues of those companies in receivership. In 1966, there were none issued by these companies.

SOURCE: *Transport Statistics in the United States*—, Interstate Commerce Commission, Washington, D.C., tables 146, 146A, 147A.

Appendix II Tables

1. Locomotives in Service, by type, 1947–67

Year	Total locomotives	Diesel	Steam	Other [1]	Total second-generation locomotives [2] (cumulative)
1947	41,719	5,772	35,108	839	....
1948	41,851	8,089	32,914	848	....
1949	40,691	10,888	28,964	839	....
1950	40,494	14,047	25,640	807	....
1951	40,036	17,493	21,747	796	....
1952	37,343	20,492	16,078	773	....
1953	35,009	22,503	11,787	719	....
1954	32,872	23,531	8,650	691	....
1955	31,429	24,786	5,982	661	....
1956	30,433	26,081	3,714	638	....
1957	30,248	27,186	2,447	615	....
1958	29,513	27,575	1,350	588	....
1959	29,493	28,163	754	576	....
1960	29,080	28,278	261	541	....
1961	28,815	28,169	112	534	288
1962	28,639	28,104	51	484	1,052
1963	28,449	27,945	36	468	1,886
1964	28,300	27,837	34	429	2,957
1965	27,816	27,389	29	398	4,344
1966	27,886	27,481	25	380	5,763
1967	27,687	27,309	21	357	6,872

[1] The "Other" category includes electric and turbine locomotives

[2] This is a cumulation of new purchases 1961–67. The technology for second-generation diesels was first sold in 1961 and it is assumed here that all new purchases thereafter were of that type.

SOURCE: Interstate Commerce Commission as summarized in *Railroad Transportation*, AAR, April 1965 for years 1948–53; all other years, *Fact Book 1969* summary of ICC information, p. 68.

2. Piggyback freight carloadings of 1 or more trailers, 1955–69

Year	Carloadings
1955	168,150
1956	207,783
1957	249,065
1958	278,071
1959	416,508
1960	554,115
1961	591,246
1962	706,441
1963	797,474
1964	890,748
1965	1,034,377
1966	1,162,731
1967	1,207,242
1968	1,337,149
1969	1,344,123

SOURCE: Association of American Railroads.

3. Automatic car identification (ACI) applications [1]

Applications	Description of Application
Commercial	
1. Intransit weighing (ore)	Scanner system, connected to a weigh-in-motion scale, computes cargo weight and transmits with car number to shipper and to RR data processing, via teletype.
2. Notice of train arrival, to customer	Scanner transmits car number and time of train passing to computer center, via teletype. Future: (1) Automatic route-setting (2) Automatic payroll information (3) Train Announcement.
Management central office uses	Linkage of Traffic, Operating, and Accounting Departments through use of car initial and number. Information access results in best car type to shipper, movement control across rails, proper charges, and collection.

3. Automatic car identification (ACI) applications [1]—Continued

Applications	Description of Application
1. Operational Control	Prevention of missed connections, and advance knowledge of power needs, train length, tonnage limits.
2. Car Accounting Department (Key Punch Section)	Closing open records on cars and trailers.
3. Car Accounting Department	Automatic audit of per diem and mileage payable and per diem receivable.
4. Car Maintenance	Mileage calculation as required for car maintenance scheduling.[2]
5. Equipment Utilization	Keeps car availability records and locates cars for special cargoes.
6. Improved Customer Service	Specific cargo information on delays (why-where-how long to shipper or consignee), if there is delay.
7. Car Tracer	Elimination of car tracer form for closing open records on cars and trailers.
Field	
1. Hump yard	Scanners at yard entrances—check incoming, outgoing cars, provide exact location of inventory; scanners on other side of hump crest (combined with yard switching systems) read labels, align switches for classification, update inventory file; scanner between classification and departure yards—produce waybill list.
2. Car Repair Track Area	Scanners at entrance and exit to car repair area—Automatic inventory of cars in shop, with automatic notification to car user.
3. Locomotive Service Area	Scanners at entrance—arrival and departure information, availability, utilization, maintenance, and I.C.C. inspection scheduling.
4. Piggyback Terminals	Scanner at each Piggyback Terminal—immediate trailer and container inventory, reduce open records.
5. Point of Interchange	Scanner shared by connecting roads—receipt and delivery information exchange, eliminate open car records.

3. Automatic car identification (ACI) applications [1]—Continued

Applications	Description of Application
6. Interlocking Plant Operation........	Automatically operate signal interlocker control equipment through scanner reading of routing label.
7. Centralized Traffic Control (CTC) Machine Operation................	Scanner identification of train priority, length, and tonnage would allow automatic CTC train dispatching from yard, enlarging dispatcher territory.
8. Line-of-Road Car Defect Detectors..	Scanners located adjacent to detectors (hotbox, broken flange, loose wheel, load imbalance, clearance, and dragging) identify defective cars and provide direct radio information to car crews.

[1] Applications limited to individual roads, pending development and adoption of national identification standards. All applications are experimental unless noted.

[2] Applications feasibility based on Chicago Transit Authority Tests.

SOURCE: Data Systems Division, Association of American Railroads, Addresses, Panel Discussion, and Workshop Papers, October 17–19, 1966.

Appendix III

1. Alternative productivity forecasting technique

An alternative method of forecasting productivity developed by the Bureau of Labor Statistics, which covers the period to 1980, tends to confirm a continued high rate of productivity increase. In this approach, productivity increments are obtained as the sum of the gain due to output increases and a gain due to time; the latter includes gains from technical change and more efficient labor-capital combinations [1]. Various transformations of data are used to eliminate shortrun cyclical disturbances which obscure the longrun behavior pattern of productivity with respect to output. The significance of this approach is its use of output as an independent variable affecting productivity.

The study was based on quarterly data for the period 1954–66, and thus, this analysis covers periods of both increasing and decreasing output, unlike the productivity estimates which are based on the experience of the 1961–67 period. Taking the final forecasting equation from the report, which is shown below, we find a quarterly rate of productivity change of 1.42 percent with output constant and an elasticity of productivity with respect to output of 0.20.

Thus, $\% \triangle Q/L = 1.42\% + .20\ (\% \triangle Q)$

Q = Output (weighted combination of freight and passenger traffic).

L = Labor.

In using this equation, the temporal variable is eliminated. Thus, with no change in output, the productivity growth rate is 1.42 percent per quarter. If output increases, as is expected in the future, a second element is added to the quarterly growth rate —for each one percent increase in output, an increment of .20 percent is added. Thus, if output were to grow by 1 percent per quarter, total productivity gain would be 1.62 percent per quarter.

[1] See *Productivity in the Railroad Industry,* Report 377, U.S. Department of Labor, Bureau of Labor Statistics, Mar. 1970.

2. Methodological note on output per man-hour

The index of total revenue traffic (RTU's) is an output series using different statistical weights to combine passenger traffic with freight traffic. These weights are derived by dividing passenger revenue per mile by freight revenue per mile for 1947–49, 1957–59, and 1963. The corresponding weights for the periods 1947–49 and 1957–59 were 1.88/1.00 and 1.99/1.00 respectively; for 1963 to date, it is 2.43/1.00. Revenue passenger miles, multiplied by the appropriate weight, results in a revenue traffic unit quantity which is added to revenue ton-miles and then converted into an index number. (For history of output per man-hour since 1939, see appendix III-3, 4).

3. Railroad transportation-revenue traffic (SIC 401) output per man-hour, unit labor requirements, and related data, all employees, 1939–70

[indexes, 1967=100]

Year	Output per—		Unit labor requirements in terms of—		Related data		
	Employee	Man-hour	Employees	Man-hours	Output	Employees	Man-hours
1939	31.4	27.9	318.0	358.4	50.5	160.6	181.0
1947	45.2	38.3	221.3	261.1	99.6	220.4	260.1
1948	44.4	37.6	225.3	265.7	96.1	216.5	255.3
1949	40.9	36.7	245.0	272.4	79.6	195.0	216.8
1950	43.5	42.0	229.6	238.3	87.1	200.0	207.6
1951	45.7	44.4	218.8	225.1	95.6	209.2	215.2
1952	45.3	44.6	220.9	224.5	91.2	201.5	204.7
1953	45.1	44.8	221.7	223.3	89.4	198.2	199.6
1954	46.3	46.6	215.8	214.5	81.2	175.2	174.2
1955	52.2	51.6	191.4	194.0	91.0	174.2	176.5
1956	54.6	54.0	183.2	185.1	94.1	172.4	174.2
1957	54.8	54.8	182.5	182.5	89.6	163.5	163.5
1958	57.5	57.6	173.9	173.5	80.1	139.2	139.0
1959	61.3	61.2	163.1	163.4	82.9	135.2	135.5
1960	63.5	63.6	157.5	157.2	82.2	129.5	129.2
1961	67.9	68.2	147.3	146.7	80.8	119.0	118.5
1962	73.0	72.6	137.1	137.7	84.7	116.1	116.6
1963	78.2	77.1	127.9	129.6	83.1	112.7	114.2
1964	84.4	82.1	118.5	121.7	92.9	110.1	113.1
1965	92.9	90.8	107.7	110.1	97.8	105.3	107.7
1966	99.6	97.5	100.4	102.5	103.1	103.5	105.7
1967	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1968	105.9	104.4	94.4	95.8	102.5	96.8	98.2
1969	111.1	109.2	90.0	91.6	105.4	94.9	96.5
1970	111.9	109.7	89.3	91.2	104.2	93.1	95.0

4. Railroad transportation-revenue traffic (SIC 401) output per man-hour, unit labor requirements, and related data, production workers 1939–70

[indexes, 1967 = 100]

Year	Output per—		Unit labor requirements in terms of—		Related data		
	Production worker	Production worker man-hour	Production workers	Production worker man-hours	Output	Production workers	Production worker man-hours
1939	30.5	27.2	328.1	367.7	50.5	165.7	185.7
1947	43.2	36.7	231.5	272.8	99.6	230.6	271.7
1948	42.5	36.1	235.5	277.1	96.1	226.3	266.3
1949	39.3	35.5	254.4	281.8	79.6	202.5	224.3
1950	41.9	40.4	238.9	247.3	87.1	208.1	215.4
1951	43.8	42.7	228.5	234.0	95.6	218.4	223.7
1952	43.5	43.0	229.9	232.6	91.2	209.7	212.1
1953	43.4	43.3	230.5	231.0	89.4	206.1	206.5
1954	44.9	45.4	222.5	220.1	81.2	180.7	178.7
1955	50.6	50.2	197.7	199.0	91.0	179.9	181.1
1956	52.9	52.7	189.1	189.6	94.1	177.9	178.4
1957	53.3	53.7	187.7	186.3	89.6	168.2	166.9
1958	56.4	57.1	177.2	175.3	80.1	141.9	140.4
1959	60.2	60.6	166.0	164.9	82.9	137.6	136.7
1960	62.5	63.2	160.1	158.2	82.2	131.6	130.0
1961	67.1	68.1	149.0	146.8	80.8	120.4	118.6
1962	72.2	72.4	138.5	138.1	84.7	117.3	117.0
1963	77.3	76.9	129.3	130.0	88.1	113.9	114.5
1964	83.5	81.9	119.7	122.2	92.9	111.2	113.5
1965	92.3	91.0	108.4	109.9	97.8	106.0	107.5
1966	99.2	97.6	100.8	102.4	103.1	103.9	105.6
1967	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1968	106.0	104.4	94.3	95.8	102.5	96.7	98.2
1969	111.4	109.3	89.8	91.5	105.4	94.6	96.4
1970	112.6	109.9	88.8	91.0	104.2	92.5	94.8

5. Leading railroads

Choice of roads

The leading railroads were chosen on the basis of a ranking of all of the 76 class I railroads reporting to the Interstate Commerce Commission in 1965. To make the data more manageable for historical analysis, while retaining representative coverage, the 76 railroads were segregated into groups on the basis of man-hour inputs. Companies having over 20,000,000 man-hours as a labor input were chosen for further analysis. Twenty-two companies fell into this category. Their man-hours comprised 82 percent of the class I total in 1965.

These 22 were then segregated into three geographic districts to permit some allowance to be made for the effect of a different traffic mix on output per man-hour in various parts of the country. The roads were then ranked within geographic districts on the basis of Revenue Traffic Units per all employee man-hour. The most efficient in each district (southern, eastern and western) was then chosen for further analysis.

As a check on the choice of these roads, an additional tabulation and ranking of the 22 large companies was made for 1956. In the 1956 ranking, the 1965 leader was also first in one district, was second in another and sixth (of 10) in the third district. Still another criteria was applied by ranking in accordance with the percent of increase in Revenue Traffic Units per man-hour from 1956–65, on the theory that the largest change ratios represented companies with good or vastly improving managements.

Procedure of study and data adjustment

A merger history of the selected companies was used to ensure comparability of beginning and end Revenue Traffic Units per all employee man-hour (referred to hereafter as productivity). The companies that were merged into the parent were included in years prior to the merger to avoid incorrect comparisons of man-hours and output.

The revenue passenger miles and revenue tonmiles were combined with the same weights as are used in the Bureau's regular work with the industry. Linking procedures were also the same as the regular method.

The data were tabulated for years 1956–66 and a weighted average was obtained for the leading railroads. The procedure was aggregation of all manhours and of all Revenue Traffic Units with subsequent division of the latter by the man-hours.

Source of data

Revenue ton-miles and revenue passenger-miles are published in the Interstate Commerce Commission's *Transport Statistics in the United States* for 1956; later data appears in the ICC's "Abstract of Individual class I roads."

The source of the man-hour data is the individual road report on file with the Interstate Commerce Commission, "Monthly Report of Employees, Service and Compensation" (4th quarter for annual). The man-hours were compiled as follows: From Service Hours under Division VIa, column 4, "Time worked and paid for a straight time rates;" plus column 5, "Overtime paid for at punitive rates;" plus Division VIb total transportation (train and engine) column 4, "Straight time actually worked;" plus column 6, "Overtime paid for;" plus column 7, "Constructive allowances." Thus, for each railroad, five individual man-hour figures were picked up to yield the total man-hours for the railroad.

6. Revenue traffic units (RTU's) per man-hour for railroads and industry, 1965

Year	Railroad "A", southern district	Railroad "B", eastern district	Railroad "C", western district	"Best" railroad average	Average for industry	Industry average as percent of "Best" railroad average
1956	435.1	324.6	325.4	369.4	314.9	85.2
1957	452.4	321.3	343.9	380.3	320.3	84.2
1958	457.3	356.4	362.2	399.3	336.1	84.2
1959	494.4	367.3	399.0	426.0	357.3	83.9
1960	510.5	374.7	418.7	439.4	372.3	84.7
1961	556.2	392.4	470.0	476.9	398.2	83.5
1962	583.9	435.8	521.8	518.1	423.5	81.7
1963	625.3	480.3	575.1	562.2	450.1	80.1
1964	659.6	522.7	630.1	606.6	478.6	78.9
1965	686.0	578.7	694.6	652.6	526.0	80.6
1966	722.1	588.2	733.1	680.8	563.3	82.7

SOURCE: Bureau of Labor Statistics and Interstate Commerce Commission.

7. Road and equipment, constant dollar value series[1]

The value of road and equipment in 1948 (the base year for the series) was obtained from the ICC as of January 1, 1949. The 1948 current dollar figure was adjusted, using the railroad construction index published by the ICC which was rebased to make the year 1958 equal 100. The method used was to divide the current dollar value (before depreciation) by the index to arrive at an approximation of the 1948 value of the road and equipment. After 1948, each year's road and equipment value was obtained by adjusting current dollar gross capital expenditures as published by the Office of Business Economics (OBE) by using the ICC index, depreciating that figure and then adding it to the preceding year's base stock which was also depreciated.

Two depreciation ratios were used to obtain the final figures for each year. First, to obtain the new base stock, a ratio of .9753 was used as the depreciation factor for that year. This ratio was obtained by assuming a 40-year life for the capital. Forty years is obviously a compromise figure, since part of the total value of the capital is that derived from land which is more likely to increase in value than decrease over time. On the other hand, an average of about 55 percent of the capital expenditures are for car purchases; these cars are very long-lived, but nevertheless, subject to economic deterioration. Other major expenditure categories are likewise long-lived, yet this equipment, too, wears out. Data for the industry from the Internal Revenue Service indicate that over the period 1954–64, the ratio of depreciation taken to the preceding year's total de-

[1] See unpublished report, Productivity Trends in U.S. Transportation Industries by John W. Kendrick, prepared for U.S. Department of Transportation (control number C–286–66). Also see Capital in Transportation, Communications and Public Utilities: Its Form and Financing, by M. J. Ulmer, Princeton, Princeton University Press, 1960.

preciable assets is consistent with the 40-year estimated depreciation schedule.

A second ratio—.9876—was used to depreciate reported gross capital expenditures before adding them to the previous year end stock. Expenditures are treated as being spaced evenly throughout the year with only half the investment subject to depreciation on the average.

8. Product and input value in U.S. railroads, 1947–68

Year	Gross product originated (millions, constant dollars)	Value of inputs [1] (millions, constant dollars)	Gross product per unit of input [2]
1947	10,700	3,482	3.07
1948	10,500	3,324	3.16
1949	8,700	2,912	2.99
1950	9,500	2,841	3.34
1951	10,600	2,952	3.59
1952	10,100	2,827	3.57
1953	9,900	2,817	3.51
1954	8,900	2,377	3.74
1955	9,900	2,482	3.99
1956	10,000	2,479	4.03
1957	9,500	2,399	3.96
1958	8,400	2,065	4.07
1959	8,900	2,122	4.19
1960	8,700	2,058	4.23
1961	8,700	1,976	4.40
1962	9,200	2,067	4.45
1963	9,700	2,090	4.64
1964	10,200	2,151	4.74
1965	11,000	2,170	5.02
1966	11,700	2,160	5.42
1967	11,200	2,068	5.42
1968 [3]	11,300	2,119	5.33

[1] These inputs include fuel, rail, ties, and other materials and supplies required to carry on day-to-day business operations.

[2] This series will have a slight upward bias since it is based on Gross Product originated by all railroads while the input data are available only for class I railroads.

[3] Preliminary.

SOURCE: Office of Business Economics, U.S. Department of Commerce and the Bureau of Labor Statistics, U.S. Department of Labor.

9. Methodological note on derivation of total fuel requirements and efficiency

The first requirement in assessing the efficiency of fuel use in the industry is to convert the several different kinds of fuel into comparable units. This was accomplished by coverting fuel from conventional units of measure into British Thermal Units (BTU's). Table 72 of the Interstate Commerce Commission's, *Transport Statistics,* lists the basic fuels used, by type and amount. Anthracite and bituminous coal are shown as separate fuels. The bituminous figure includes other fuels, used in small quantities, but whose unit measure is "ton." Fuel oil (kerosene), diesel oil, and gasoline are shown as separate entities. "Fuel oil" includes other fuels, not otherwise shown, measured in gallon units. Each of these latter four fuels are shown in ICC's table 72 with gallons as the unit of measure. All liquid measures were converted to barrels, using a conversion factor of 42 gallons per barrel, since BTU equivalents were for barrel units. This base data was tabulated for the years 1948 and 1954 through 1966. BTU conversion factors, for gasoline, fuel oil, diesel and coal, as shown in the following table, were obtained from the U.S. Department of Interior's Bureau of Mines, and for wood and electricity from *Petroleum Facts and Figures,* by the American Petroleum Institute.

Base Fuel	*Unit of measure*	*BTU conversion factors (In thousands)*	
		1948	*1954–66*
Bituminous coal	Ton	26,200	26,200
Anthracite coal	Ton	25,400	25,400
Fuel oil	Barrel	6,287	6,287
Diesel oil	Barrel	5,825	5,825
Gasoline	Barrel	5,218	5,248
Wood	Cord	40,000	40,000
Electricity	KWH	3	3

In order to arrive at the end product which would be shown in billions of BTU's, the base data were multiplied by the appropriate conversion factor. The BTU's for the seven base fuels were totaled for each given year and an index was constructed using the 1957–59 average as a base.

The number of gross ton-miles of freight and passenger cars and contents was taken from the AAR's *Railroad Transportation, A Statistical Record,* for the years 1948 and 1954 through 1963, and was taken from the Interstate Commerce Commission's *Transport Statistics,* table 162, for 1964 through 1966. An index of gross ton-miles of class I Line-Haul Railways was then developed, using the 1957–59 average as the base. To arrive at the fuel consumed by class I Line-Haul Railways per gross ton-mile, the BTU index was divided by the gross ton-mile index (appendix III-10).

10. Fuel consumed by Class I line-haul railways per gross ton-mile[1], selected years, 1948–66

Year	Fuel index of BTU's used (1957–59=100)	Index gross ton-miles (1957–59=100)	Fuel per gross ton-miles (1957–59=100)
1948...	536.8	116.3	461.6
1954...	152.4	100.7	151.3
1955...	150.3	108.5	138.5
1956...	136.3	110.3	123.6
1957...	115.4	105.7	109.2
1958...	92.9	95.8	97.0
1959...	91.8	98.4	93.3
1960...	90.7	97.2	93.3
1961...	88.0	94.9	92.7
1962...	90.7	97.9	92.6
1963...	92.3	100.4	91.9
1964...	93.9	104.0	90.3
1965...	96.6	107.0	90.3
1966...	100.0	111.6	90.4

[1] Freight and passenger, cars and contents.

SOURCE: Interstate Commerce Commission and Bureau of Labor Statistics.

Appendix IV tables

1. Concentrations of railroad employment, 23 leading SMSA's, March 1957 and March 1967

City and State	Employment [1] (thousand) March 1957	Employment [1] (thousand) March 1967
Chicago, Illinois	63.4	48.6
New York City, New York	28.7	19.9
St. Louis, Missouri–Illinois	21.5	15.7
Philadelphia, Pennsylvania–New Jersey	23.3	15.2
Pittsburgh, Pennsylvania	23.8	13.9
Los Angeles–L.B., California	16.8	13.8
Minneapolis–St. Paul, Minnesota	17.6	12.2
San Francisco–Oakland, California	17.3	11.5
Kansas City, Missouri–Kansas	13.7	10.8
Cleveland, Ohio	13.3	9.8
Baltimore, Maryland	13.7	8.6
Detroit, Michigan	11.0	9.4
Buffalo, New York	12.2	8.0
Omaha, Nebraska–Iowa	10.4	7.9
Cincinnati, Ohio, Kentucky	10.3	6.7
Jersey City, New Jersey (Newark)	18.3	6.6
Houston, Texas	7.9	6.3
Louisville, Kentucky–Indiana	8.6	6.3
Portland, Oregon–Washington	7.8	5.7
Sacramento, California	5.4	5.7
Washington, D.C., Maryland, Virginia	5.6	8.0
Jacksonville, Florida	5.4	3.2
Boston, Massachusetts	5.4	10.1
Total Employment, 23 Leading SMSA's	366.4	259.0
Total Railroad Employment, United States	1,121.0	698.0
Total, 23 Leading SMSA's as a Percent of all Railroad Employment	32.7	37.1

[1] While data are generally comparable for 1957 and 1967, some counties have been added or removed from SMSA's in the interim. Where comparisons were made, differences were less than one percent.

NOTE: Total railroad employment 1957–1967 percent change: −37.7
SMSA railroad employment 1957–1967 percent change: −29.3

SOURCE: From unpublished Bureau of Labor Statistics data for SMSA's; total railroad employment, 1957, 1967, Office of Business Economics.

2. Changes in composition of SMSA's, March 1957 and 1967

Chicago, Illinois	McHenry County, added Lake County, deleted
St. Louis, Missouri–Illinois	Jefferson County, added 12/58 Franklin County, added 10/63
Los Angeles–Long Beach	Orange County, deleted 10/63
Minneapolis–St. Paul, Minnesota	Washington County, added 12/58
San Francisco–Oakland, California	Solano County, deleted 10/63
Kansas City, Missouri–Kansas	Cass and Platte Counties, added 10/63
Cleveland, Ohio	Geauga and Median Counties, added 10/63
Baltimore, Maryland	Carroll and Howard Counties, added 6/59 Harford County, added 3/67
Cincinnati, Ohio, Kentucky, Indiana	Clermont and Warren Counties, Ohio, and Boone County, Kentucky, and Dearborn County, Indiana, added 10/63
Houston, Texas	Brazoria, Ft. Bend, Leberty, and Montgomery Counties, added 3/65
Sacramento, California	Placer and Yolo Counties, added 10/63
Washington, D.C., Maryland, Virginia	Loudoun and Prince William Counties, Virginia, added 3/67
Boston, Massachusetts	Some towns were added in 6/59 and in 10/63. Breakout of railroad data not available by towns.

Appendix V

1. Railroad unions[1]

A. The operating brotherhoods

BLE	Brotherhood of Locomotive Engineers (Independent)
UTU	United Transportation Union

B. The nonoperating unions

RASA	American Railway and Airline Supervisors Association
TDA	American Train Dispatchers Association
BBF	International Brotherhood of Boilermakers, Iron Shipbuilders, Blacksmiths, Forgers and Helpers
BMWE	Brotherhood of Maintenance of Way Employees
BRASC [2]	Brotherhood of Railway, Airline and Steamship Clerks, Freight Handlers, Express and Station Employees
BRC	Brotherhood of Railways Carmen of America
BRS	Brotherhood of Railroad Signalmen
SCP	Brotherhood of Sleeping-Car Porters
HREU[2]	Hotel and Restaurant Employees and Bartenders International Union
IAM	International Association of Machinists and Aerospace Workers
IBEW	International Brotherhood of Electrical Workers
IBFO	International Brotherhood of Firemen and Oilers
RYA	Railroad Yardmasters of America
SMW	Sheet Metal Workers' International Association
TWU [2]	Transport Workers Union of America, Railroad Division
DIST 50	International Union of District 50, Allied and Technical Workers of the United States and Canada (Independent)
UTSE	United Transport Service Employees
USA	United Steel Workers of America

C. Marine unions in railroading

BRASC	Brotherhood of Railway, Airline and Steamship Clerks, Freight Handlers, Express and Station Employees
GLLO	Great Lakes Licensed Officers Organization (Independent)
HREU	Hotel and Restaurant Employees and Bartenders International Union
ILA	International Longshoremen's Association
IUOE	International Union of Operating Engineers
MMP	International Organization of Masters, Mates, and Pilots
MEBA	National Marine Engineers Beneficial Association
NMU	National Maritime Union of America
RMU	Railroad Marine Union
SIU	Seafarers International Union of North America
TWU	Transport Workers Union of America
DIST 50	International Union of District 50, Allied and Technical Workers of the United Sates and Canada (Independent)

[1] All unions listed are AFL–CIO, unless otherwise designated.
[2] Also appears in Marine Union List.
SOURCE: 34th Annual Report of the National Mediation Board (Washington, Government Printing Office, 1968) pp. 88–89.

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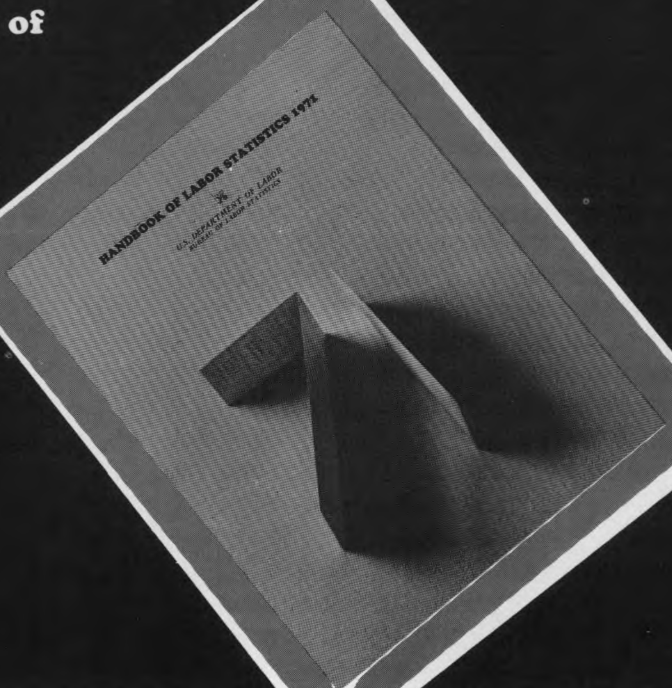

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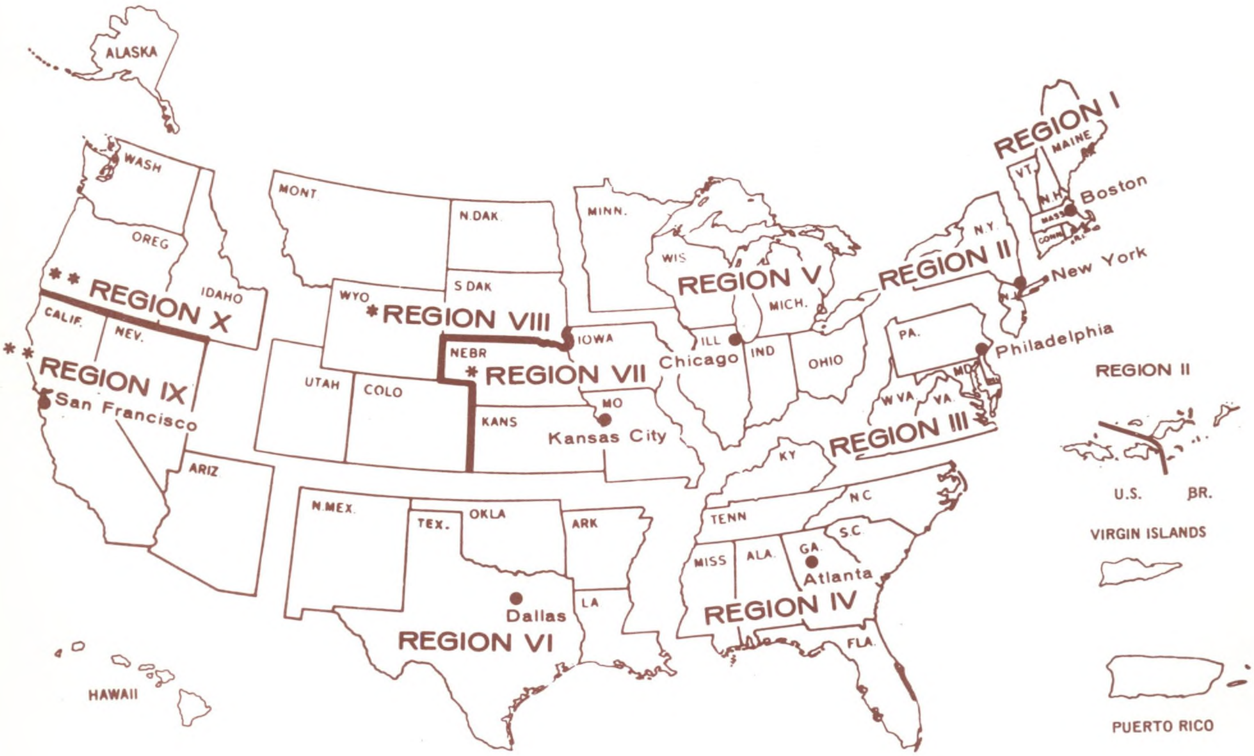

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