FOUO 37

FIXED CAPITAL OF RAILROAD TRANSPORTATION

4 SEPTEMBER 1980 BY A. V. IZOSIMOV 1 OF 3

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4 September 1980

USSR Report

TRANSPORTATION

(FOUO 3/80)

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By

A.V. Izosimov

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FIXED CAPITAL OF RAILROAD TRANSPORTATION

Moscow OSNOVNYYE FONDY ZHELEZNODOROZHNOGO TRANSPORTA in Russian 17 Jul 79 pp 1-232

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CONTENTS

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Annotation

This book reviews the questions of the location, development, and use of the production fixed capital of railroad transportation, its physical wear and obsolescence, and service life. The book demonstrates the role of depreciation deductions as a crucial source for reproduction and replacement of fixed capital under conditions of accelerated technical progress.

The book is intended for scientific (academic) workers, but it may also be used by economic planning, finance, and engineering-technical workers in railroad transportation.

The book has 19 illustrations, 42 tables, and a bibliography with 131 entries.

Introduction

The most important advantage of the socialist economy over the capitalist economy is that it develops on the basis of a single state plan that envisions planned, proportional growth of productive forces. When planning the development of sectors of the national economy planners begin from the general problems of siting productive forces for the coming period taking into account the territorial relations among economic sectors, the production specialization of rayons and oblasts, the location of fuel-energy and raw material bases, the availability and degree of development of transportation, and other conditions that determine the efficiency of public production.

V. I. Lenin attached great importance to the question of rational location of productive forces. In his works he developed the most important principles of siting productive forces in a socialist economy. These principles are the following: even location of production with due regard for fullest possible use of raw material, processed material, and labor resources; development of public division of labor in the republics and economic regions of the country on the basis of equality and mutual help among all the republics and peoples of the USSR; bringing industrial enterprises closer to sources of raw material and fuel; comprehensive development of the economies of the republics and economic regions with due regard for their specialization in those sectors of industry and agriculture for which these republics and rayons have especially favorable conditions; development of the economies of the nationality-based republics and oblasts; building up the country's defense capability.

During the years of Soviet power these principles have been elaborated and given concrete form in five-year national economic plans.

All sectors of the socialist economy are developing with a basic objective of maximally increasing the efficiency of public production. This means that the development and work of enterprises in the producing sectors of physical production and enterprises in the sectors that serve production and market output must be carried on with minimal expenditures of live and embodied labor. The service sectors play an important part in the process of public production. In 1977 they accounted for 17.4 percent of all fixed capital, 20.8 percent of capital investment, and 17.0 percent of all persons employed in the national economy.* Transportation occupies a special place among these sectors, and railroad transportation is the paramount form.

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* Calculated from data published in the statistical yearbook "Narodnoye Khozyaystvo SSSR v 1977 g." [The USSR National Economy in 1977], Moscow, Statistika, 1978, pp 40, 353, 375.

The work of transportation and its role in the national economy depend on the functions which it performs. Transportation that moves raw materials, fuel, processed materials, and semifinished goods around within enterprises is called internal or industrial transportation. It participates directly in the enterprise production process and is very important for its operation. The operating length of railroads at industrial enterprises and organizations as of the start of 1978 was 89,000 kilometers. In 1977 73.1 billion ton-kilometers of transportation work was done on them, moving 10.3 billion tons of various articles [82, p 311].

Transportation also has a major role in carrying on relations between various enterprises. Transportation ships the finished goods of various sectors of the economy from the place of production to the place of consumption and thus creates the necessary conditions for enterprise work. Continuing the production process in the sphere of circulation, transportation operates as a special economic sector that serves production. In this case it is general-use transportation, an independent sector of physical production.

The degree of development of transportation and its location by particular oblasts and regions of the country predetermines transportation and economic ties, the regularity and time of delivery of raw and processed materials and fuels for enterprises, and the amount of transportation expenditures to ship the output of the national economy. According to calculations made in the division of economics of the Central Scientific Research Institute of the Ministry of Railroads, the total sum of expenditures in the national economy for shipping in 1977 was 86.7 billion rubles. Railroad transportation accounted for 20.8 billion rubles or 23.9 percent of this amount [113, p 12].

Transportation expenditures increase the cost of physical output that has already been produced. Transportation expenditures account for 30-35 percent of the prime cost of iron and manganese ore, 20-25 percent of the prime cost of coal and petroleum products, 18 percent for cement, and 15 percent for lumber shipments [100]. Railroad transportation has a significant share of these expenditures.

The location of enterprises of different economic sectors depends greatly on development of transportation routes. At the same time, the development of transportation itself is closely linked to and depends on the location of enterprises. This interdependence demands a certain proportionality in the development of transportation as a whole and of its particular forms. This development must correspond to the location of industrial enterprises and agriculture, which will create conditions for satisfying the demands made on transportation to move freight and passengers. Fullest and most efficient use of the material-technical base of enterprises of the national economy is extremely important for raising the efficiency of all public production.

The role of transportation in the siting of productive forces has been considered in detail in a number of major works which have demonstrated the technique for consideration of the transportation factor in siting production [63, 106]. These matters have also been investigated in the doctoral dissertations of A. I. Zhuravel' (1969) and B. I. Shafirkin (1974).

General-use transportation comprises five forms: rail, maritime, river, motor vehicle, and air. The pipelines, which transport liquid and gaseous products, and high-voltage power transmission lines supplement the uniform transportation system of the country. All the forms of transportation work together, supplementing and, when necessary, replacing one another. They must be used in such a way that total calculated expenditures for the transportation of freight and passengers, including both current operating costs and capital investment, are minimal.

Railroad transportation plays the leading role in the uniform transportation system of the USSR. It performs a significant share of all freight and passenger conveyance. On 1 January 1976 the length of the general-purpose rail network reached 138,300 kilometers; the volume of freight shipping in 1975 was 3,236.5 billion ton-kilometers and passenger conveyance was 312.5 billion passenger-kilometers [84, pp 458-460]. Significant growth in freight and passenger conveyance was planned for the 10th Five-Year Plan. By 1980 railroad freight traffic was expected to increase by about 22 percent and passenger traffic by 14-15 percent.

Development and strengthening of the production fixed capital of railroad transportation, as envisioned in the document "Basic Directions of Development of the USSR National Economy in 1976-1980" and the decree of the CPSU Central Committee and USSR Council of Ministers entitled "Steps to Develop Railroad Transportation in 1976-1980," are very important for successfully performing such an enormous volume of shipping. Plans for the 10th Five-Year Plan envision the construction of 3,400 kilometers of new rail lines and laying 4,000 kilometers of second tracks and double-track inserts in the most heavily used sections of the network.

Plans call for electrification of 4,500 kilometers, outfitting 16,800 kilometers of rail lines with automatic blocking and centralized dispatching, and automating three and mechanizing 30-35 classification yards.

Considerable attention is being focused on supplying railroads with more rolling stock and modern types of machinery and equipment that insure greater mechanization of loading and unloading and high quality repair and ongoing maintenance of the fixed capital of railroad transportation. During the 10th Five-Year Plan railroad transportation is to receive 400,000 freight cars, 16,600 passenger cars, 2,200 electric locomotives, 6,400 sections of mainline diesel engines, and 2,500 diesel switch engines [81].

In the first three years of the 10th Five-Year Plan the production fixed capital of railroad transportation grew 12 percent. Many new roads, second tracks, electrified segments, and lines equipped with automatic blocking and centralized dispatching units were put into operation. Industry delivered 1,350 electric locomotives, 1,800 mainline diesel engines, 225,000 freight cars, and 9,000 passenger cars to the railroads. In 1978 the railroads performed 3,429.1 billion ton-kilometers of freight shipping and 332.1 billion passenger-kilometers.

To insure timely and uninterrupted satisfaction of economic needs for shipping and better shipping work by the railroads the most important thing is not building up the stock of technical equipment but making fullest and most intensive use of available production fixed capital, above all means of transportation. Intensification of the use of production fixed capital in railroad transportation leads to an increase in the traffic [propusknaya] and carrying [provoznaya] capacity of the rail lines, stations, and junctions. Like the introduction of new machinery, improving the use of fixed capital reduces the expenditures of live and embodied labor necessary to perform shipping work, which is expressed in growth in labor productivity in railroad transportation and a drop in the prime cost of shipping.

The large part played by the production fixed capital of railroad transportation in the shipping process and the multifaceted, profound influence exerted by it on the working efficiency of rail enterprises demand constant attention to the development, reproduction, and use of this fixed capital.

It is very important to insure rational location and comprehensive development of the fixed capital of rail transportation with due regard for the freight and passenger shipping work being done by the railroads. In this case certain types of fixed capital should be developed so that when they are used fully the traffic and carrying capacity of the railroads will be maximum.

Comprehensive development of fixed capital is an essential condition for devising an optimal capital structure which achieves maximally efficient use of fixed capital.

Timely performance of capital repair, reconstruction, and replacement of capital on a high technical level for the purpose of maintaining an optimal structure and insuring that existing capital is in good condition are also important steps to improving the use of the production fixed capital of railroad transportation.

Timely replacement of obsolete and wornout fixed capital with new, improved forms is essential to raise the traffic and carrying capacity of the railroads and reduce labor, material, and financial expenditures for shipping.

Correct, economically substantiated determination of the service life of fixed capital is an important problem directly linked to highly productive use of the fixed capital of railroad transportation. The amounts of depreciation deductions depend on service lives, especially that part of the deductions which is used to finance capital investment to replace fixed capital being withdrawn with new, technically and economically more progressive forms. Service life also influences the expenditures necessary for capital repair and modernization of fixed capital. Depreciation deductions in railroad transportation come to a significant amount, and the challenge is to see that they are used with maximum efficiency.

The fixed capital of railroad transportation has a number of distinctive features when compared to the fixed capital of other economic sectors. They arise from the shipping process itself. Foremost among them are the existence of expensive, long-lasting structures, location of production fixed capital throughout the territory of the entire country with due regard for the regional climatic and geological conditions, closer interaction of the different forms of railroad fixed capital, performance of repair work on fixed capital in conditions where train traffic does not stop, and constant renovation of track structures during the process of capital repair.

These special characteristics make it necessary (1) to develop the fixed capital of railroad transportation in a comprehensive manner, observing strict proportions in the capacity and technical equipment of different subdivisions of railroads based on insuring the required traffic and carrying capacity in entire sectors; (2) to perform capital repair of fixed capital under conditions where railroad transportation continues uninterrupted functioning, on the basis of introducing new, improved machinery and observing conditions that envision maximally efficient and full use of all fixed capital. The purpose of this book is to reveal the role and importance of the production fixed capital of railroad transportation, show special characteristics of its development under conditions of accelerated scientific-technical progress, establish lines of action to improve fixed capital given its highly intensive use and the steadily growing volume of shipping, and identify reserves for improving the use of fixed capital based on the introduction of new machinery and progressive technology, widespread dissemination of progressive labor methods, and employment of sophisticated methods for operations, ongoing maintenance, and repair.

Under current conditions where, thanks to new construction, expansion, reconstruction, and technical re-equipping the fixed capital of railroad transportation is growing rapidly, improving its use is an important lever for enlarging the traffic and carrying capacity of the railroads, raising the efficiency of the entire shipping process, and meeting the shipping needs of the economy and the population as fully and as well as possible.

The problems to be considered in this book are very complex and multifaceted, so the book does not claim to treat them exhaustively. The author expresses his gratitude to B. N. Lakhman, chief of the division of capital repair of the Main Economic Planning Administration of the Ministry of Railroads, docent F. P. Mulyukin, and candidate of economic sciences docent K. N. Tverskiy, as well as other comrades, for their useful remarks directed to improving the book.

Chapter 1. The Economic Essence of Fixed Capital and Classification of It

1. Transportation — a Part of the Productive Forces of Society

In any labor process, no matter what form of public production it may be performed under, people and means of production always participate. The means of production are means of labor and objects of labor. Objects of labor also include those things or groups of things which are used by a person in the process of working with various objects of labor to give them a definite use value. Therefore, the means of labor are above all implements of labor: power-supply and working machines and equipment, means of transportation, stocks, tools, and other implements of production. In addition, the means of labor include buildings and various other structures which do not participate directly in the labor process but create the necessary conditions for it to be done in general or to be done in an improved manner.

The classification of various types of equipment, machinery, means of transportation, stocks, and tools as means of labor or objects of labor depends on the place they occupy in the production process. Thus, an electric locomotive being built at the plant is an object of labor. But the same locomotive in use on a rail line for hauling is no longer an object, but rather a means of labor used to convey freight and passengers. Thus, objects are classified as means of labor only if they participate in the production process. Equipment which is standing in the warehouse of the plant that manufactured it is finished output. If this equipment is to become a means of labor, it must be shipped to the place where it will be used for its designated purpose and receive a productive application.

The various forms of means of labor play different roles in the process of public production. Implements of labor characterize the level of development of production much more than means of labor do; the means of labor serve to preserve objects of labor or create the physical conditions for the process of labor without participating actively in it. K. Marx, noting the important role of implements of labor, wrote: "Within the group of means of labor itself, mechanical means of labor, which taken together can be called the bone and muscle system of production, constitute the typical and distinctive features of a definite epoch of public production much more than those means of labor which serve only to preserve objects of labor and which can be called, taken together, the vascular system of production" [1, vol 23, p 191].

Objects of labor also include those materials on which a person works while creating output. Virtually all industrial sectors except the extracting sectors use raw material as the object of labor, which means material in which labor has been invested at an earlier time. In most industrial sectors raw material constitutes the principal part of the value of the finished output. A complete lack of raw material is characteristic of all types of transportation, railroads included. The bulk of the expenditures making up the cost of transportation output is wages. The objects of labor in transportation are the objects being shipped, but they do not belong to transportation and their value is not included in the value of transportation output.

The means of production and people who possess definite production skills and qualifications are the productive forces of society. In all stages of development people are the most important productive force. V. I. Lenin wrote: "The first productive force of the entire human race is the worker, the toiler" [2, vol 38, p 359].

The degree of development of productive forces determines the economic status of the country. The condition of the entire national economy depends on how highly developed and fully used these productive forces are.

Transportation is an important part of society's productive forces, and its means of production comprise a significant share of all the means of production at the disposal of society. More than 9 million people are employed in all forms of transportation, roughly 2.5 million in railroad transportation.

Transportation is one of the major sectors of the national economy. Each year large amounts of capital investments are spent for the development of transportation. Of 1 January 1975 the production fixed capital of USSR transportation was estimated at 148 billion rubles, 20 percent of all production fixed capital in the national economy.

Railroad transportation occupies an important place in the country's transportation system. It accounts for almost 75 percent of all domestic freight shipping in the USSR and 40 percent of passenger traffic. Railroad transportation has approximately eight percent of the production fixed capital of the national economy.

Describing the place of transportation in a national economy K. Marx observed that "on the one hand the transportation industry is an independent sector of production, and therefore also a special sphere for investment of productive capital. But on the other hand, it differs because it is a continuation of the production process within and for the process of circulation" [1, Vol 24, p 171].

General-use transportation serves the entire national economy. It conveys the freight of enterprises in various sectors as well as passengers, changing their location. The movement of freight and passengers from one region of the country to another is the output of transportation. The volume depends on the amount of freight and number of passengers conveyed and the distances that they are conveyed. Therefore, transportation output is measured in ton-kilometers and passenger-kilometers.

The output created by transportation is not a physical thing and it is consumed simultaneously with its production. This is one of the most important features of transportation. It does not follow from this, however, that transportation is not a sector of physical production. K. Marx worte: "In addition to extracting industry, farming, and manufacturing industry there is a fourth sphere of physical production which also goes through the different stages of production, artisans, small shops, and machine-based, in its development. This is the transportation industry, whether it is moving people or goods" [1, Vol 26, pt 1, p 422].

A second distinctive feature of general-use transportation is that the freight being carried, the object of labor, does not belong to the transportation enterprise but rather is the property of enterprises in various sectors of the economy. This is reflected in the formula of the cycle of production capital in transportation, which has no stage of conversion of transportation output into a commodity.

2. Fixed and Working Capital

The division of the means of production employed in railroad transportation into fixed and working capital is based on differences in the way they circulate. This was noted by K. Marx, who wrote: "That which gives the character of fixed capital to the part of capital value expended for means of production lies exclusively in the unique form of circulation of this part of capital. This special manner of circulation follows from the special way in which the given means of labor transfers its value to the product, or from that special role which it plays during the production process as a factor in the formation of value. This follows, in its turn, from the characteristic features of the functioning of different means of labor in the process of labor" [1, Vol 24, p 179].

Therefore, the quality of the material from which means of production are manufactured, mobility or assignment to one place, and duration of use in the labor process are not factors that determine the division of capital into fixed and working capital. This division depends exclusively on the way that means of production circulate, on how their value is transferred to the output and how it is replaced when this output is sold.

In the course of their work the employees of railroad transportation who are conveying freight and passengers use various means of labor and objects of labor which form the value of transportation output in different ways. When freight is shipped its value grows by the additional value created by the labor of transportation workers and the value of the means of production consumed. When passengers are conveyed the value of the use effect or service formed is consumed entirely by the passengers during their movement.

Some of the means of production in transportation are means of labor such as production and service buildings, railroad track, power supply, signal, and communications devices, supply structures, locomotives, cars, and various types of machinery, equipment, and tools which do not wear out completely in one shipping cycle, but rather are used many times over an extended period. Therefore, the value of these means of labor is transferred to the value of the transportation output gradually, as they wear out.

These means of labor are wearing out continually in the process of shipping operations, and their value is constantly decreasing until the means of labor have finally served out their life and their entire value has been transferred to the value of transportation output.

As the value transferred by means of labor to transportation output accumulates and is converted into money, new means of labor are acquired and replace old means of labor that are completely used up. This is the cycle of means of labor. The period during which they are used in the shipping process is very long in most cases, averaging 60 years in railroad transportation. Therefore, unlike the working means of transportation that complete their cycles of use in 75-80 days and demand constant replacement, the means of labor used in the shipping process for an extended time, gradually transferring their values to output, are called the fixed capital of transportation.

Fixed capital includes both the means of labor used constantly in the production process and those held in reserve, ready to go into use at any moment. The reserve power unit installed at a traction substation and designed to insure uninterrupted operation of the power supply devices of an electrified road is included with the fixed capital of transportation just like the power unit operating at the particular moment. Analogously, the stock of track measured by kilometer, wheeled pairs of locomotives and cars, and sets of spare parts for rolling stock acquired through capital investment and designated to insure stable operation of the track superstructure and railroad rolling stock are included in fixed capital.

Most of the means of labor classified as fixed capital have high costs and long service lives. To simplify planning and record-keeping, means of labor which have low costs or are used up in a short time are included in a special group of low-cost, fast-depleted objects even though, formally speaking, they should be classified as fixed capital. Therefore, they are included in working capital, not fixed capital.

It is accepted today that means of labor with service lives of less than one year are not fixed capital regardless of their cost, and neither are means of labor costing less than 50 rubles apiece regardless of their service life. In addition, instruments, automation equipment, and laboratory equipment purchased by scientific research organizations and costing less than three hundred rubles per unit will not be fixed capital. A complete list of the means of labor not classified as fixed capital is given in the "Statute on Accounting Records of the Fixed Capital of State, Cooperative, and Public Enterprises and Organizations (Except Kolkhozes)" published by the Finansy Publishing House in Moscow in 1977.

In addition to fixed capital, such means of production as fuel, lubricants, various processed materials, and spare parts are used in the process of shipping freight and passengers. These are classified as the working stocks [fondy] of transportation. They are expended in full during one shipping cycle and their entire value is included in the value of the transportation output created during the cycle. This part of means of production must be replaced continuously for the process of shipping to go on without interruption.

Working stocks and circulating funds [fondy], including the finished output of subsidiary enterprises and monetary capital, form the working capital [sredstva] of transportation. That part of working capital which is controlled by norms (production stocks of materials and equipment, fuel, lubricants, and so on) is the norm-controlled working capital.

Production fixed capital and norm-controlled working capital participating in the formation of the value of transportation output are called the production capital of transportation. This concept cannot be equated with means of production, which includes means of labor that do not have value: land, water resources, lumber and ore, and mineral products.

Production fixed capital accounted for 98.7 percent of the total production capital in railroad transportation in 1977, and working capital was just 1.3 percent. The composition of the production capital of railroad transportation differs significantly from its composition in other forms of transportation and in other sectors of the economy. Production fixed capital accounted for 79.3 percent of the total volume of production capital in industry in 1977, for example, while working capital was 20.7 percent.*

As technical progress occurs over time and fixed capital develops, its share in production capital shows a tendency to increase, while the share of working capital tends to decrease.

The fixed capital [fondy] of a socialist economy differ fundamentally from the fixed capital [kapital] that represents the means of labor in a capitalist economy. In our country the means of production are public socialist property which exists in two forms: state and cooperative-kolkhoz. The fixed capital of general-use railroad transportation is state property, that is, it belongs to all the people. As a result, it is not separate from the people and opposed to them, as capitalist fixed capital is, and thus it is not used to exploit the working people.

In a socialist economy fixed capital is the most important part of public wealth. Growth and refinement of fixed capital provide a graphic indicator of increase in the country's productive capacity, steady increase in its economic might, and a rise in the material and cultural standard of living.

The situation is different in the capitalist countries where the means of production are privately owned. Fixed capital there belongs to individual capitalists or monopolistic associations of them and is used to exploit the workers.** Growth in capitalist fixed capital is

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* Calculated according to figures published in the statistical yearbook "Narodnoye Khozyaystvo SSSR v 1977 g." [The USSR National Economy in 1977], Moscow, Statistika, 1978, pp 40, 547.

** In some capitalist countries the fixed capital of certain sectors of the economy has been nationalized and put in the hands of the state. This does not change its capitalist nature, however, because the results of the public production continue to go to private parties.

evidence of a further increase in the wealth of the bourgeoisie which simultaneously impoverishes the working class. This crucial difference in socioeconomic nature between socialist fixed capital [fondy] and capitalist fixed capital [kapital] reflects the enormous superiority of the socialist economic system over the capitalist system.

Another important difference between socialist and capitalist fixed capital is that the former develops on a planned basis, in conformity to the law of planned proportional development of the national economy. This insures more rational siting of fixed capital, which creates favorable conditions for full-capacity and highly productive use. Under capitalism, by contrast, fixed capital develops in a spontaneous manner on the basis of the law of value, the law of competition, and production anarchy. Therefore, chronic underloading and incomplete use are typical of fixed capital under capitalism. The economic crises that periodically rock all sectors of the capitalist economy make the use of fixed capital even worse. Workers who operate the machinery have no interest in using it productively, because this does not improve their standard of living but only increases profit for the capitalists.

Thus, socialist fixed capital differs significantly from fixed capital under capitalism in terms of location, development, and use. The fixed capital of all sectors of the USSR economy is used much more intensively than fixed capital in any capitalist country.

In railroad transportation, when the track, locomotives, cars, and various machines and equipment are used more intensively and fully, the shipping process is more efficient and freight and passenger conveyance is cheaper. This makes it possible to use the money saved for development of the national economy and improving the material and cultural standard of living of the people. The material interest of railroad transportation workers in the results of their labor is an important stimulus to maximum use of fixed capital and raising labor productivity.

Socialist fixed capital also differs from capitalist fixed capital in composition. The capitalist monopolies invest primarily in those structures, machines, and equipment which will make it possible to intensify exploitation of the workers and raise the profit norm. In the socialist economy the machinery used not only raises labor productivity but also improves the working and domestic conditions of the working people.

3. Description of the Fixed Capital of Railroad Transportation

The fixed capital of the Ministry of Railways includes above all the fixed capital of railroad transportation itself, the fixed capital of the railroads that is used in conveying freight and passengers. In addition, the Ministry of Railroads includes enterprises and organizations whose fixed capital is related to other sectors of the economy. These enterprises and organizations facilitate successful accomplishment of the shipping process by their activities. They include industrial enterprises that repair rolling stock and produce spare parts and certain special types of machinery and equipment used primarily by railroad transportation; construction and planning organizations that perform repair work on railroad track and other fixed capital and work out plans and estimates for the construction of new and repair and reconstruction of existing installations; trade and public catering organizations. The Ministry of Railroads also has its own housing and municipal services system, cultural, educational, and public health institutions, and other enterprises and organizations that serve employees of railroad transportation and members of their families. On 1 January 1975 the urban subways which carry passengers within the cities were transferred to the Ministry of Railroads.

Thus, the fixed capital of the railroads and other enterprises and organizations included in the Ministry of Railroads comprises many different types of capital that are classified with transportation, industry, construction, and other sectors of the national economy.

The fixed capital is subdivided by designated purpose into production and nonproduction capital. The production fixed capital of railroad transportation comprises all fixed capital participating in the shipping process. This group includes track and power supply structures, signal and communications devices, machinery and equipment for repairing the track and rolling stock, locomotives and cars, various types of production buildings, tools and stocks, means of protecting the track against snow and sand drifts and so on.

The production fixed capital of enterprises and organizations that relate to other sectors of the national economy is fixed capital participating directly in the production processes of these enterprises and organizations whose activities are essential for successful accomplishment of freight and passenger conveyance.

All the production fixed capital of railroad transportation can be divided into two large groups:

1. Buildings, permanent structures, and transmission devices;

2. Rolling stock, machines, equipment, production tools and stocks.

Railroad transportation has a large number of different types of production buildings. Among them are locomotive and car depots, the buildings of car sections, water supply buildings, technical servicing points for cars and locomotives, automatic brake check points, washing and steaming stations and others. The permanent structures of railroad transportation are even more diverse. Foremost among them is the track itself, including the roadbed with drainage, water diversion, and reinforcement structures, the superstructure, and artificial structures. In addition, permanent structures include devices for equipping locomotives and cars, passenger platforms, freight and container yards, loading-unloading platforms, and the like.

Transmission devices include the catenary system of electrified roads, overhead and cable-type power and communications lines, the network of water supply pipes, production sewage systems, and the like.

The rolling stock, track and construction machines, equipment, production stocks and tools constitute the active part of production fixed capital. The volume of transport output and the use of all other types of production fixed capital of railroad transportation depends on how fully they are used. Within this group of fixed capital rolling stock is most important.

It should be remarked that the idea has been expressed in the economic literature of recent years that a significant part of the permanent structures and installations, including the track superstructure, communications and signaling, centralization, and blocking devices, the catenary system, and other units must be included in active fixed capital [21, p 65]. This position is hardly correct, however, because the permanent structures and installations do not play an active part in the shipping process. This means that although maintaining them in model condition and doing exemplary repair create the essential conditions for highly productive work by rolling stock, the use of the structures and devices themselves depends on how efficiently the locomotives and cars which represent the active part of fixed capital are operated.

The nonproduction fixed capital of railroad transportation includes those facilities which do not participate in the shipping process, but are used to serve the railroad workers and members of their families. This category includes above all residential buildings, the buildings, equipment, and stocks of municipal and domestic service enterprises, and institutions of culture, education, public health, and other nonproduction sectors.

The proportion of the fixed capital of different enterprises and organizations in the total fixed capital of the Ministry of Railroads on 1 January 1978 is given below (as percentage of the total):

Railroad (Primary Activity)	92.2
Included in above, Production Fixed Capital.	82.0
Subways (Metropolitans)	4.0
Industrial Enterprises	2.3

[Continued on next page]

Worker Supply Organizations	0.6
Construction and Planning Organizations	0.7
Other Enterprises and Organizations	0.2
Total	100.0

Thus, the fixed capital of the railroads, which participates in shipping and comprises the production fixed capital of transportation, clearly predominates, accounting for 82.0 percent of the total fixed capital of enterprises and organizations of the Ministry of Railroads. The non-production fixed capital of enterprises and organizations related to the primary activity of the railroads accounts for 10.2 percent. The fixed capital of other enterprises and organizations of the Ministry of Railroads constitutes 7.8 percent of the total value of fixed capital.

4. Classification of Fixed Capital

All the fixed capital of railroad transportation is joined into definite groups and subgroups in conformity with the "Model Classification of Fixed Capital of the USSR National Economy," ratified by the USSR Central Statistical Administration on 30 April 1970 and put into effect on 1 January 1971 (published by Statistika Publishing House, Moscow, 1971).

A correctly constructed classification of fixed capital is very important for accurate and complete accounting for the value of the capital and planning of reproduction. It makes it possible to establish the structure of fixed capital and determine the technical equipment available per worker in railroad transportation. The classification of fixed capital plays an important part in planning and figuring depreciation, determining the capital-transportation output ratio, and solving various other problems.

The classification of fixed capital is uniform for all sectors of the national economy. It subdivides fixed capital into groups, subgroups, and positions which are determined on the basis of the production and technological designation of various types of fixed capital. The specific features of the fixed capital of various sectors of the economy are taken into account in the classification by establishing subgroups and positions for distinctive types of fixed capital.

The classification of fixed capital may differ in degree of completeness depending on the purpose. A classification designed for current accounting of fixed capital and conducting general inventories and re-evaluations of fixed capital must be most detailed. Such a classification singles out all types of fixed capital used in the particular sector of the economy.

A less detailed classification of fixed capital can be used for planning and recording depreciation deductions. Although the number of groups and subgroups in it is the same, there are many fewer positions within the subgroups because it is possible to consolidate several types of fixed capital relating to different positions but having the same normative depreciation deductions. The classification of fixed capital required for long-range planning of depreciation deductions in railroads and at the Ministry of Railroads can be even less detailed.

In conformity with the Model Classification, the fixed capital of the railroads is subdivided into the following groups and subgroups:

I. Buildings

II. Structures
Included in Above:
(1) Roadbed of Railroads;
(2) Superstructure of Railroads;
(3) Metal Bridges with Spans Longer than 25 Meters;
(4) All Other Structures.

III. Transmission Devices

IV. Machines and Equipment
Included in Above:
(1) Power Supply Machines and Equipment, automatic;
(2) Power Supply Machines and Equipment, nonautomatic;
(3) Working Machines and Equipment, automatic;
(4) Working Machines and Equipment, nonautomatic;
(5) Measurement and Regulating Instruments and Devices and Laboratory Equipment, automatic;
(6) Measurement and Regulating Instruments and Devices and Laboratory Equipment, nonautomatic;
(7) Computer Equipment, automatic;
(8) Computer Equipment, nonautomatic;
(9) Other Machines and Equipment, automatic;
(10) Other Machines and Equipment, nonautomatic.

V. Means of Transportation
Included in Above:
(1) Broad Gauge Electric Locomotives;
(2) Broad Gauge Diesel Locomotives;
(3) Electric Trains;
(4) Broad Gauge Diesel Trains and Cars;
(5) Broad Gauge Steam Locomotives and Tenders;

[Continued on next page]

(6) Broad Gauge Freight Cars;
(7) Broad Gauge Passenger Cars Engaged in Passenger Conveyance and Special Passenger-Type Cars;
(8) All Other Means of Transportation (Wheel Pairs, Sets of Spare Parts, All Narrow Gauge Rolling Stock, Motor Vehicle Transportation, Draft Animal Transportation, and the Like).

VI. Tools

VII. Production Stocks and Accessories

VIII. Administrative Stocks

IX. Working and Productive Livestock

X. Perennial Plantations

XI. Capital Expenditures for Land Improvement (Without Structures)

XII. Other Fixed Capital

A detailed list of the fixed capital recorded in the various groups and subgroups of the classification is given in "Instructions on Accounting for Fixed Capital at Railroad Transportation Enterprises and Economic Organizations" (Moscow, Transport Publishing House, 1978, pp 120-136).

It should be noted that it is advisable to identify a series of subgroups within several groups of fixed capital in order to keep more complete records of the value of fixed capital and computed depreciation. This refers primarily to the "Structures" group, within which various subgroups should be identified in addition to metal bridges with spans longer than 25 meters.

Additional subgroups would be other metal bridges, reinforced concrete bridges and pipes, railroad tunnels, and other artificial railroad structures. Such a grouping can provide a fuller representation of the value of all artificial structures, as well as the value of the railroad track as a whole and the dynamics of growth and change in the structure of this group of fixed capital.

Within the "Transmission Devices" group it is advisable to single out units of the catenary system, high-voltage power transmission and automatic blocking lines, and overhead and cable communications lines.

It is equally important within the "Machinery and Equipment" group to keep accounts separately for electrical engineering and power supply equipment of traction substations of electrified railroads, track machines and mechanisms, automatic blocking and centralized dispatching equipment, and equipment for electrical centralization of switches and signals.

Putting these types of fixed capital into subgroups will create the necessary conditions for more correct planning of their structure and the amount of depreciation deductions both in current and future plans for the development of railroad transportation. This will permit better founded plans for the introduction of new machinery in railroad transportation, which is important for timely implementation of measures to increase the carrying and traffic capacity of the railroads.

Given the extensive application of electronic computers today, separate accounting for expensive types of fixed capital in railroad transportation presents no special difficulties. But it does insure the necessary conditions for improving the planning of expenditures for reproduction and capital repair of fixed capital.

For more exact planning of depreciation deductions it is wise to revise the accounting for fixed capital not only by groups and subgroups but by individual positions established in conformity with the Model Classification of Fixed Capital ratified for the entire national economy. Each position for which norms of depreciation deductions have been ratified should include inventory objects of fixed capital for one production-technological purpose with roughly equal average service lives.

Along with the need for more detailed breakdown of certain groups of fixed capital into subgroups, the presence of other groups and subgroups in the classification arouses question. Thus, as far back as the classification of fixed capital introduced in 1960, structures and transmission devices were consolidated in one group. Later, however, during a revision of the classification the "Transmission Devices" group was again singled out. Without reviewing the advisability of this breakdown here (transmission devices are a type of structure), it must be observed that under conditions of rapid scientific-technical progress when complex sets of machinery and devices are being introduced in all the sectorial systems of railroad transportation, separate accounting for transmission devices often causes difficulty. As a result, built-in elements which are transmission devices are frequently separated out from the composition of large independent objects of fixed capital.

For example, automatic blocking and centralized dispatching equipment is recorded in the "Machinery and Equipment" group, but high-voltage signal lines are put in the "Transmission Devices" group. This leads to a situation where the value of one inventory object, automatic blocking or centralized dispatching, is split up into two different classification groups, even though the parts that are singled out are not independently important. In this case the norm of depreciation deductions should, one would expect, be established not for the inventory object, the automatic blocking or centralized dispatching, as a whole, but for its individual parts; this is hardly a correct procedure.

The pipelines and equipment of devices to supply water and sand to locomotives and devices to supply diesel fuel, lubricants, and other things to diesel locomotives are also recorded in different classification groups.

It should be emphasized that transmission devices are independent inventory objects only if they are not an inseparable part of some machine or building, that is, of another inventory object. Thus, a pipeline which is used to deliver water to a building is an independent inventory object, but a pipe which carries water within the building is no longer one because it is part of another inventory object, the building. Therefore, within the "Transmission Devices" group it is advisable to record only those objects of fixed capital which have independent purposes.

Chapter II. The Composition and Structure of the Fixed Capital of Railroad Transportation

1. Current Accounting of Fixed Capital

When deciding questions of the reproduction, use, and depreciation of the fixed capital of railroad transportation it is very important to have precise figures on the qualitative and quantitative composition of the capital, its replacement cost, and degree of wear. Current accounting of fixed capital plays a large role here; it must reliably reflect the value and technical condition of the fixed capital. Well-organized current accounting makes it possible to monitor the condition of fixed capital and replace it at the proper time.

Enterprises and organizations of the Ministry of Railroads use two kinds of current accounting of fixed capital: statistical and bookkeeping. The statistical records reflect the quantitative composition of fixed capital in physical units. These records are kept on special forms and describe the technical equipment available in railroad transportation as a whole and for particular sectors and enterprises. Bookkeeping records make it possible to have information on the value of the inventory objects of fixed capital, expenditures for their capital repair and modernization, and the amounts of calculated depreciation deductions.

At the present time, the fixed capital which is leased out, the fixed capital of subsidiary transportation enterprises, and reserve equipment are singled out from the total value of the production fixed capital of railroad transportation.

The production fixed capital related by the classification to other sectors of the national economy is recorded as a whole with the fixed capital of subsidiary industrial enterprises, construction organizations, and trade and public catering organizations singled out as "included in the above."

Nonproduction fixed capital is recorded as a total amount. For certain particular subgroups it shows separately as "included in the above." This includes the fixed capital of the housing system with identification of line buildings and other capital depreciated through expenditures for shipping and the cars of track machine stations that are used for housing; the municipal service system; educational, cultural, and artistic institutions; public health and physical training institutions.

The fixed capital for which depreciation is not figured is singled out from the total value of all fixed capital of railroad transportation, including the amount related to shipping.

The fixed capital that includes tools, production, and administrative stock and accessories, working and productive livestock, perennial plantations, and other fixed capital is shown on a single line. The relatively small amount of the value of this fixed capital in railroad transportation has made it possible to consolidate this figure in a single group.

There are several essential conditions for correct organization of current bookkeeping records of fixed capital. They are a carefully developed classification of fixed capital, accurate and timely reflection of all changes that take place with fixed capital, and strict observance of the system of bookkeeping entries in monetary form to record these changes.

The accounting unit of fixed capital is the inventory object. Each object used for an independent purpose or each group of objects working together as a single whole unit and used in the performance of a definite production function may be an inventory object. A correct definition of inventory objects is an important aspect of organizing fixed capital accounting.

The entire aggregate of fixed capital of railroad transportation may be represented as consisting of simple inventory objects which can exist independently of one another. The crucial characteristic of them is uniformity from an accounting point of view. Moreover, simple inventory objects are always uniform in terms of the material from which they are made and their designated purpose. In railroad transportation the simple inventory objects are: embankments, excavations, ditches, gutters, siphons, ties, transfer beams, rails, switches, bridges, tunnels, pipes, pumps, internal combustion engines, electric motors, turbines, transformers, permanent and portable batteries, measuring instruments, and so on.

During the process of railroad operations the simple objects of fixed capital interact with one another and are combined in complex inventory objects.

For example, the rails with their fastening, the switches, ties, transfer beams, and ballast all taken together form a single complex object, the track superstructure. Other complex objects are the catenary system of electrified railroads, automotic blocking, electrical centralization of switches and signals, centralized dispatching, and so on. Simple and complex inventory objects, interacting with one another within a definite territory, make up the composite inventory objects of fixed capital: the railroad, plant, and the like.

Unlike simple inventory objects, complex inventory objects which have the same designated purpose in the production process differ from one another. For example, while wooden ties of a definite type are the same on all roads, the superstructure, while it has the same purpose, will differ by the composition of simple objects it includes: ties, rails, ballast, and the like.

According to the "Model Classification of Fixed Capital of the USSR National Economy," in the "Buildings" group each separately built building with all the outside structures and barriers (fencing) serving this building alone is an inventory object. If these outside structures are designed to serve two or more buildings, they are considered independent inventory objects.

An inventory object in the "Structures" group is any separate structure with all the devices included in it to make one whole unit. For example, a bridge, which includes the supports, spans, roadbed, and regulating structures, is an inventory object. The railroad bed is a complex inventory object that includes embankments and excavated ditches. Various drainage, water diversion, and reinforcement structures located within the roadbed and serving it are not included as part of this inventory object because their presence differs in every kilometer of the bed and depends on the geological conditions of the terrain through which the road runs. Therefore, all drainage, water diversion, and reinforcement structures of the roadbed are independent inventory objects. However, these objects are not subdivided by types of structures, but rather depending on the material from which they are made. They are recorded in two groups: wooden and earthen; reinforced concrete, concrete, stone, and metal. Crossings of busy railroad tracks, including planking, traffic control gates, and signal devices, are separate inventory objects.

Thus, every separate structure is an inventory object on the condition that the units it includes are not part of the composition of other inventory objects.

In the "Machinery and Equipment" group, each individual machine, device, aggregate, and installation with all its included attachments, accessories, control and measurement instruments, tools, electrical equipment, shielding, and foundation if the object is mounted on a separate foundation, is an inventory object. In the locomotive depot, for example, the gantry crane, which includes moving and hoisting mechanisms, trucks, and electrical equipment, is an inventory object.

Individual machines, machine tools, and aggregates may be consolidated into groups that are similar in technological purpose. In these cases they are complex inventory objects. For example, the electrical engineering equipment of the traction substations of electrified railroads, which includes control panels, switches, distribution devices, and other simple inventory objects, is a complex inventory object.

In the "Means of Transportation" group each locomotive, car, motor vehicle, or other transportation unit with its accessories and tools is an inventory object.

The simple and complex inventory objects of railroad transportation are given in the "Index of Inventory Objects and Norms of Depreciation Deductions of Fixed Capital of Railroad Transportation" (Moscow, Transport Publishing House, 1976).

Accounting records must provide information on the value of each inventory object. To a certain extent this is related to the fact that the norms of depreciation deductions for full replacement and capital repair are set for inventory objects as a whole, not for their particular parts.

According to the instructions of the Ministry of Railroads for bookkeeping accounting of the fixed capital, railroad transportation enterprises and organizations keep records of objects of fixed capital on inventory cards. The technical condition and degree of wear of the inventory objects of fixed capital are determined on the basis of the entries made on these cards.

Each object of fixed capital is assigned a six-digit inventory number. The first number represents the sector of the national economy. The second is the number of the fixed capital group according to the classification. The third number is the number of the subgroup. The fourth, fifth, and sixth digits are the ordinal number of the object.

In railroad transportation the inventory objects of fixed capital are recorded on card forms FOU Nos 1, 3, 4, and 5 corresponding to standard interdepartmental forms OS Nos 6, 7, 8, and 9. Particular forms of inventory cards have been established for the objects of different types of fixed capital. For example, buildings, structures, and transmission devices are recorded on FOU No 1 (OS-6) inventory cards, locomotives, passenger and refrigerator cars, machines and equipment, tools, and production and administrative stocks are recorded on FOU No 3 (OS-7) cards, and working and productive livestock and perennial forested windbreak plantations are recorded on FOU No 5 (OS-8) cards.

Freight cars, containers, wheeled pairs and sets of railroad rolling stock spare parts, old-style unitary rolled car wheels, old-style tread bands, and production stocks of aggregates and assemblies for diesel locomotives and electrical rolling stock at repair plants are recorded on FOU No 4 (OS-9) inventory cards. The same cards are used to record series of similar production or administrative stock objects, tools, machine tools, and other items received at the same time in a shop or division and having the same purpose, description, and value.

An inventory card is filled out for each inventory object. Complex inventory objects are recorded on the card by constituent elements or the simple inventory objects that they include.

All changes taking place with the object in the course of its service life are recorded on the inventory cards: capital repair, modernization, reconstruction, wear, and the like.

In addition to the inventory number of the object the cards contain a code figure for depreciation expenditures which shows which accounts are used to figure the depreciation.

The accounting office of the enterprise stores the inventory cards in a definite order, broken down by sectors of the national economy, classification groups and subgroups, and by groups that reflect the status of the objects of fixed capital in operations, reserve, storage, repair, or on lease.

The inventory cards and the entries they contain are the basis for keeping cards to record the movement of fixed capital using form FOU No 6 (OS-12). These cards are used to compile reports on the movement of fixed capital, expenditures for capital repair, and the calculated depreciation fund. They are also used to calculate the payment for production capital.

The accounting procedure for fixed capital that is received and being withdrawn is presented in detail in the "Concise Instructions on

Filling Out and Using Forms for Keeping Accounting Records of Fixed Capital," ratified by the Finance Administration of the Ministry of Railroads on 28 December 1973.

2. Inventory and Re-Evaluation of Fixed Capital

Periodic (usually annual) and general inventories of fixed capital are conducted regularly to check and refine current accounting data. The annual inventories are taken when annual reports and balances are being written for the condition as of 1 January in the year following the report year.

Annual inventories are taken at all enterprises and organizations of railroad transportation by specially formed inventory commissions. The inventory results are ratified by the management of the enterprises and organizations where the inventories were taken.

Annual inventories conducted regularly and carefully provide necessary checks on the preservation and use of fixed capital and the quality of bookkeeping reports, eliminate problems with current accounting, and determine the actual presence of fixed capital exactly. But annual inventories do not determine the amount of wear or re-evaluate operating fixed capital in current prices. These jobs are done only during general inventories of fixed capital which are conducted at the same time in several or all sectors of the national economy.

The need to take general inventories and make re-evaluations arises from the fact that production conditions, the prices of materials and equipment, wage rates, and the level of labor productivity and wages change with the passage of time. Therefore, identical types of fixed capital built or purchased at different times are recorded on enterprise balances at different prices. To record fixed capital in the same prices its replacement cost is determined; this is the cost of reproducing the fixed capital under current conditions.

Replacement cost expresses the expenditures necessary to build or purchase existing fixed capital at operative prices, given the level of labor productivity and production organization that has been attained. Considering that these conditions and prices ordinarily change with the passage of time, the replacement cost of operating fixed capital deviates from its initial cost and, after ratification, is adopted in the balance instead of the original cost.

In addition, general inventories determine the residual value of fixed capital, which shows its actual cost minus wear. This value is determined as the difference between the replacement or balance value, that is the value at which the fixed capital was taken onto the balance after re-evaluation, and the value of its wear established during the general inventory and re-evaluation.

The most recent re-evaluation of the fixed capital of railroad transportation was carried out between 1 August and 31 December 1971 in conformity with the "Instructions on Re-Evaluation and Determining Wear of the Fixed Capital of State and Cooperative Enterprises and Organizations (Except Kolkhozes) Based on Conditions of 1 January 1972" (Moscow, Statistika Publishing House, 1970). The instructions established a general procedure for determining replacement cost and wear of fixed capital in all sectors of the national economy in which this work was done. The document specified which types of fixed capital were to be re-evaluated and which were to be included in reports on re-evaluation according to original value.

The re-evaluation and determination of wear of fixed capital was done using data from the annual inventory conducted before compiling the annual bookkeeping report and balance for 1971.

To supplement the instructions mentioned above the Ministry of Railroads developed its "Instructions on Re-Evaluation of the Fixed Capital of Railroad Transportation Based on Condition as of 1 January 1972" (Moscow, Transport Publishing House, 1970), which took into account the special characteristics and procedures for doing this work in railroad transportation. The re-evaluation covered buildings for all purposes, the roadbed, the superstructure, artificial structures, power supply devices, passenger and freight platforms and other railroad structures, power supply and working machines and equipment, signal and communications devices and equipment, and means of transportation including locomotives, passenger and freight cars, diesel switch engines, and the like.

The following items of fixed capital of railroad transportation were not re-evaluated, but rather were recorded at original value: old-style track superstructure material (rails, fastening devices, and switches), reserve rails measured by kilometer, locomotive and car wheeled pairs, sets of spare parts for locomotives and cars, the equipment of electric rolling stock, locomotive and car trucks, production and administrative stocks, tools, working and productive livestock, library resources, and wooded windbreaks planted to protect railroads.

The replacement cost of rolling stock, machinery, and equipment received by import or domestically produced but no longer in production by industry at the time of re-evaluation was established on the basis of prices given in price lists for similar current equipment with corrections for differences in speed, tractive force, productivity, economy, and other indicators. For example, the replacement cost B_y of domestic locomotives of an outdated design and locomotives received from import, not given in price list No 100 for re-evaluation of rolling stock, was determined to the formula

$$B_y = \frac{B_c v_y M_y}{v_c M_c}, \quad (1)$$

where B_c is the replacement cost given in price list No 100 for currently produced domestic locomotives; v_c and v_y are the operating speeds of the current (c) domestic and obsolete (y) or imported locomotive over an extended period of work, in kilometers per hour; M_c and M_y are the tractive force of the current domestic and obsoleter or imported locomotives over a prolonged period of work, in ton-force.

The replacement cost of the rolling stock, machinery, and equipment of railroad transportation obtained by this formula took obsolescence into account.

It was also very important to determine the technical condition of fixed capital, that is, the degree of physical wear. This was established in three ways: (1) inspecting the acutal inventory objects and ascertaining their technical condition; (2) based on average service lives; (3) by volume of work performed.

The degree of wear in all methods was determined in rubles and percentage of the replacement cost of the fixed capital.

During examination of the technical condition of the entire object as a whole and of its principal design elements, wear was established by external inspection of the object and using technical documents describing its physical condition. Wear based on average service life (volume of work) was determined by comparing the age of the object (volume of work performed by it) to an average normative service life (normative work volume) [15].

It was recommended that wear be determined by other methods on a sampling basis to check the data on wear of fixed capital obtained by one of these three methods. When the results differed the wear determined by the inventory commission examining the physical object was adopted.

The re-evaluation established precise information on the availability of fixed capital at cost accounting enterprises and organizations of railroad transportation, obtained a complete and uniform replacement cost for it in current reproduction prices, and disclosed the degree of wear. In other words, it obtained all the indicators necessary for planning new construction, capital repair, modernization, and reproduction of fixed capital.

The change in the value of the particular groups of fixed capital of railroad transportation after their re-evaluation based on condition as of 1 January 1972 is shown below (in percentage) [70]:

Buildings	+25
Structures	+48
Included in above	
Roadbed	+19
Artificial Structures	+51
Superstructure	+59
Transmission Devices	+18
Means of Transportation	+ 2
Machiner, Equipment, and Other Fixed Capital	- 3
All Fixed Capital	+26

An analysis of the materials of the re-evaluation showed that the increase in replacement cost of fixed capital occurred chiefly through rise in the cost of construction of track structures, buildings, and transmission devices. The main explanation for the increase in cost is that the prices adopted during the re-evaluation envisioned replacement of the fixed capital on a higher technical level appropriate to current conditions and norms of reproduction [53]. In addition, the increased cost of building transportation structures was related to a rise in prices for materials, fuel, and electricity and the growth in wages of workers and employees.

The replacement cost of rolling stock and various machinery and equipment was virtually unchanged, and in some cases it was even less. The basic explanation for this is that the prices took account of the obsolescence of locomotives, cars, machinery, and equipment, which involved lowering their reproduction cost because of lower productivity and economy compared to current, progressive models.

The wear on all fixed capital of railroad transportation was 29 percent. For particular groups of fixed capital the wear, according to [32], was as follows (in percentage):

Buildings	23
Structures	30
Transmission Devices	32
Means of Transportation	30
Machinery, Equipment, and Other Fixed Capital	37

A re-evaluation and wear assessment of the fixed capital of the budget organizations and institutions subordinate to the Ministry of Railroads was carried out from 1 July to 31 December 1972 based on condition as of 1 January 1973. As the re-evaluation showed, the fixed capital of these organizations had grown 26 percent and its level of wear was 30 percent.

As a result of the re-evaluation, the value of the fixed capital of railroad transportation increased more significantly than that of other sectors of the national economy. Whereas the value of fixed capital for all cost accounting enterprises and organizations of all sectors of the national economy rose 10 percent, which included a figure of nine percent for industry and six percent for agriculture, the growth for all forms of transportation was 18 percent and for railroad transportation it was 26 percent.

Thorough and deep analysis of the materials from the re-evaluation of the fixed capital of railroad transportation promoted an improvement in the planning of capital investment directed to reproduction of fixed capital and further development of railroad technology.

3. Structure of Fixed Capital

In recent years the composition and structure of the fixed capital of railroad transportation have changed significantly. Continuing scientific-technical progress is exerting a major influence on this change. It is seen primarily in supplying the railroads with new types of locomotives and cars, working and power supply machinery, and various types of equipment, and in the introduction of more sophisticated railroad track designs, signal and communications devices, and automation and mechanization equipment. As a result of equipping railroad transportation with improved technical means, building new railroads, and reconstructing and developing rail junctions and stations, the value of the production fixed capital has grown substantially.

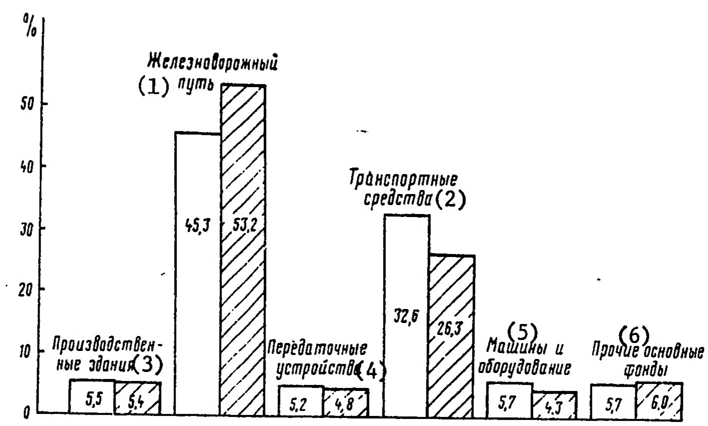
Table 1 below shows the changes in the structure of production fixed capital of railroad transportation between 1960 and 1978.

Table 1. Change in the Structure of the Production Fixed Capital of Railroad Transportation, percentage of total.

Fixed Capital	1960	1965	1970	1975	1978
Production Buildings	6.6	6.0	5.5	5.5	5.6
Track Superstructure	31.1	27.9	25.2	29.5	28.0
Roadbed	18.8	15.9	14.0	11.6	11.1
Other Structures	17.9	15.2	13.7	14.6	13.8
Transmission Devices	-	3.8	4.4	4.9	5.0
Machinery and Equipment	2.9	4.3	5.2	4.9	5.5
Means of Transportation	21.8	25.9	31.2	28.4	30.4
Other Fixed Capital	0.9	1.0	0.8	0.6	0.6
Total	100.0	100.0	100.0	100.0	100.0

The change in structure of production fixed capital was particularly noticeable after the re-evaluation made in 1967 prices considering the cost of reproducing fixed capital in current conditions. The re-evaluation led to an increase in the cost of fixed capital and a change in the ratios among the different groups of fixed capital in railroad transportation.

Figure 1. Structure of the Production Fixed Capital of Railroad Transportation Based on Condition as of 1 January 1972 (left-hand columns — before re-evaluation; hatchured columns — after revaluation).



Key: (1) Railroad Track;
(2) Means of Transportation;
(3) Production Buildings;
(4) Transmission Devices;
(5) Machinery and Equipment;
(6) Other Fixed Capital.

It can be seen that the share of railroad track structures in the composition of the production fixed capital of the railroads increased by almost eight percent after the re-evaluation, while means of transportation dropped 6.3 percent and machinery and equipment 1.4 percent.

Significant changes also occurred in the distribution of fixed capital by sectors of the railroad system, which can be seen from Table 2 below.*

Table 2. Distribution of Fixed Capital by Sectors of the Railroad System (percentage of total).

Sectorial Line Enterprises (Sectors of the System)	1 Jan 1960	1 Oct 1965	1 Jan 1972
Track Units [distantsii]	63.7	54.7	48.8
Locomotive Depots	9.7	13.3	16.0
Car Depots (considering car fleet)	14.1	15.4	18.7
Units of Civil Structures	3.7	5.7	4.0
Signal and Communications Units	2.2	2.9	3.6
Power Supply Sections	2.0	4.1	5.1
Other Road Enterprises	4.6	3.9	3.8
Total	100.0	100.0	100.0

Note: Figures for 1972 are given without considering re-evaluation.

It can be seen from Table 2 that track units account for the largest share of production fixed capital. Next come car and locomotive depots, power supply sections, and other sectorial line enterprises which to a certain extent represent the corresponding sectors of the railroad system. The share of track units in fixed capital, however, is decreasing from year to year, while that of enterprises such as the locomotive and car depots, power supply sections, and signal and communications units is growing. This is related primarily to greater capital investment to buy locomotives, cars, and various types of machinery and to reconstruct signal, centralization, blocking, and communications units than capital investment for the construction of new railroads and second tracks, development of rail junctions and stations, and introduction of new track designs.

The re-evaluation of fixed capital brought about substantial changes in the distribution of capital by sectors of the rail system, which can be seen from Figure 2 below. The significant increase in the

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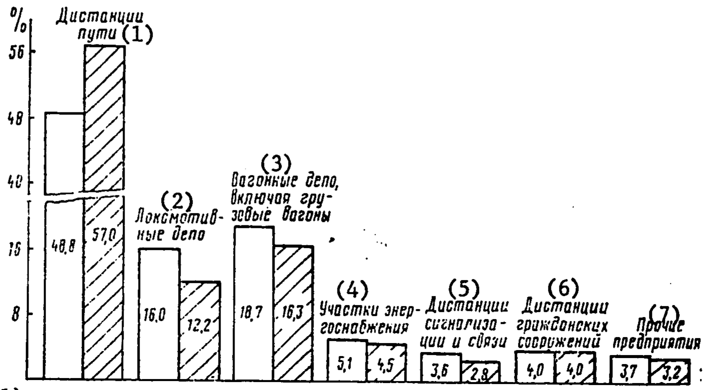
* The currently existing reports do not give a full picture of the distribution of fixed capital by sectors of railroad transportation. Such a distribution, with some level of precision, can be obtained only from the materials of the re-evaluations of fixed capital (for example, based on condition as of 1 January 1960 and 1972) or by special inquiries (for example, on 1 October 1965). In this case the most important sectorial line enterprises are equated with sectors of the railroad system, which is not entirely accurate.

Figure 2. Distribution of Production Fixed Capital by Sectors of the Railroad System Based on Condition as of 1 January 1972 (left-hand column — before re-evaluation; hatchured column — after re-evaluation).



Key:
- (1) Track Units;
- (2) Locomotive Depots;
- (3) Car Depots, including freight cars;
- (4) Power Supply Sections;
- (5) Signal and Communications Units;
- (6) Units of Civil Structures;
- (7) Other Enterprises.

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value of track structures after the re-evaluation led to an increase in the proportion of fixed capital in track units from 48.8 to 57 percent. The share of the fixed capital of other sectorial line enterprises dropped noticeably, although the absolute amount of their fixed capital rose. For example, the share of locomotive depots dropped from 16 to 12.2 percent and that of car depots went from 18.7 to 16.3 percent. This is because after the re-evaluation the value of locomotives and cars, which constitute the largest part of the fixed capital of the locomotive and car systems, rose only a very small amount in connection with obsolescence. The decrease in the share of the fixed capital of signal and communications units and power supply sections was caused in part by a drop in the value of certain types of equipment at these enterprises, chiefly because of obsolescence.

Thus, the decrease in the share of most of the line enterprises in the total fixed capital of railroad transportation is a relative thing and related to a significant increase after the re-evaluation in the value of track structures and production in service buildings.

The distribution of production fixed capital by types and most important sectorial line enterprises of the railroads after the re-evaluation based on condition as of 1 January 1972 is shown below (as percentage of total):

Track Units	57.0
Included in Above:	
Roadbed	12.9
Artificial Structures	9.9
Superstructure	30.4
Track Buildings	0.4
Other Fixed Capital	3.4
Locomotive Depots	12.2
Included in Above:	
Means of Transportation	10.7
Buildings of the Locomotive System	0.7
Equipment and Structures	0.5
Other Fixed Capital	0.3
Car Depots	16.3
Included in Above:	
Means of Transportation	15.2
Buildings of Car Systems	0.6
Equipment and Structures	0.4
Other Fixed Capital	0.1
Power Supply Sections	4.5
Included in Above:	
Catenary System	2.1
Equipment of Traction Substations	0.6
Buildings and Structures	0.6
Other Fixed Capital	1.2
Signal and Communications Units	2.8
Included in Above:	
Overhead and Cable Communication Lines	1.0
Machinery and Equipment	1.6
Other Fixed Capital	0.2
Units of Civil Structures	4.0
Included in Above:	
Structures and Transmission Devices	1.1
Buildings	2.8
Other Fixed Capital	0.1

[Continued on next page]

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Other Railroad Enterprises	3.2
Included in Above:	
Buildings	1.0
Structures and Transmission Devices	1.4
Equipment	0.6
Other Fixed Capital	0.2
All Fixed Capital	100.0

It can be seen that a significant share of the fixed capital of the locomotive and car systems is means of transportation. Deliveries of locomotives and cars to railroad transportation are steadily growing. In the Ninth Five-Year Plan domestic industry produced 7,197 sections of trunk diesel locomotives, 1,799 trunk electric engines, 346,700 mainline freight cars, 10,014 passenger cars, and 7,431 cars for subways. In addition, the USSR railroads received a considerable amount of rolling stock by import from the socialist countries.

Track structures account for the largest share of the fixed capital of the railroads. The three most important elements alone, the roadbed, artificial structures, and superstructure, account for more than 53 percent of all production capital.

In railroad transportation fixed capital is distributed over the following types of activity: shipping; subsidiary activity; housing; municipal services; other road enterprises and organizations. The distribution of the fixed capital of railroads by types of activities on 1 January 1978 is shown below (as percentage of total):

Shipping	87.2
Subsidiary Transportation Enterprises	3.9
Housing System	8.0
Municipal Services	0.4
Other Road Enterprises and Organizations	0.5
Total	100.0

At the present time all production fixed capital of railroad transportation relates to shipping except the fixed capital of subsidiary transportation enterprises and leased fixed capital. The fixed capital of trade and public catering enterprises, line-track buildings, and other objects of fixed capital depreciated on the basis of expenditures for shipping, and the fixed capital of educational, cultural, artistic, public health, and physical training institutions carried on the balances of the railroads and related to support for shipping work are also classified with shipping.

The fixed capital of subsidiary transportation enterprises, leased fixed capital, and the cars of track machine stations being used for housing are classified with subsidiary activity. Subsidiary transportation enterprises include the fixed capital of passenger service offices, motor vehicle pools, track machine stations, materials and fuel storage facilities, service shops, power plants, water supply enterprises, ice supply points, quarries, mechanized accounting factories, and the like.

All residential buildings except line-track buildings and cars of track machine stations used for housing are the fixed capital of the housing system.

The buildings and equipment of the bathhouses, laundries, shower rooms, and other such facilities are classified as the fixed capital of the municipal service system.

The other railroad transportation enterprises and organizations include the fixed capital of the Central Communications Station, labor and wage administrations, computer technology administrations, the paramilitary guard, and the like.

4. Location and Characteristics of the Structure of the Fixed Capital of Railroad Transportation

The location of the fixed capital of railroad transportation differs significantly from the pattern of location of fixed capital of the enterprises of other economic sectors. Whereas industrial fixed capital is concentrated at the sites of industrial enterprises, the fixed capital of the railroads is dispersed throughout the territory of the USSR. It should be observed that the rail network does not cover the territory of our country evenly. It is more dense in the European part. In 1977 the USSR had 6.2 kilometers of railroads per 1,000 square meters of area and 0.5 kilometers per 1,000 inhabitants.

Before the Great October Socialist Revolution virtually the entire rail network of Russia was in the European part of the country. There were very few railroads in the remaining regions. During the years of Soviet power many new rail lines were built in Siberia, the Far East, Kazakhstan, and the Central Asian republics. The construction of railroads was linked with the cultural, industrial, and agricultural development of formerly backward republics and regions.

The structure of production fixed capital varies significantly for the particular railroads, depending largely on the character and volume of jobs done by each road in the shipping process: classifiying cars, loading and unloading, passing transit freight flows through, the extent of passenger traffic, and other factors.

The railroads which do large volumes of transit shipping have more heavy-duty fixed capital linked to the operations necessary to move trains: track superstructure with heavy rails on a gravel base, a significant fleet of heavy-duty train locomotives, sophisticaged signal communications equipment, and the like. The fixed capital of railroads that do large volumes of loading work and operations to form and rearrange trains includes many loading-unloading structures, machines, and mechanisms used for loading and unloading. These roads have highly developed station track and large numbers of freight stations, mechanized and automated classification yards, switch engines, and other fixed capital designated for initial and terminal operations and work on forming and breaking up trains.

The geological, climatic, and meteorological conditions of the regions through which the roads run have a significant effect on the composition and structure of railroad fixed capital. For example, the proportion of buildings and structures that make work possible in severe cold and heavy snow is greater on roads that work in harsh climatic conditions. On roads located in mountainous regions the proportion of the roadbed and artificial structures (railroad tunnels, bridges, and retaining walls) is higher. In the southern regions of the country's buildings of lighter design are built on the railroads and fewer heating units are required.

The structure of the production fixed capital of transportation differs significantly from the structure of the fixed capital of other sectors of the national economy. This is because transportation, as a sector of physical production, has significant differences from all other sectors, above all from industry. The location of transportation routes throughout the country and their operation out of doors require special structures: highways and dirt roads, roadbeds, track superstructure, tunnels, bridges, culverts, and production buildings and equipment to repair and operate various types of machinery and rolling stock in the different forms of transportation. Table 3 below presents a comparison of the structure of the production fixed capital of transportation and other sectors of the USSR national economy as of 1 January 1972 [83, p 64].

It can be seen from Table 3 that the share of structures in transportation is more than double their share in industry and the proportion of machinery and equipment is scarcely one-sixth as much. The enormous share of means of transportation, which accounts for 40.3 percent of fixed capital in transportation, draws attention; in industry this form of fixed capital accounts for just 2.1 percent, while in agriculture it is 4.1, in construction 9.8, and in communications 2.8 percent.

The structure of fixed capital also differs significantly by particular forms of transportation, which is related chiefly to difference in the technology of the shipment process. The railroads convey freight and passengers in cars moved by locomotives along railroad tracks,

Table 3. Structure of Production Fixed Capital of Principal Economic Sectors (percentage of total)

Types of Fixed Capital	All Economic Factors	Included in That: Industry	Agriculture	Construction	Transportation	Communications
Buildings	44.4	30.3	41.7	26.4	7.1	16.9
Structures	16.5	19.5	12.0	11.0	42.0	6.3
Transmission Devices	7.4	11.6	2.2	2.9	3.9	42.5
Machinery and Equipment	20.4	35.8	19.0	47.7	6.2	30.6
Means of Transportation	7.6	2.1	4.1	9.8	40.3	2.8
Other Fixed Capital	3.7	0.7	21.0	2.2	0.5	0.9
Total	100.0	100.0	100.0	100.0	100.0	100.0

while water transportation does its shipping in barges and vessels that travel along maritime and river waterways, motor vehicle transportation travels on vehicular roads, and so on. Table 4 below gives a comparison of the structure of the production fixed capital (considering the re-evaluation) by types of transportation according to condition as of 1 January 1972.

Table 4. Structure of the Production Fixed Capital of Various Forms of Transportation (percentage of of total)

Types of Fixed Capital	All Forms of Transportation	Included in That: Rail	River	Maritime	Motor Vehicle	Air
Buildings	7.1	5.4	2.3	3.2	8.4	8.1
Structure	42.0	58.5	40.3	13.0	69.0	14.3
Transmission Devices	3.9	4.8				1.7
Machinery and Equipment	6.2	4.3	11.4	7.0	3.3	12.6
Means of Transportation	40.3	26.3	45.4	76.6	19.0	62.6
Other Fixed Capital	0.5	0.7	0.6	0.2	0.3	0.7
Total	100.0	100.0	100.0	100.0	100.0	100.0

Note: The fixed capital of motor vehicle transportation includes the value of highways.

As can be seen from this comparison, the share of means of transportation is significantly higher in river, maritime, and air transportation while that of structures is lower than for the railroads. The share of fixed capital in production buildings is higher for motor vehicle, air, and rail transportation.

Chapter III. Development of the Production Fixed Capital of Railroad Transportation

1. Fixed Capital in the Prewar Period and During the Great Patriotic War

The fixed capital of the railroads of Tsarist Russia was very backward technically. The superstructure was particularly weak, usually laid with sand ballast and pine ties, mostly untreated. Light rails of types III a and IV a, weighing an average of 32.9 kilograms per meter, were used for great distances. There were few railroads. In 1913 the total length of the Russian rail network was just 70,990 kilometers. The fixed capital of railroad transportation was estimated at 7,683 million gold rubles [102, p 623].

By the start of the Great October Socialist Revolution the Russian rail network (within current USSR boundaries) had increased slightly to a total length of 71,700 kilometers, of which 15,300 kilometers had double tracks. Inadequate development of station and junction tracks limited the traffic capacity and made the work of the railroads more difficult. Signal and communications equipment was particularly underdeveloped. The principal means of communication during train travel were the electrical staff system, telegraph, and telephone. Only 13 percent of the length of the network had semiautomatic blocking devices.

The railroads also lacked adequate rolling stock, especially on roads belonging to the state. There were 23 steam locomotives, 600 freight cars, and 39 passenger cars per 100 kilometers of length of the railroad network in Russia. At the same time for the same measure England had 45 steam engines, 2,453 freight cars, and 143 passenger cars, while in Germany the figures were 35 steam locomotives, 794 freight cars, and 132 passenger cars [109, pp 227-228].

The inadequate amount of rolling stock was in poor technical condition and poorly used. More than half of the steam locomotives, 17,000 units in 1913, were low-powered series O steam engines. The fleet of freight cars, including about 450,000 units, consisted almost entirely of two-axle cars with capacities of 15-16.5 tons. The average daily run of steam engines in all types of traffic was 119.1 kilometers, while for freight cars it was 72 kilometers. Freight trains had a net weight of 573 tons and a section speed of 13.6 kilometers an hour.

Russian railroad transportation found itself in a particularly difficult situation during World War I. The railroads, which had been seriously neglected, could not handle the shipping work. The percentage of locomotives and cars in poor condition increased severalfold. Only the overthrow of capitalism and nationalization of the railroads saved transportation from ultimate ruin.

Immediately after the Great October Socialist Revolution railroad transportation began to be restored. It was essential for defense of the country, the operation of industry, and maintaining communication between the cities and the countryside. During the period of civil war and struggle against foreign intervention the railroads carried on a large volume of troop shipments and shipments of industrial and agricultural goods, thus helping defeat the enemy rapidly.

The fixed capital of railroad transportation suffered greatly in these years. During the time of World War I and the Civil War 4,332 bridges were destroyed, which was more than 12 percent of the total number, as well as 1,885 kilometers of main tracks, 2,904 switches, 760,000 square meters of buildings and civil structures, and 45,000 kilometers of snow barriers, to say nothing of the destruction of enormous amounts of stocks and equipment [97, p 121].

The railroad fixed capital that survived was badly worn. By the end of 1921 61.6 percent of the steam engines in the fleet of rolling stock were out of order, as were 28.3 percent of the freight cars. The rails on the tracks were 40-50 years old; the ties had been used well beyond their service lives and 30 million new ties needed to be laid [77, p 124].

After the end of the Civil War and defeat of foreign and domestic foes of the Soviet state, the national economy began rebuilding rapidly. Already in 1921 the decree of the Soviet of People's Commissars "On Electrification," which was ratified by the 9th All-Russian Congress of Soviets, laid out a major program for construction of power plants and electrification of heavy-duty trunk rail lines on this basis. "To establish the most rational links between the chief industrial regions of the RSFSR," the decree said, "it is essential to do the following: a) gradually prepare for and convert the following rail lines to trunk mainlines with subsequent electrification: Petrograd — Moscow — Kursk — Donets Basin — Mariupol' (through Khar'kov or Kupyansk), Krivoy Rog — Aleksandrovsk — Chaplino — Debal'tsevo — Likhaya — Tsaritsyn, and Moscow — Nizhniy Novgorod with later continuation to the Urals and Siberia" [7, pp 29-0291]. Thus, from the first years of Soviet power electrification of the railroads was adopted as the leading element in reconstruction of railroad transportation.

By 1926 the fixed capital of the railroads was almost completely restored and the volume of shipping exceeded the 1913 level.

The reconstruction period in transportation continued until 1928. Between 1918 and 1928 (without the fourth quarter of 1928) the volume of capital investment in railroad transportation was 389 million rubles or 8.8 percent of all capital investment in the national economy [82, 352]. This money went for new railroad construction, laying second tracks, and reconstruction of railroads. During the years of the Civil War and in the period of reconstruction a total of almost 7,000 kilomters of new road was built.

During the First Five-Year Plan the USSR national economy developed rapidly and transportation was greatly strained to perform its shipping work because the reconstruction of transportation lagged behind the general rate of development of other sectors of the economy.

The decisions of the June 1931 Plenum of the Central Committee of the All-Union Communist Party (Bolshevik) were very important for improving the work of railroad transportation. The Plenum ratified the basic directions of railroad reconstruction "in the direction of electrification of railroads, introduction of heavy-duty rolling stock (steam, electric, and diesel locomotives), 50-60-ton cars, automatic coupling, automatic brakes, automatic blocking, reconstruction of the superstructure of the track, reequipping traction devices, water supply, communications, mechanization of loading-unloading work, and so on" [6, p 534].

In July 1932 the first all-Union conference on reconstruction of railroad transportation, which was not meeting the heightened demands made of it, was called [103]. This conference focused great attention on the most efficient combination of work by different forms of transportation, improving the methodology of planning shipping, reconstruction and rationalization of the entire transportation network, redesigning traction and the fleet of cars, the developmental prospects of locomotive and car building, and providing qualified workers for the entire rail network. The major steps laid out by the conference toward technical reconstruction of the railroads demanded additional capital investment. For this reason capital investment in railroad transportation in the Second Five-Year Plan was increased 2.5 times over the First Five-Year Plan.

The timely steps that were taken made it possible to straighten out the work of transportation and overcome the lag in its development. The railroads improved their work significantly during the Second Five-Year Plan. In 1931 the average daily run of a steam locomotive was 101.5 kilometers; in 1936 it had been raised to 233 kilometers. Car turnaround time was reduced in the same period from nine to 6.7 days. Labor productivity rose 23.7 percent. The growth in shipping in 1936 alone equalled the freight work of railroad transportation for all of prerevolutionary Russia. In May and June of 1937 the workload in the rail network reached 95,000-100,000 cars a day.

A significant part (roughly 45 percent) of the capital investment in railroad transportation in the Second Five-Year Plan went for the construction of new railroads and second tracks and purchase and modernization of rolling stock. During these years roads such as the Sverdlovsk — Kurgan, Vyaz'ma — Bryansk, Ob' — Proyektnaya, Lokot' — Ridder, Dema — Ishimbayevo, and others which were very important for industrial development were built.

As a result of the significant capital investment made during the period of reconstruction and the first three five-year plans before the beginning of the Great Patriotic War, railroad transportation developed substantially and was well-equipped with domestically produced machinery. Its fixed capital increased almost 2.5 times during these years with a 6.5-fold increase in freight traffic. By 1 January 1941 the operating length of the general-use rail network had reached 106,100 kilometers, an increase of 34,400 kilometers over 1917. The length of double-track lines was 28,500 kilometers [36, p 12]. The production fixed capital of railroad transportation grew to 11.5 billion rubles.

The technical equipment of the railroads improved markedly and their traffic capacity rose as the result of the steps that were taken. Large quantities of new rails and treated ties were laid down and the number of switches set on gravel ballast increased. A number of lines in very mountainous country were switched to electrical traction. The total length of electrified railroads on 1 January 1941 was 1,870 kilometers. The length of roads equipped with automatic blocking increased to 8,400 kilometers. Many freight and classification stations were built and a significant share of the classification yards were mechanized.

During the years of the prewar five-year plans the fixed capital of the railroads was significantly replenished with new rolling stock. The locomotive fleet increased to 11,900 steam locomotives, composed chiefly of series FD, IS, and SO engines. The fleet of cars increased by more than 284,000 freight cars, including 166,900 four-axle cars, and by 11,100 passenger cars. During this time 13,400 kilometers of new rail lines and 9,100 kilometers of second tracks were built [69, p 51].

Railroad transportation carried an enormous burden during the Great Patriotic War. The work of the railroads was enormously important in preparation for and conduct of the military operations of the Red Army to drive the German fascist aggressors out of our native land. But even during this difficult time for our country technical development of the railroads continued. The traffic capacity of the Ural railroads and of the most important rail junctions (Chelyabinsk, Sverdlovsk, Tagil', Novosibirsk, and Kirov) was bolstered and a number of new lines were built along the Volga and in the eastern and northern regions of the country [19]. During the war years a total of about 10,000 kilometers of new railroad was put into operation. Between 1 July 1941 and 1 January 1946 2,379 million rubles was invested in railroad transportation, which was 11.6 percent of all capital investment in the USSR national economy in this period [82, p 353].

The availability of qualified workers and the high technical level of equipment enabled USSR railroad transportation to perform an enormous volume of troop and evacuation shipping during the Great Patriotic War in addition to freight shipments for industry and agriculture. In jus~ the first three months after the start of the war more than 1,360 large enterprises, primarily defense enterprises, were evacuated to the East. This required almost 1.5 million railroad cars [40, p 232]. During the war railroad transportation shipped more than 9.9 million cars carrying military cargo.

Railroad transportation also performed an enormous amount of work in mobilizing the Red Army and moving it to the front and in supplying the troops with ammunition and food. In addition to shipping to supply the army, railroad transportation carried out tactical and strategic movements of military units throughout the war to insure the necessary troop mobility, concentrate troops in attack regions, bring up essential reserves, and the like. During the war 9.8 million cars carrying troops were delivered. The railroad lines near the front worked under extraordinarily difficult wartime conditions.

The fixed capital of railroad transportation suffered enormous losses during the Great Patriotic War. Of the 44 railroads that existed at that time 26 were completely knocked out and eight were badly damaged. The enemy destroyed 65,000 kilometers of track and 500,000 kilometers of wire communications lines, in addition to 13,000 bridges with a total length of about 300 kilometers, 4,100 railway stations, 317 steam locomotive depots, 129 steam locomotive and car repair plants, dozens of railroad machine building plants, 1,200 pumping plants, 1,600 water towers, and 3,200 water columns. The enemy destroyed, damaged, and carried off 15,800 steam locomotives and small diesel switch engines and 428,000 cars [62, pp 4-5].

As the territory seized by the enemy was liberated, the fixed capital of the railroads was rapidly rebuilt, which was enormously important to maintain the high rate of offensive operations by the Soviet Army. The cost of rebuilding ruined structures was about 30 percent of the value of the permanent installations of railroad transportation that existed on the eve of the war [88, p 251].

Reconstruction work went forward with exceptional speed. For example, the average rate of railroad reconstruction in the Smolensk — Orsha — Minsk — Baranovichi — Brest — Lukow — Siedice — Warsaw sector was 16.5 kilometers a day and in the Gomel' — Zhlobin — Osipovichi — Molodechno — Vil'nyus — Kayshadoris — Shyaulyay — Yelgava sector it was 14.6 kilometers a day [69, p 302].

During the war years the personnel of formations of the Main Administration of War Reconstruction Work and other construction organizations of the People's Commissariat of Railroads rebuilt 83,800 kilometers of trunk lines (31,900 kilometers in the territory of foreign countries) and 24,400 kilometers of station tracks, 190 steam locomotive depots, 61,700 switches, 2,734 large bridges with a total length of 230 kilometers, more than 2,300 water supply points, more than 719,000 kilometers of communications lines, and more [68, p 296].

2. Fixed Capital in the Years of the Postwar Five-Year Plans

During the postwar years replacement of the fixed capital of railroad transportation took on large scope. One of the principal challenges of the Fourth Five-Year Plan (1946-1950) was to "insure priority restoration and development of heavy industry and railroad transportation, without which rapid and successful restoration and development of the entire USSR national economy is impossible" [8, p 250].

Large amounts of capital were appropriated for restoration and continued development of railroad transportation to meet this challenge. The total sum of capital investment in railroad transportation grew steadily from five-year plan to five-year plan. If all capital investment in railroad transportation in the Fourth Five-Year Plan (the first after the war) is taken as 100 percent, the investment figure in comparable prices for subsequent five-year plans would be 121.6 percent in the Fifth, 157.9 in the Sixth, 216.7 in the Seventh, 263.4 in the Eighth, and 351.2 percent in the Ninth Five-Year Plan.*

The fixed capital of railroad transportation was almost completely restored as the result of successful fulfillment of the Fourth Five-Year Plan. The operating length of railroads was 116,900 kilometers, which included 26,000 kilometers of double-track lines [36, p 14].

Fixed capital developed significantly in subsequent five-year plans, during which 18,500 kilometers of new road and 17,800 kilometers of second tracks were built, 34,900 kilometers of lines were electrified, and 48,400 kilometers of rail lines were equipped with automatic blocking and centralized dispatching. A large number of switches were equipped with electrical centralization.

The technical condition of the fixed capital of the track system was improved. Railroad transportation received large quantities of new rails and the length of track laid with heavy rails increased severalfold. Railroad rolling stock was replenished with new types of

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* Calculated from figures published in the statistical yearbook "Narodnoye Khozyaystvo SSSR v 1975 g." [The USSR National Economy in 1975], Moscow, Statistika, 1976, pp 503-507.

locomotives and cars. The sector received new types of four-axle cars and gondolas and special trains with mechanical cooling to transport perishable freight.

By the end of 1975 the fixed capital of railroad transportation was 2.5 times that of 1950. Figure 3 below shows the introduction of new railroads and second tracks and electrification of systems.

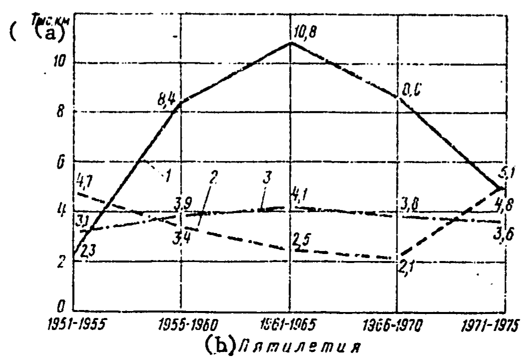


Figure 3. Construction and Electrification of Railroads in the Period 1951-1975.

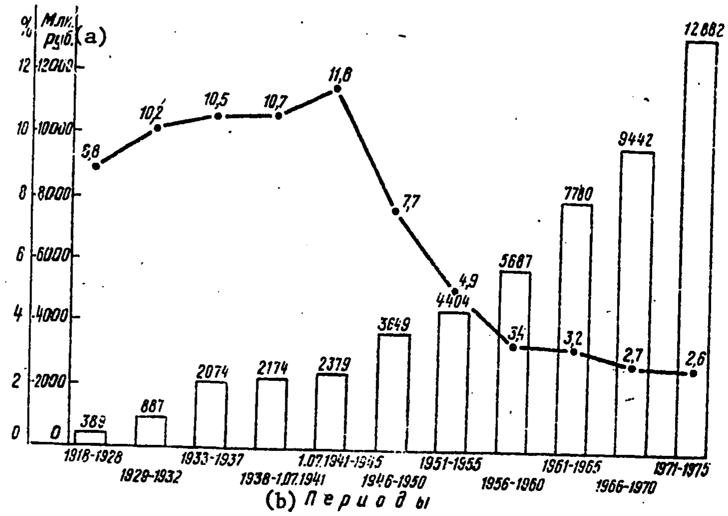
Key: (1) Electrified Lines;
(2) Second Tracks;
(3) New Lines;
(a) Thousands of Kilometers;
(b) Five-Year Plans.

The fixed capital of railroad transportation developed especially fast during the Ninth Five-Year Plan. In this time 14,700 kilometers of road was equipped with automatic blocking and centralized dispatching and 43,500 switches were outfitted with electrical centralization. The railroads received more than 2,000 electric locomotives, 5,500 sections of mainline and 2,500 switch diesel engines, 373,600 freight cars, and 15,300 passenger cars; 3,600 kilometers of new roads and 5,100 kilometers of second tracks were built and put into operation and 4,800 kilometers were electrified [81].

Despite large-scale development of the material-technical base of railroad transportation, the planned volumes of increase in fixed capital in physical terms were not entirely fulfilled. Figure 4 below shows that, although a large amount of capital investment was directed to the development of railroad transportation, its share of total capital investment in the national economy has dropped steadily.

The relative decrease in the proportion of capital investment in railroad transportation has led to a decrease in its share of the production fixed capital of the national economy (see Figure 5 below).

Figure 4. Growth of Capital Investment in Railroad Transportation (in millions of rubles) and Its Share of all Capital Investment in the USSR National Economy (in percentage)



Key: (a) Millions of Rubles;
(b) Periods.

This illustrates the change in the proportion of development of the material-technical base of railroad transportation and other sectors of the national economy, in particular industry.

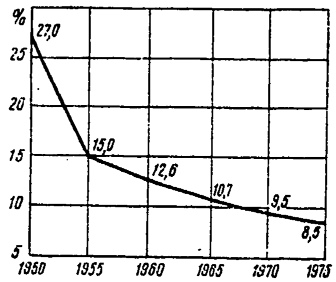


Figure 5. **Share of Railroad** Transportation in USSR Production Fixed Capital

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The problem of establishing economically substantiated optimal proportions between the development of transportation, including railroads, and other sectors of the national economy requires special study. The significant decrease in the share of railroad transportation in total capital investment and production fixed capital of the national economy has been reflected in a decrease in the reserves of traffic and carrying capacities of the railroads and has created difficulties in taking on steadily growing shipping volumes.

The inadequacy of capital investment in transportation and other sectors of the production service sphere was noted by General Secretary of the CPSU Central Committee Comrade L. I. Brezhnev at the 25th CPSU Congress: "It cannot be ignored," L. I. Brezhnev said, " that in the upcoming period we will have to allocate more resources for accelerated development of transportation, communications, and the material supply system, everything that goes by the name of the infrastructure. In the past we have simply failed to give proper attention to many sectors in this sphere, in particular road construction and storage facilities. Now it is time for us to work on this, and work hard" [5, p 44].

The high rate of national economic development in the 10th Five-Year Plan (1976-1980) makes heightened demands on the sectors that serve production, above all transportation. Especially great demands are being made of railroad transportation, whose freight and passenger traffic continues to grow rapidly.

To handle the growing volume of shipping in the 10th Five-Year Plan it will be necessary to build up the traffic and carrying capacity of the railroads, increase the speed of travel of freight and passenger trains, enlarge the volume of shipping by unit trains, and improve the qualitative indicators of rolling stock use.

The document "Basic Directions of Development of the USSR National Economy in 1976-1980" laid out the task of "insuring a further increase in the carrying and traffic capacity of the railroads in busy freight sectors, an increase in the processing capacity of classification yards and freight stations, and a reduction in the turnaround time of freight cars" [5, p 208]. Further development of the material-technical base of railroad transportation and a significant expansion and renovation of its fixed capital are envisioned.

Railroad transportation is receiving new, improved machinery that makes it possible to perform large volumes of passenger and freight conveyance at high speed and more economically. During the 10th Five-Year Plan production should begin on: two-section mainline 8,000-horsepower diesel freight engines and 6,000-horsepower diesel passenger engine sections, eight-axle gondola and tank cars with capacities up to 125 tons, specialized cars for shipping grain, flour, mineral fertilizer, and other output, and new, highly productive equipment for construction and repair of railroad track" [5, p 186]. The length of new railroads, second tracks and electrified lines, and roads equipped with automatic blocking and centralized dispatching will increase significantly. The number of switches and signals equipped with electrical centralization will rise. Facilities for repair of locomotives, cars, and track machinery will be strengthened, and the equipment of locomotive and car depots engaged in repairing rolling stock will be replaced.

The track will be significantly reinforced both by laying new rails, for the most part thermally hardened, and by broad introduction of new track designs. By 1980 64,000 kilometers of road should have reinforced concrete ties, and 60,000 kilometers will have unjointed track [81, p 32].

Total capital investment in production facilities for railroad transportation in the 10th Five-Year Plan will be more than 17 billion rubles [81, p 25]. Production fixed capital will grow significantly as the result of substantial capital investment. According to calculations the amount of fixed capital will increase roughly 21.5 percent during the 10th Five-Year Plan.

3. The Relationship Between Transportation and Other Sectors of the National Economy

It is important to maintain the essential level of development of transportation for successful work by enterprises of all sectors of the economy. This means that to insure the planned dimensions of production transportation must be developed so that it is able to perform the necessary volume of shipping of raw materials, fuel, processed materials, semifinished products, and equipment from their points of production to their points of consumption. The amount of output shipped by each sector depends on what part of output is consumed on the spot and what must be shipped. The shipping coefficient, which is the ratio of output shipped to output produced, characterizes the proportion between the production and shipping volume of the particular output. Table 5 below gives the shipping coefficients for the output of sectors of the national economy in 1975 [115, p 96].

Table 5. Shipping Coefficients of the Most Important Types of Output

Output	Shipping Coefficient, %
Hard Coal	102
Petroleum	79
Iron Ore	99
Cement	80
Peat	48
Coke	42
Ferrous Metals	67
Salt	126
Sugar	110
Sugar Beets	33

The total volume of shipping also depends on the rate of growth in production of particular types of output of sectors of the national economy which determine the structure of output. When production of output with a high shipping coefficient grows more rapidly the volume of shipping increases faster than the production of all output.

In addition, the volume of shipping is affected by changes that take place in the location of the enterprises in sectors of physical production. The average length of freight shipment depends on where they are located. The more rationally productive forces are sited, that is to say the closer enterprises are put to sources of raw material, fuel, processed materials, and points of consumption, the smaller the volume of transportation work per unit of finished output will be. The average length of a freight shipment is gradually increasing. Relative to 1940, the average length was 114 percent in 1960, 125 percent in 1970, and 128 percent in 1975. To a significant degree, however, this growth is caused not by long irrational shipments by rather by changes that have taken place in the location of production in the country and its development in remote regions.

Evening out the levels of development of the productive forces of all the republics and economic regions of the country and their specialization and comprehensive development led to a deepening of the division of labor and intensified production and economic ties among them. As a result of this, the volume of shipping between republics and regions is steadily growing.

The construction of new and reconstruction of existing enterprises underway today cannot be carried on without considering the capacities of existing types of transportation and prospects for their development. Enterprises planned for construction require substantiation of the availability of labor, raw materials, fuel, energy, and transportation. The question of whether these enterprises should be built is decided on the basis of such substantiation.

For its part, transportation develops from the necessity to provide for the shipping needs of enterprises in all sectors of the national economy and the needs of the population. The pioneering role of transportation development in regions that are not yet fully developed in the industrial and agricultural senses should be emphasized. As a rule the construction of new railroads and vehicular roads precedes the beginning of construction on enterprises and development of new regions. A vivid example of this is construction of the Baikal-Amur Mainline, which has as its purpose the development of an enormous region rich in many types of mineral products.

Thus, it is very important for successful development of the national economy to observe and maintain, on a planned basis, the essential proportions between development of transportation and development of all other sectors of physical production. These proportions take shape under the influence of the volume of shipping presented for transportation and depend on the scope and structure of production, its location, and future changes in the consumption of raw and processed materials, fuel, and finished output.

Scientific-technical progress exercises an important influence on the proportionality of development of transportation and other sectors of the economy. It brings about the formation of new sectors of production, increases the dynamic quality of the sectorial structure, and demands constant adjustments in the location of enterprises of various sectors.

In transportation scientific-technical progress exercises a significant influence on handling growing volumes of shipping, the quality of the work, and related expenditures. It creates the necessary prerequisites for establishing more healthy and less arduous working conditions and promotes an increase in the level of technical sophistication and qualifications of transportation workers.

The fixed capital of transportation is also developed on the basis of scientific-technical progress directed to the introduction of new machinery and improved technological processes in the organization of shipping. Acceleration of scientific-technical progress, replacement of obsolete machinery with new machinery, growth in traveling speeds, increase in the use efficiency of means of transportation, machinery, and equipment, and a faster rate of replacement of this equipment are factors that increase the capacities of the fixed capital of transportation.

The introduction of new fixed capital in transportation has a significant effect on intersectorial proportions and the territorial structure of production. The fixed capital necessary to replace old machinery with new, to modernize and reconstruct existing communications lines and build new ones, to mechanize loading and unloading work, to automate the switching process, and to renovate the technical base of repair enterprises must be supplied by industry. Railroad transportation is a major consumer of the output of almost all industrial sectors. It consumes a significant part of the output of transportation machine building, rail plants, and plants producing reinforced concrete and metal design components. Each year more than 1.5 million tons of rails, about 500,000 tons of rail fastenings, 9 million cubic meters of timber, 600,000 tons of cement, and large amounts of various types of energy and mechanical equipment are delivered to railroad transportation.

Each year the railroads receive from domestic industry thousands of freight and passenger cars, locomotives, and various machines necessary to carry out shipping and repair fixed capital. In 1977 alone, the country produced 1,344 sections of mainline diesel locomotives with a total capacity of 3.7 million horsepower, 423 mainline electric locomotives with a total capacity of 3.3 million horsepower, 71,200 mainline freight cars and 2,110 passenger cars, and 286 subway cars [82, p 166]. Almost all of this rolling stock was delivered to USSR railroad transportation.

Thus, railroad transportation must have sufficient capacity so that it can satisfy national economic needs for shipping fully and at the proper time with minimum expenditures of time and labor. To accomplish this the fixed capital of railroad transportation must be developed in an appropriate manner, and its needs for rolling stock, rolled ferrous and nonferrous metals, fuel, and electricity must be fully met by industrial and construction enterprises and organizations of the national economy.

Chapter IV. Reproduction of Fixed Capital and Technical Equipping of Railroads

1. Growth and Renovation of Fixed Capital

Fixed capital is the most important part of the mat rial-technical base of society. Its development and scale largely define the level of this base. Enormous sums are spent to create and improve fixed capital. Total capital investment in the USSR national economy from 1918 to 1977 surpassed 1,703 billion rubles. In the Ninth Five-Year Plan 493 billion rubles was invested in all sectors of the national economy, which was 41.7 percent more than in the Eighth Five-Year Plan. In the 10th Five-Year Plan it is expected that more than 621 billion rubles will be invested in development of the country's economy.

As a result of the significant capital investment fixed capital in the national economy is growing rapidly. Between 1918 and 1977 a total of 1,571.5 billion rubles of fixed capital was put into use. By the end of 1977 the total magnitude of fixed capital reached 1,438 billion rubles, which included 934 billion rubles of production fixed capital. The value of all fixed capital increased 29 times over 1913, while the value of production fixed capital rose 34 times [82, pp 40-41].

The fixed capital of railroad transportation has also grown enormously. Between 1918 and 1977 58.0 billion rubles was invested in it, including 12.9 billion rubles in the Ninth Five-Year Plan [82, p 353]. The total value of the production fixed capital of railroad transportation at the end of 1977 was 70.1 billion rubles, which was 7.5 percent of all the production fixed capital of the USSR economy.

Scientific-technical progress and accelerated development of the sectors of machine building and construction which provide enterprises of the national economy with new machinery and equipment, structures, and devices that promote growth in the productivity of public labor and reduce expenditures for the manufacture of output are playing a growing role in expanded reproduction of production fixed capital. Scientific-technical progress begins with the improvement of implements of labor and is determined in large part by the number and quality of new types of machinery, equipment, and means of transportation produced by industry. Thanks to scientific-technical progress the fixed capital of railroad transportation is being steadily renewed.

New technology in all sectors of the national economy, railroad transportation included, is introduced on the basis of electrification. On railroads electricity provides the basis from which broad application of modern automated, remote control, cybernetic, and radio devices proceeds. These are devices that make it possible to automate the switching process and make the labor of railroad workers more productive and at the same time easier and less exhausting.

The equipping of enterprises of the national economy with new, improved production fixed capital depends significantly on the rate of scientific-technical progress. In the Ninth Five-Year Plan the share of such fixed capital in all production fixed capital rose to 43 percent, while in railroad transportation it increased to 20 percent.

The following figures show the increase in technical equipment available per kilometer of operating rail lines (in comparable prices):

Year	Rubles	Percentage
1960	281,500	100.0
1965	332,000	117.9
1970	383,000	136.1
1975	458,000	162.7
1977	501,600	178.2

The high rate of growth of public production in the USSR is linked to constant renewal and increase in fixed capital. The growth and renovation of fixed capital is an important part of expanded socialist reproduction and significantly influences the production activities of enterprises of the national economy. In railroad transportation the quality of transportation output and the profitability of railroad work depend on the dimensions and technical level of production fixed capital.

Expanded reproduction of the production fixed capital of railroad transportation is essential for it to perform the growing volume of shipping required. This must be done on a planned basis, with an eye to achieving highly efficient use of all fixed capital.

The problem of reproduction of the fixed capital of railroad transportation is related to the process of its circulation. As time passes fixed capital wears out and is withdrawn from operations as the result of its use in shipping and owing to the effects of the natural environment. To insure continuity in the shipping process fixed capital that is withdrawn must be replaced by new capital at the proper time. In addition, capital repair and modernization of fixed capital must be carried out on time so that operating fixed capital can serve out its stipulated service life; in other words, there must be partial compensation for the wear on fixed capital. Finally, the growth of shipping usually demands development and strengthening of the fixed capital of railroad transportation.

Expanded reproduction of fixed capital may be accomplished either extensively, that is, by building new railroad systems and equipping them with the necessary amounts of rolling stock and equipment, or intensively, that is, by intensifying the use of operating fixed capital by expansion, reconstruction, and modernization of this capital on a new technical base.

Under contemporary conditions of accelerated technical progress, the reproduction of fixed capital in railroad transportation is intensive. Fixed capital is continuously being renovated and replaced by new, improved, highly productive and economical locomotives, cars, machines, and equipment. New machinery is delivered that makes it possible to fully mechanize production processes and automate them more completely.

Expanded reproduction of the fixed capital of railroad transportation has a significant impact on the efficiency of its use. Newly introduced fixed capital, even though it is often very expensive, provides greater carrying and traffic capacity for the roads, better operating and technical indicators, and as a result of this, growth in labor productivity and the capital-output ratio. Expanded reproduction of fixed capital by technical reconstruction and modernization is especially efficient; these processes reduce obsolescence and prolong the service life of fixed capital while increasing its productivity and use efficiency. In this case it is possible to obtain significant growth in labor productivity, begin handling larger volumes of freight and passenger traffic, and therefore significantly increase the capital-output ratio in railroad transportation with less capital investment.

Technical reconstruction and modernization of the fixed capital of railroads is also very important for its socioeconomic impact, which involves improving and easing the working conditions of the workers, raising the qualifications level, reducing the proportion of manual labor, and so on.

In 1977 capital investment for technical reconstruction and expansion of railroad transportation structures accounted for more than 60 percent of all capital used for capital construction.

The reproduction of fixed capital is characterized by the coefficients of introduction and withdrawal.

The coefficient of introduction of fixed capital K_{BB} is determined according to the following formula (in percentage)

$$K_{BB} = (\Phi_H/\Phi_{Cr})100, \qquad (2)$$

where Φ_H is introduction of new fixed capital during the year; Φ_{Cr} is the average annual cost of operating fixed capital.

The coefficient of withdrawal of fixed capital K_{B6} is calculated by this formula (in percentage)

$$K_B = (\Phi_{B6}/\Phi_{C\Gamma})100, \quad (3)$$

where Φ_{B6} is the withdrawal of fixed capital during the year.

The change in coefficients of introduction and withdrawal of production fixed capital of railroad transportation during the years of the Ninth Five-Year Plan is shown below (in percentage):

Year	K_{BB}	K_{B6}
1971	4.33	0.75
1972	5.04	0.46
1973	4.57	0.61
1974	4.48	0.54
1975	4.54	0.61

It can be seen from these figures that in an average year 4.5 percent of the operating fixed capital was launched in operation and 0.6 percent was withdrawn.

The ratio of the coefficients of withdrawal and introduction shows the proportion of new fixed capital going for simple reproduction of fixed capital. The coefficient of replacement K_3 which characterizes this proportion is determined according to the following formula.

$$K_3 = K_B / K_{BB} \quad (4)$$

Unlike the coefficient of replacement, the coefficient of growth in fixed capital K_{Π} shows that part of fixed capital that goes for expanded reproduction. It is found from the formula

$$K_{\Pi} = 1-K_3, \quad (5)$$

According to calculations, 12.2 percent of all newly introduced fixed capital in railroad transportation in 1977 went for simple reproduction of fixed capital withdrawn during the year. The remaining 87.8 percent of new capital went for expanded reproduction of fixed capital. Between 1961 and 1977 the growth of production fixed capital in railroad transportation was 46 percent, including 71 percent for means of transportation, 82 percent for machinery and equipment, and 26 percent for permanent structures and transmission devices.

To raise the indicator of the capital-output ratio it is essential that newly introduced fixed capital on railroads afford higher labor productivity and better economic indicators for shipment than operating fixed capital.

National income is the most important source of capital investment for expansion and renovation of fixed capital in all sectors of the national economy. In 1975, from USSR national income of 362.4 billion rubles, 61.2 billion rubles or 16.9 percent was appropriated for growth in fixed capital. Of this amount 38.8 billion rubles or 10.7 percent was allocated for growth in production fixed capital [85, pp 565, 566).

Depreciation deductions for full reproduction of fixed capital are a major source for financing capital investment. These deductions are designated to replace wornout and obsolete fixed capital with new, technically improved and more productive capital.

Depreciation deductions are designed for simple reproduction of fixed capital. Under conditions of large-scale production, however, the depreciation fund, which is part of the value of fixed capital converted into money, is very large and "may serve to expand the enterprise or carry out modifications in machinery that will raise its efficiency" [1, Vol 24, p 193].

The amounts of fixed capital in the sectors of the USSR national economy are very large and this makes it possible to use depreciation, figured on full replacement, for expanded reproduction of fixed capital.

The share of depreciation deductions designated for replacement of withdrawn fixed capital in total capital investment used for development of the national economy was 18.5 percent in 1965, 20.0 percent in 1970, and 28.4 percent in 1975;* in other words, it rose more than 50 percent in one decade. The remaining capital investment (almost 72 percent) was financed through socialist savings, which represents a high rate of growth in fixed capital. If all production fixed capital in 1965 is taken as 100 percent, in 1970 it was 148 percent, in 1975 225 percent, and in 1977 260 percent (in comparable 1967 prices).

Reproduction of the production fixed capital of railroad transportation is carried on through capital investments allocated for the construction of railroad buildings and structures and purchase of rolling stock, machines, and equipment. Money from the state budget, depreciation deductions for full replacement of fixed capital, and deductions from profit are the sources for financing capital investment. In 1977 state budget capital accounted for 18.9 percent

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* Calculated from figures published in the statistical yearbook "Narodnoye Khozyaystvo SSSR v 1975 g." [The USSR National Economy in 1977], Moscow, Statistika, 1978, pp 348, 558.

of the total sum of capital investment in the development of railroad transportation and the remaining 81.1 percent was the capital of the Ministry of Railroads and bank credit; 41.0 percent was deductions from profit made through railroad shipping activities. The share of depreciation deductions for full replacement of fixed capital in capital investment in railroad transportation was 29.9 percent in 1965, 29.5 percent in 1970, 39.6 percent in 1975, and 40.4 percent in 1977.

Therefore, the development and technical reconstruction of railroad transportation is being accomplished primarily through socialist savings. At the same time, the significant role of depreciation deductions in capital investment illustrates that they are an important source for renewal of the operating fixed capital of the railroads.

2. Scientific-Technical Progress and Qualitative Changes in the Fixed Capital of Railroad Transportation

The efficiency of the work of railroad transportation depends to a significant degree on the technical equipment of the railroads. When the railrods have more sophisticated fixed capital their carrying and traffic capacity will be greater, labor productivity of the employees will be higher, and the prime cost of shipping will be lower.

A major program is now underway to accomplish a qualitative change in the fixed capital of railroad transportation based on scientific-technical progress. The introduction of new machinery in all sectors of the rail system aims at moving freight and passengers with maximum national economic efficiency. In 1977 the freight traffic of USSR railroad transportation was more than double the figure for 1960 and almost triple the freight traffic performed by railroads in the United States. Our railroads also handle a large volume of passenger traffic. Considerable future growth in freight and passenger traffic is expected. This will require not only construction of new railroads and second tracks to expand and rationalize the existing network of lines, but also and primarily a significant increase in the intensity of use of already existing fixed capital.

Among the notable new lines planned for construction in the 10th Five-Year Plan are the Uritskoye — Kustanay line which will complete construction of the Central Siberian Mainline that links the regions of Siberia and the Far East with the Urals and the European part of the SSR and the Surgut-Nizhnevartovsk and Synya — Usinsk lines, among others.

Construction of the Baikal-Amur Mainline is continuing. This road "will cut through the ancient Taiga, crossing a region of enormous wealth that must be put into the service of our country. In this land a major new industrial region will be developed and new cities and communities will be built."* The 220-kilometer Tynda — Berkakit line will go into operation at the end of the 10th Five-Year Plan. It is a continuation of the Bam — Tynda line which was turned over for permanent operation in 1977.

By the end of the five-year plan the total length of railroads will be about 142,000 kilometers.

The existing railroad system is also being intensified by laying second tracks and double-track inserts, lengthening station tracks and developing classification tracks, and reconstructing stations.

A great deal of work is being done to improve the design of the track. The superstructure is being strengthened by laying gravel and crushed rock ballast, reinforced concrete ties, heavy rails, and improved types of fastenings and switches. More thermally hardened rails are being laid. They have now been put down on almost 40,000 kilometers of tracks. Experience shows that their service life is 50 percent greater than unhardened rails. This reduces the metal requirement in railroad transportation and expenditures for track repair.

Laying heavy rails on a crushed rock and gravel base increases the capacity of the road, which makes it possible for heavy trains to pass at high speed. New types of fastening, rail anchors, and crosspieces insure track strength and traffic safety. Laying unjointed track, which reduces fuel and energy expenditures as well as expenditures for repair of rolling stock and the track superstructure, is especially important. At the present time unjointed tracks has been laid on more than 44,000 kilometers of the system.

The increase in track capacity is characterized to a significant extent by the greater average weight of one meter of rails. This figure was 49.7 kilograms in 1964, 53.1 in 1970, and about 55.6 kilograms in 1975 [12, 22].

The introduction of progressive types of traction, electric and diesel, plays an important part in increasing the carrying and traffic capacity of the railroads and improving their work efficiency. Electrification is the foundation of technical progress. V. I. Lenin emphasized the enormous importance of electrification many times. As long ago as 1920 he said, "We must have a new technical base for new

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* Brezhnev, L. I., "O Kommunisticheskom Vospitanii Trudyashchikhsya. Rechi i Stat'i" [Communist Indoctrination of the Workers. Speeches and Articles], Moscow, Politizdat, 1974, p 530.

economic building. This new base is electricity. We will have to build everything on this base." [2, Vol. 40, p 108].

By 1978 40,500 kilometers of railroads used electric traction, which was 29 percent of the entire operating length of the rail system [82, p 112]. In the 10th Five-Year Plan a number of other important rail sectors are to be switched to electric traction. Electrification of segments of the Transsiberian Railroad from Bira to Khabarovsk and from Bira to Arkhara will be continued. Other segments that are being electrified are the Vyaz'ma — Orsha, Orsk — Orenburg, Derbent — Makhachkala — Guderems, Kamen'-na-Obi — Srednesibirskaya, Tyumen' — Sverdlovsk, Tselinograd — Ekibastuz, and others. The total length of electrified lines in 1980 will be 43,400 kilometers, or 31 percent of the total operating length of the system [81, p 26].

In 1977 more than half of all freight traffic in railroad transportation was moved by electric traction. The freight intensity on electrified lines was 43.8 million ton-kilometers net/kilometers with an average freight intensity for the entire system of 24.0.

Along with electrification work is going forward to install cable communications lines, construct automatic blocking systems, introduce electrical centralization of switches and signals, and rearrange and lengthen station tracks. The transition of the railroads to electric traction promotes the electrification of industry and agriculture in adjacent regions. In 1975 alone, the delivery of electricity to non-transportation customers from tracks and substations of the railroads was 18.2 billion kilowatt-hours.

At the present time, electric traction is used on many long sectors of the system: Moscow — Novosibirsk — Irkutsk — Karymskaya (6,400 kilometers), Moscow — Gor'kiy — Sverdlovsk — Kurgan (2,100 kilometers), Leningrad — Moscow — Rostov — Tbilisi — Yerevan (3,500 kilometers), Moscow — Kiev — L'vov — Chop (1,700 kilometers), Moscow — Simferopol' (1,500 kilometers), and others.

As electrification of the railroads proceeds industrial-frequency alternating current is used more and more. Alternating current was first used in electrification of railroads in 1955, and by the beginning of 1977 15,100 kilometers of electrified road or 38.1 percent of the total length (39,600 kilometers) was being operated by this progressive current system.

The use of alternating current reduces capital investment in electrification of railroads and decreases the need for nonferrous metals. In addition, an industrial frequency AC system has unquestioned advantages with respect to such indicators as labor productivity, prime cost of shipping, carrying and traffic capacity of the roads, and others. AC electrification provides conditions for building improved electrical engines and trains.

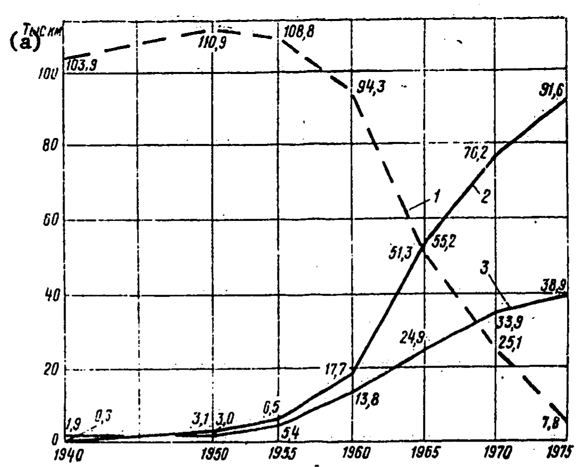
A major reserve for raising the efficiency of electric traction is eliminating points where segments with different current systems join. Given the growing freight traffic intensity on the railroads it is advisable to switch to AC, gradually eliminating DC sectors.

Diesel traction has become widespread. The total length of railroads working on diesel traction rose to 91,600 kilometers by the end of the Ninth Five-Year Plan. This growth is being accomplished both by building new roads with diesel traction and by switching roads operating on steam traction (on 1 January 1978 there were 2,700 kilometers of steam traction roads still in operation). At the same time, the length of roads with diesel traction is being reduced by switching the busiest freight lines to electric traction.

Diesel traction is extensively used in switching work. By the start of 1978 more than 90 percent of all railroad switching work was done by diesel engines.

Figure 6 below shows the recent history of reconstruction of traction systems in railroad transportation. It shows that 130,500 kilometers of

Figure 6. Length of USSR Railroads Working on Various Types of Traction



Key: (1) Steam Traction;
(2) Diesel Traction;
(3) Electric Traction;
(a) Thousands of Kilometers.

railroads were working on electric and diesel traction in 1975, which was 94.2 percent of the entire rail system. The complete elimination of steam traction on railroads is envisioned in the near future.

Table 6 (below) shows that as electric and diesel traction are introduced their share of railroad freight traffic grows steadily.

Table 6. Share of Freight Traffic Carried by Different Forms of Traction, percentage.

Type of Traction	1940	1950	1960	1965	1970	1975	1977
Electric	2,0	3,2	21,8	39,5	48,7	51,7	52,8
Diesel	0,2	2,2	21,4	45,0	47,8	47,9	47,1
Steam	97,8	94,6	56,8	15,5	3,5	0,4	0,1

The national economic efficiency of electric and diesel traction has been thoroughly treated in various works in the literature [41, 80, and others]. The use of progressive forms of traction improves the operating and economic indicators of the work of railroad transportation. Moreover, electric traction increases the carrying and traffic capacity of railroads roughly 30-50 percent more than diesel traction.

The high economy of electric traction is a result of more efficient use of energy resources. According to calculations by E. D. Fel'dman, this efficiency is 19-24 percent with electricity supplied from thermal power plants and 46-55 percent for hydroelectric power. The efficiency of diesel traction is 17.5-24.5 percent.

It is most efficient to use electric traction on segments with large freight and passenger flows and heavy track profiles. It is more economical to use diesel traction on lines with relatively small shipping volumes and easy track profiles.

The broad introduction of electric and diesel traction exercised a significant influence to reduce the prime cost of shipping, as can be seen from the data in Table 7 below. Of course, these data do not characterize the comparative efficiency of different types of traction and one cannot draw conclusions from them concerning how much more economical one form of traction is than another because they are not being used in comparable conditions.

The transition of railroads to electric and diesel traction made it possible to significantly reduce expenditures of energy and shipping costs. According to calculations by N. N. Barkov, the savings of operating costs for shipping through reconstruction of traction alone were more than 31 billion rubles for the 20 years between 1956 and 1975 [22].

Table 7. Prime Cost of Shipping Freight and Passengers in 1975 by Different Forms of Traction, kopecks.

Indicators	Types of Traction					
	Electric	Diesel	Steam	Electric Train	Diesel Train	All Types
Prime Cost of 10 Scheduled Ton-Kilometers	2.052	2.875	9.150	-	-	2.478
Prime Cost of 10 Passenger-Kilometers	5.092	7.566	16.381	4.645	11.273	6.063

The railroads are receiving new rolling stock at a fast pace thanks to scientific-technical progress.

The locomotive fleet of the railroads consists of heavy-duty electric and diesel engines and is steadily receiving new, improved models. At the present time, the 6,520-kilowatt $VL80^k$ AC electric freight engines are widely used. Dual power VL82 engines have been devised on the basis of the $VL\ 80^k$ engine and can operate on both AC and DC segments.

In 1972 the Novocherkassk Electric Locomotive Building Plant began producing powerful (6,520 kilowatt) $VL80^T$ AC electric engines for freight traffic. The VL80 engine has a rheostat brake with automatic adjustment of braking force and devices to set the necessary speed when traveling downhill. This was the first mainline electric locomotive to receive the Mark of Quality.

The railroads have also begun to receive the series-produced $VL80^P$ electric engines which have a fluid contactless speed regulation system and regenerative braking.

Among the DC freight engines we should note the 5,200-kilowatt VL10 engine which has regenerative braking. The efficiency of this electric locomotive is 93 percent.

The three-section 7,850-kilowatt VL11 DC locomotive, which can handle trains of up to 10,000 tons, has been designed and is being produced for use on especially busy freight lines. In the 10th Five-Year Plan the electrical engineering industry is supposed to begin production of "mainline electric freight locomotives with more than 10,000 horsepower" [5, p 186].

Long-distance passenger trains on roads with electric traction are pulled by six-axle engines produced in Czechoslovakia: the $ChS2^T$ for direct current and the $ChS4^T$ for alternating current. The ChS2 began to be delivered in 1973. The Škoda enterprises in Czechoslovakia have built the ChS200 eight-axle double-section passenger locomotive for high-speed passenger trains. This locomotive is designed for lines electrified with 3,000-volt direct current. This electric engine is twice as powerful as the ChS2.

The ER200, a domestically produced electric train with an output of 10,320 kilowatts, has been built for high-speed passenger traffic and is undergoing testing. It can develop a speed of 200 kilometers an hour.

The ER2 and ER9P electric trains are used to carry passengers at conventional speeds in suburban sectors; the designs of these trains are being improved year after year. The $ER22^M$ electric train equipped with regenerative braking and elongated cars with three entry doors, is also used for suburban passenger traffic.

The diesel locomotive fleet is made up in large part of TE3 and 2TE10L engines. Production of 2TE10L diesels has now been stopped, and 2TE10V engines with 6,000 horsepower (in two sections) have begun to replace them on the road. These engines have four-stroke diesels and are equipped with improved AC-DC drive and "jawless" [beschelyustnyy] trucks with an axial load of 23 ton-force. New diesel freight locomotives with 4,000 horsepower in one section and an axial load of 25-27-ton force are going to be produced. An experimental engine of this type was built in 1977 by the Voroshilovgrad Diesel Engine Plant.

The 2TE116 two-section diesel engines with 3,000 horsepower in one section have been produced for freight use since 1971. The 2TE116 engine has four-stroke diesels, electrical AC-DC drive, contactless modular electric equipment, electrodynamic brakes, and new, more powerful traction electric motors. The axial load of these diesel engines is 23 ton-force.

In passenger traffic the diesel engine fleet is being replenished with TEP60 engines. Models of the TEP70 diesel engine with 4,000 horsepower and the DC75 with 6,000 horsepower have been built and are undergoing testing. The TEP75 engines have AC-DC drive and a design speed of 160 kilometers an hour.

Suburban and local traffic in sectors with diesel traction is carried on by four-car diesel trains supplied from Hungary and six-car trains produced by the Riga Car Building Plant. A design is being developed for diesel trains with coupled cars that will make it possible to change the composition of the train depending on the amount of passenger traffic. In sectors with between 600 and 5,000 passengers a day diesel cars will be used that are powerful enough that an additional one or two passenger cars can be hitched to them.

The fleet of switch engines is being replenished with TEM2 and ChME3 diesel switch engines with 1,200 and 1,350 horsepower. Plans envision building more powerful diesel switch engines with electric drive and diesel engines with hydraulic drive.

The improvements in the new electric locomotives can be judged by the indicator of power per ton of coupled weight. AC electric engines have the best indicators of specific power.

For diesel engines an important indicator that characterizes their design is the weight of the engine per horsepower. According to this indicator the 2TE10V and TEP60 diesel locomotives are superior.

Plans for the near future envision replenishing the locomotive fleet with electrical and diesel locomotives with increased axial loads.

As the result of technical reconstruction the railroad car fleet today consists chiefly of four-axle freight cars and all-metal passenger cars.

During the 10th Five-Year Plan improved designs of freight and passenger cars will appear on the railroads. Deliveries of eight-axle gondola and tank cars with capacities of 125 and 120 tons respectively will increase. The number of refrigerator cars and sections with mechanical cooling will increase by 70 percent and by the end of 1980 they will account for more than 85 percent of the total fleet of isothermic cars [72].

Deliveries of other specialized cars will also grow significantly: gondolas with solid bodies for transporting loose bulk freight, two-tiered flat cars for transporting automobiles, tank cars with enlarged tank volumes, cars for transporting cement and hot agglomerate, special four-axle flat cars for container shipping, and others. Deliveries of conventional four-axle gondola cars, flat cars, and enclosed cars will also increase. They will be highly reliable cars. For example, the gondolas are to have metal siding instead of wood.

The production of freight cars with sliding bearings will be completely stopped in the near future and all freight cars will have roller bearings.

Work is continuing to improve certain assemblies of the cars, above all the axle box assembly. The Mipor (microporous rubber) insulation material in refrigerator cars will be replaced by better quality polystyrolor polyurethane. Rubber-metal shock absorbers for automatic coupling devices with good shock absorbing properties will undergo testing.

The fleet of passenger cars with electrical heating and air conditioning will increase significantly. Plans envision the use of stronger and, at the same time, lighter materials for car manufacture, for example, polyurethane, low-alloy steels, plastic, aluminum, and the like. Plans also call for the development of new techniques of applying protective coatings on the metal siding of the body, walls, and floor of the car to increase the service life of its parts and assemblies without dismantling design elements and applying new protective coatings.

As the data in Table 8 below indicate, the significant increase in production of new domestic locomotives and cars by plants of transportation machine building in recent years has played a significant part in renovating the rolling stock of railroad transportation [99, pp 92-93; 82, p 166].

Table 8. Production of Mainline Railroad Rolling Stock

Type of Rolling Stock	1940	1950	1960	1965	1970	1975	1977
Electric Locomotives:							
Units . . .	9	102	396	641	323	395	423
Horsepower	29,400	333,000	2,082,000	3,902,000	2,428,000	2,972,000	3,306,000
Diesel Locomotives:							
Units . . .	5	125	1,303	1,485	1,485	1,375	1,344
Horsepower	5,000	170,000	2,618,000	3,287,000	3,794,000	3,867,000	3,705,000
Freight Cars, units	30,900	50,800	36,400	39,600	58,300	69,900	71,200
Passenger Cars, units	1,051	912	1,655	1,991	1,791	2,090	2,110

Virtually all rolling stock built at domestic plants was delivered to USSR railroads as necessary replacements for the fleet of locomotives and cars. In addition, a certain share of means of transportation were obtained by import. Total import in the Ninth Five-Year Plan included more than 1,380 diesel and electric locomotives, 488 refrigerator trains, about 5,000 passenger cars, and more than 31,000 enclosed freight cars and tankers.

The total value of imported railroad rolling stock and auxiliary equipment for it was 1,668,000,000 rubles.*

Equipping railroad transportation with new types of locomotives and cars demands further reconstruction and development of the production base of the locomotive and car system, that is, the enterprises and installations for repair and ongoing maintenance of rolling stock. During the 10th Five-Year Plan these enterprises are to be bolstered with new equipment. Mechanized techniques of supplying trains and cars will become widespread. Automatic and semiautomatic lines including specialized and mounted equipment will be introduced on a broad scale for rolling stock repair. More than 1,100 flow lines and more than 1,200 mechanized sections and work positions are already in use at locomotive depots today [91].

The share of devices and equipment that provide full mechanization of loading and unloading work, repair and ongoing maintenance of rolling stock, and repair and maintenance of permanent structures, above all the track, in the total value of the production fixed capital of the railroads has grown significantly in recent years.

One of the most important challenges set down by the 25th CPSU Congress is to reduce labor expenditures for production of output. Increasing the capital-worker ratio in railroad transportation is very important to solving this problem, because that will reduce the share of live and increase the share of past labor in the prime cost of transportation output. In connection with this, the role of mechanization of loading and unloading work and ongoing maintenance and repair of the track and rolling stock is growing significantly.

The figures given in Table 9 below describe growth in the mechanization of loading and unloading work in railroad transportation.

The freight handling system of the railroads received substantial development through construction of freight yards, mechanized warehouses, container yards, and sorting platforms, and building up the stock of loading and unloading machinery by delivery of hoisting cranes mounted on trucks and railroad cars, electric and gas lift trucks, fork and bucket loaders, conveyor belts, and the like.

The document "Basic Directions of Development of the USSR National Economy in 1976-1980" formulates the challenge: "Raise the level of

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* Klochek, V. I. and Pichugin, B. M. (editors), "Vneshnaya Torgovlya SSSR: Itogi Devyatoy Pyatiletki i Perspektivy" [USSR Foreign Trade: Results of the Ninth Five-Year Plan and Future Prospects], Moscow Mezhdunarodnyye Otnosheniya, 1977, pp 57-59.

Table 9. Growth in Mechanization of Loading and Unloading Work, in percentage.

Indicators	1950	1960	1965	1970	1975	1977
Level of Mechanization of Loading and Unloading Work:						
On Sidings at Industrial Enterprises and Organizations	70	87	89	92	95	95
At Railroad Freight Yards	31	67	79	87	92	93
Level of Full Mechanization of Loading and Unloading Work at Railroad Freight Yards	*	50	64	80	90	90

* No information.

full mechanization of loading and unloading work in railroad transportation to 93 percent. Significantly raise the level of mechanization of work for ongoing repair of railroad track" [5, p 208].

Highly productive machinery and equipment has been built and put into use in recent years to mechanize track and rolling stock repair work. These devices make it possible to perform hard, labor-consumptive jobs quickly, to reduce expenditures of labor and materials, and to perform repair work well.

A complex of technologically interrelated, heavy track machines is used extensively for track repair. This set of machinery includes track layers, electric ballasters, dosing hoppers, gravel cleaners, and tie packers. Among the noteworthy track machines in use today are the ShchOM-4, ShchOM-DO, and ShchOM-3y machines for gravel cleaning, the ShPM-02 tie packing machine which has a vibration unit, the AShPM-1200 cyclical-action trueing-packing machine, the VPO-3000 trueing-packing-finishing machine, the UK-25 track laying crane which is used to lay 25-meter rail units with reinforced concrete ties, machines used for replacement of individual reinforced concrete and wooden ties, PRL-3 track repair trucks, SM-3 and SM-4 self-propelled snow removal machines, and others.

In addition to machinery and mechanisms, various types of electrical and hydraulic tools are used for ongoing track maintenance. Defectoscope cars and trucks are being introduced more and more widely to inspect the condition of the rails.

The level of mechanization of track work in railroad transportation is steadily rising (see Table 10 below).

Table 10. Growth in Mechanization of Work in On-going Maintenance and Repair of the Railroad Track, in percentage.

Indicators	1950	1960	1965	1970	1975	1977
Level of Mechanization of Track Repair:						
Capital Repair	17.2	48.0	68.3	74.4	80.4	82.3
Medium Repair	13.0	39.5	55.4	61.3	67.4	69.1
Track Lifting	-	27.0	48.3	53.4	59.4	61.2
Level of Mechanization of Ongoing Track Maintenance	-	13.5	24.2	29.7	34.2	36.0

The capital-worker ratio of the track system has increased several-fold in recent years, and in 1977 was almost 2,000 rubles per worker.

Scientific-technical progress in railroad transportation is being accomplished especially fast in the area of introducing means of automation, remote control, radio, communications, and computer technology.

In 1971-1975 the length of line equipped with automatic blocking and centralized dispatching increased by 14,700 kilometers and 43,500 switches were outfitted with electrical centralization. Automation of traction substation control is being introduced broadly. By the start of 1979 28,700 kilometers of electrified railroad had been switched to remote control [91].

In the 10th Five-Year Plan the length of track with automatic blocking and centralized dispatching is to be increased 16,800 kilometers, 45,000 switches are to be outfitted with electrical centralization, the rail system will complete the transition to train radio communications, and 8,500 kilometers of trunk communications lines will be switched to cable [107, p 33].

Equipping railroads with automatic blocking, centralized dispatching, electrical centralization of switches and signals, and automatic locomotive signaling improves train traffic safety, increases the carrying and traffic capacity of the roads, reduces shipping expenditures, and affords growth in the labor productivity of railroad transportation workers. For example, automatic blocking introduced on a single-track line increases its traffic capacity by 10-20 percent, and by 25 percent where train traffic moves on a grouping schedule. On a double-track line automatic blocking increases traffic capacity 2-3 times. Electrical centralization of switches and signals reduces time required to prepare unit trains and increases the traffic capacity of the stations 1.5-2 times. When electrical centralization is introduced

30-50 fewer switch workers are needed for every 100 switches, and labor productivity rises 35-40 percent.

Centralized dispatching, which combines automatic blocking and electrical centralization, increases the traffic capacity of single-track lines 40-50 percent and reduces the need for switch and station duty workers by 40-50 persons per 100 kilometers.

The speed with which trains are formed and broken depends greatly on the equipment of the classification humps. Mechanization and automation of the humps increases the processing capacity of the stations, raises the labor productivity of station workers, and frees them from the performance of difficult operations related to car classification. In 1971-1975 two classification humps were automated, 21 were mechanized, and nine new classification stations and systems were built [26]. At the present time almost half of the large and medium-sized classification humps have been mechanized, and at some stations they have been automated. New, more powerful KNP-5-73 delay mechanisms have begun to be installed during mechanization of the humps.

Computers are used more and more every year on the railroads. Computer centers and computer technology laboratories are being formed to do jobs related to planning operations work, bookkeeping and statistical accounting for fixed capital, material-technical supply, and the like.

Automatic devices for customer service are being introduced widely. Among them are indicators of the destination of passenger trains, automatic baggage storage compartments, automatic seat distribution devices, and special communications for advance ticket sales. The Moscow rail center is introducing the Ekspress automated system by stages. The system is designed to reserve places and sell tickets on long-distance passenger trains.

3. The Effect of the Technical Equipment of Railroads on Labor Productivity.

The amount and quality of the fixed capital used in the shipping process has a significant effect on the labor productivity of railroad transportation workers. The principal role is played by such fixed capital as rolling stock, machinery, and equipment, in other words the active part. When the locomotives used on the railroads are more powerful, car capacity is greater, and the rolling stock is better technically and economically (that is, it has better technical and operating indicators and greater reliability and economy in operation), where other conditions are equal it will be possible to attain higher labor productivity.

Labor productivity is the most important indicator of the quality and degree of use of production fixed capital. A distinction should be made between the productivity of live labor, which is the labor of people who perform a particular job and produce a definite output, and the productivity of all public labor, which includes live labor and the past labor embodied in means of production.

In railroad transportation the productivity of live labor is characterized by the volume of shipping per employee of the operations contingent. In 1977 the productivity of labor of workers employed in shipping was 1,742,000 calculated ton-kilometers.

The productivity of all public labor in railroad transportation could be represented as the sum of all transportation output in calculated ton-kilometers per unit of live and embodied labor expended to perform the shipping. But because it is difficult to express the labor embodied in means of production that participate in the shipping process in physical terms, that is in worker-hours, it is customary to determine only the productivity of live labor. The productivity of embodied labor can be expressed by the indicators of capital-output ratio and material intensiveness.

So taken together the indicators of the productivity of live labor, capital-output ratio, and material-intensiveness characterize the productivity of all public labor expended for shipping. They determine the degree of efficiency of labor by employees in railroad transportation, the completeness and intensity of the use of fixed capital, and economical and thrifty expenditure of materials. Production fixed capital, while not itself creating new value, exercises a major influence on growth in the productivity of live labor, the capital-output ratio, and the material-intensiveness of output. Therefore, the efficiency of its use can be evaluated most fully only by a comprehensive approach, measuring all of these indicators.

When evaluating the efficiency of production fixed capital the indicator of the capital-labor ratio per member of the operations contingent is also very important. Let us consider what influence this indicator has on the capital-output ratio and labor productivity. We will use the following designations: Π_T — productivity of live labor; Ч — number of employees engaged in operations work; Φ_B — capital-labor ratio; Φ — value of production fixed capital of railroad transportation; Φ_0 — return per ruble of production fixed capital; T_{KM} — transportation output in calculated ton-kilometers.

Using these designations we stipulate:

$$\Pi_т = T_{км} : Ч; \quad (6)$$

$$\Phi_в = \Phi : Ч; \quad (7)$$

$$\Phi_о = T_{км} : \Phi. \quad (8)$$

From expression (7) we find the number of workers in the operations contingent

$$Ч = Ф : Ф_в, \quad (9)$$

and from expression (8) the volume of transportation output.

$$T_{км} = Ф_о Ф. \quad (10)$$

Substituting these values into expression (6), we will determine labor productivity

$$П_т = Ф_о Ф_в. \quad (11)$$

Thus, the productivity of live labor is equal to the output-capital ratio multiplied by the capital-labor ratio. This is not, however, an absolute principle and is correct only if the output-capital ratio of newly introduced production fixed capital that raises the capital-labor ratio is higher than its average value for operating capital. But if new fixed capital being introduced has a lower output-capital ratio than the average currently operating capital, labor productivity will drop, even though the capital-labor ratio may increase.

The dependence of the productivity of live labor on material intensiveness is identified in almost the same way, but in this case it has a somewhat different nature.

We will define material intensiveness M_e as the quotient from dividing the value of material resources expended M_o by the amount of transportation output

$$M_е = M_о : T_{км}. \quad (12)$$

this

$$T_{км} = M_о : M_е. \quad (13)$$

substituting the values from formulas (9) and (13) in formula (6), we obtain

$$П_т = M_о Ф_в : M_е Ф. \quad (14)$$

Thus, the productivity of live labor will be higher when the material intensiveness of the output is lower and the total amount of production fixed capital is less. Even in this case, however, labor productivity will rise only on the condition that the new fixed capital being introduced does not cause greater demand for material resources and a consequent increase in material intensiveness compared to the values of the indicators for operating fixed capital.

In various sectors of the national economy the ratio among the individual elements of expenditures for production and output differs. In railroad transportation the ratio of wages and material expenditures in the prime cost of shipping is 1:0.6 whereas in industry it is 1:5. Therefore, reducing expenditures of live labor, which are seen in the form of wages, is especially important in railroad transportation. The higher labor productivity is, the smaller the part of the value of production fixed capital that will be transferred to the output produced with its participation.

Emphasizing the importance of raising labor productivity, V. I. Lenin wrote the following: "Raising labor productivity is one of the fundamental challenges, for without it the final transition to communism is impossible" [2, Vol 38, p 97].

In the first 60 years of Soviet power labor productivity in railroad transportation rose 13.6 times. The advantages of the socialist social system, involving above all the elimination of private ownership of the means of production and the absence of exploitation of one person by another, are the foundation for the high rate of growth in labor productivity. The interest of the working people and the results of their labor and formulation of a system of material incentive for high work indicators are reflected in growth in labor productivity in all sectors of the national economy.

Labor productivity in railroad transportation rose 24.1 percent in the Ninth Five-Year Plan. The document "Basic Directions of Development of the USSR National Economy for 1976-1980" envisions 18-20 percent growth in labor productivity in railroad transportation. This is supposed to account for 95 percent of all increase in shipping planned during the 10th Five-Year Plan.

Growth in labor productivity in railroad transportation between 1950 and 1975 is shown in Figure 7 below.

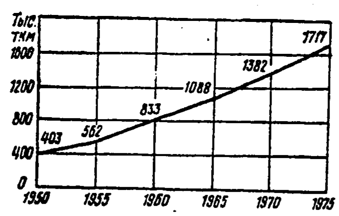

Figure 7. Growth in Labor Productivity in Railroad Transportation (thousands of calculated tons-kilometers per operations employee; vertical axis is in thousands of ton-kilometers).

Accelerating the growth rate of labor productivity is becoming especially important because the potential for additional enlistment of labor in transportation and handling shipping growth in this way has been largely exhausted. According to calculations by Soviet economists, the problem of supplying labor for sectors of the national economy will become even more difficult in the next decade. "We will have to rely not on attracting additional labor," General Secretary of the CPSU Central Committee L. I. Brezhnev pointed out in the Accountability Report to the 25th Party Congress, "but only on raising labor productivity. Sharply reducing the share of manual labor and full mechanization and automation of production are becoming essential conditions of economic growth" [5, p 143].

Scientific-technical progress plays an important part in the elimination of manual labor. Mechanization and automation of production processes are especially important. "The entire progressive work of human technology is to replace manual labor with machine labor. The more highly developed the technology is," V. I. Lenin wrote, "the more broadly human manual labor will be supplanted and replaced by increasingly complex machinery" [2, Vol 1, p 100].

Until quite recently the proportion of manual labor on railroads was quite high for loading and unloading work and work related to ongoing maintenance and repair of the track and rolling stock.

Technical reconstruction of railroad transportation led to a significant rise in the level of mechanization and automation of loading work and track maintenance and repair. The number of mechanized and automated flow lines, overhead cranes, hoisting and conveying devices, and machines in the repair shops of locomotive and car depots increased sharply. The number of track machines used for ongoing maintenance and repair of the track grew.

Growth in the technical equipment available to workers in railroad transportation, which doubled between 1955 and 1975, brought about a significant rise in labor productivity. According to calculations, more than 90 percent of the growth in labor productivity was a result of the introduction of new machinery [90].

Despite large-scale introduction of machinery and mechanisms in railroad transportation, however, a significant proportion of manual labor remains in the jobs of switch workers, crossing guards, repair workers, and others. Reducing manual labor and increasing the number of workers who use machines offer enormous reserves for raising labor productivity.

The development of improved locomotives, cars, machines, and equipment has a profound and multifaceted impact on all aspects of the shipping process and leads to renewal of the active part of the fixed capital of railroad transportation and an improvement in its structure. Ultimately, the introduction of new technology provides a decrease in total labor expenditures for shipping.

The more productive the machinery used is, the greater the economy of live labor will be. K. Marx emphasized that "the productivity of a machine is measured by the degree to which it replaces human work force" [1, Vol 23, p 402]. In addition to a savings of live labor, machines provide a decrease in material and fuel-energy expenditures per unit of transportation output. Thus, with an increase in labor productivity in railroad transportation expenditures for wages and for means of production used in the shipping process decrease in the prime cost of shipping.

Scientific-technical progress significantly affects the ratio of live and past labor in the prime cost of output. "Raising labor productivity means precisely that the share of live labor is reduced and the share of past labor is increased, but it is increased so that the total sum of labor contained in the commodity is less, that is, so that the amount of live labor is decreased more than the increase in past labor" [1, Vol 25, Pt 1, p 286].

The decrease in expenditures of live labor in railroad transportation can be estimated by the drop in the proportion of wages within the prime cost of shipping. Figure 8 shows that between 1950 and 1975 this proportion dropped from 45.2 to 39.8 percent. It should be considered,

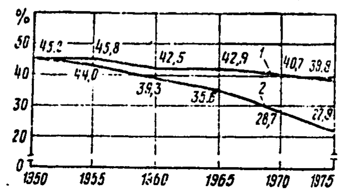

Figure 8. Proportion of Wages in Prime Cost of Shipping on Railroads

Key: (1) Considering Increase in Wage Schedules;
(2) With Constant Wage Schedules.

however, that wages rose several times in the period under consideration. Therefore, a comparison must be made with constant wage rates. In this case, the proportion of wages in the prime cost of shipping decreased to 22.9 percent in 1975, which is a more correct description of the decrease in expenditures of live labor for shipping.

Scientific-technical progress in railroad transportation is leading to the appearance of new highly productive fixed capital whose introduction reduces the expenditure of live and embodied labor necessary to perform a unit of shipping. This decrease in labor expenditures leads to a decrease in the operating costs of the railroads. In the period under consideration the prime cost of shipping has been reduced by decreasing wage costs (that is, live labor) as well as expenditures for fuel, electricity, materials, and depreciation deductions (that is, labor embodied in the means of production). In this case the share of expenditures of embodied labor in the prime cost of shipping depends on the degree of use of fixed capital. The more fully fixed capital is used, the less embodied labor there will be per unit of transportation output. This reduction together with the savings of live labor is what characterizes fixed capital efficiency.

4. Reproduction of the Fixed Capital of Foreign Railroads

Unlike socialist expanded reproduction of fixed capital, which is carried on according to plan, expanded reproduction of fixed capital [kapital] in the capitalist countries occurs spontaneously. The contradiction between the social nature of production and private form of acquisition of the results of production gives capitalist production a cyclical nature in which upswings alternate with declines. The steady narrowing of the market for goods is an enormous hardship with which capitalistic expanded reproduction must deal.

Whereas under socialism the reproduction of fixed capital and introduction of new technology to make labor easier and raise labor productivity is a powerful source of improvement in working conditions and rise in the material and cultural standard of living of all members of society, under capitalism expanded reproduction of fixed capital is linked to unrestrained exploitation of the working people and the battle to receive more profits. Like the monopolies in other sectors of the capitalist economy which are trying to secure higher profits, the railroad companies direct their capital to those enterprises where the profit norm is highest. As a result, the development and siting of fixed capital are extremely uneven.

There are many cases in the United States, for example, where several railroads run between two cities and wage bitter competitive struggles. The cities of Chicago and Omaha are connected by six rail systems belonging to different companies. Chicago itself has eight passenger terminals which are also owned by different railroad companies.

Expanded reproduction under capitalism involves enormous losses of labor. "The reason for this," K. Marx wrote, "is that nothing is done according to a public plan. Everything depends on infinitely varied circumstances, means, and the like which the individual capitalist takes into account. All this leads to enormous dispersion of productive forces" [1, Vol 24, pp 193-194].

The rate of expanded reproduction of fixed capital in the capitalist countries depends significantly on the share of depreciation deductions in capital investment. At the present time growth in fixed capital takes place chiefly through profit which is concealed primarily in depreciation deductions. At the same time it should be observed that scientific-technical progress, which makes it necessary to devise new machinery and equipment and accelerate the obsolescence of operating machinery, demands an increase in the share of capital investment out of savings. Despite some increase in this share, the bulk of capital investment has its source in depreciation, which accounts for more than 70 percent.

The share of depreciation deductions for replacement of withdrawn fixed capital in the total volume of capital investment in railroad transportation in the capitalist countries is steadily growing. For example, depreciation deductions accounted for 48 percent of total capital investment in U. S. railroad transportation in 1975. In the economically developed capitalist countries of Europe the share of depreciation deductions is also significant, roughly 60 percent of all capital investment in railroad transportation. The remainder of capital investment comes from the profit of the railroads. In the United States where the railroads are privately owned, the companies are forced to use a significant part of their profit to finance capital investment. State capital investment in railroad transportation is negligible.

The bulk of this investment goes for the development of motor vehicle and air transportation.

The high proportion of depreciation deductions in capital investment in the fixed capital of railroad transportation characterizes the low rate of growth in railroad fixed capital. In West Germany, Belgium, Italy, France, and other countries the growth of railroad fixed capital occurs through various kinds of loans. In France the growth of fixed capital is also accomplished by using capital provided for maintenance and repair of various installations, equipment, and rolling stock. In Italy appropriations from the state budget are used in addition to loans to increase the fixed capital of the state railroads.

It should be noted that in the capitalist countries the money used for repayment of loans enlisted to increase railroad fixed capital is taken out of profit. Therefore, depreciation norms are often combined with interest rates on loans.

In the United States the interest rate on capital invested in railroads is very low. As a result the railroad companies have virtually no incoming capital to reconstruct, expand, and modernize means of labor; so they use part of profit and depreciation deductions for these purposes. Profit and depreciation account for 90 percent and more of total capital investment there. According to figures from the Interstate Commerce Commission given in a report on the operation of U. S. railroads in 1975, capital investment in railroad transportation was about $1,790,000,000, and the largest part of this, $1,303,000,000, went for replacement of rolling stock while $487,000,000 went for reconstruction and new construction of railroad buildings and structures [129]. In addition to this capital investment, nontransportation companies and shippers spent about $800,000,000 each year, chiefly to purchase rolling stock.

As analysis shows, capital investment in railroad transportation is used mainly to replace and modernize fixed capital. None of the economically developed capitalist countries except Japan is carrying on new railroad construction today. The networks of railroads in these countries are being reduced by shutting down inactive and underloaded lines, which can be seen from the figures in Table 11 below [83, p 112; 85, p 123].

Between 1960 and 1975 the British rail network was cut back by 11,500 kilometers or 38.5 percent. During these same years the length of U. S. railroads was reduced by 28,000 kilometers or eight percent.

The number of freight and passenger cars is decreasing, as is the number of diesel engines engaged in train and switching work. In Great Britain, for example, the number of freight cars dropped from 947,000 in 1960 to 364,900 in 1970, a decrease of more than three-fifths.

Table 11. Change in the Operating Length of Railroads of the Developed Capitalist Countries (at year's end).

Country	1960	1965	1970	1975
Great Britain (without Northern Ireland)	29,600	24,000	19,000	18,100
France	38,800	37,800	36,000	34,300
West Germany	36,000	35,200	33,100	32,000
Italy	21,700	21,100	20,100	20,200
Canada	66,600	66,500	66,500	66,400*
United States	350,000	341,000	332,000	322,000
Japan**	20,300	20,600	20,800	21,100

* 1974 Figures
** State Railroads.

In this same period the number of passenger cars dropped from 40,100 to 18,700, a decrease of about five-ninths, while the number of seats in passenger cars dropped from 2,331,000 to 1,155,000, roughly in half.

The number of diesel locomotives including diesel cars fell from 4,811 to 4,126 sections or 14.2 percent during this time [59].

The fleet of railroad rolling stock in the United States is steadily decreasing. Between 1970 and 1975 the number of freight cars decreased from 1,784,200 to 1,723,600 or 3.4 percent. Thanks to the delivery of new cars with greater freight capacity, however, the total freight capacity of the class I railroad cars increased slightly during this period.* The number of passenger, baggage, and mail cars dropped from 11,177 to 6,471, a decrease of two-fifths, during this same time [129]. Orders for these cars also dropped off significantly.

In connection with the economic crisis and decrease in shipping in recent years, deliveries of locomotives and cars to railroads have fallen significantly. In 1976 deliveries of new and fully overhauled freight cars in the United States were 53,600 units, 20,400 cars fewer than in 1975. The delivery of new and rebuilt diesel locomotives in 1976 was 747 units, significantly less than deliveries made in earlier years.

It must be observed that the new cars being delivered have greater freight capacity and the diesel engines are more powerful. This was

* At the present time all U.S. railroads are divided into two classes. Class 1 lines are systems with incomes of more than 10 million dollars a year; class II lines have less than that amount of income. In 1975 class I railroad companies operated 96 percent of the rail lines existing in the country and received more than 99 percent of all income.

reflected in the average freight capacity per car, which rose from 60.3 tons in 1970 to 66.1 tons in 1976 and the average power of a diesel engine, which increased in this same period from 1,942 to 2,165 horsepwer.

The purpose of curtailing the railroad networks of the capitalist countries is to reduce maintenance expenditures and increase competitiveness in the battle with other forms of transportation. In their effort to keep freight and passenger shipping business, the private companies and state railroads of the economically developed capitalist countries are modernizing railroad transportation. An important aspect of modernization is electrification. About one-third of the total length of rail lines in Japan and several capitalist countries of Western Europe is already working on electric traction today. Table 12 below shows the increase in length of electrified lines in recent years [83, p 144; 85, p 124].

Table 12. Growth in Length of Electrified Railroads in Developed Capitalist Countries (at year's end).

Country	1960		1965		1970		1975	
	Km	%*	Km	%	Km	%	Km	%
Great Britain (without Northern Ireland)	2,034	6.9	2,885	12.0	3,162	16.7	3,611	19.9
France	6,920	17.8	8,430	22.3	9,359	26.0	9,327	27.2
West Germany	4,242	11.8	6,863	19.5	8,883	26.8	10,323	32.3
Italy	9,585	44.1	9,788	46.3	9,330	46.4	9,505	47.1
Canada	170	0.26	160	0.25	31	0.05	31#	0.05
United States (Class I)	3,172	0.95	2,910	0.90	2,861	1.00	2,861	1.00
Japan (State Railroads)	2,699	13.3	4,228	20.5	6,021	29.0	7,628	36.1

* Percentage of Total Operating Length
\# 1974 Figures.

It can be seen from Table 12 that electrification of railroads has spread significantly in most of the economically developed capitalist countries in the last decade. At the same time, virtually no railroads have been electrified in such an important country as the United States.

In connection with the energy crisis and the rise in prices for oil and diesel fuel, many articles have been published in the United States which demonstrate the advantages and wisdom of electrification of American railroads. This question is also considered in detail in the report of the Committee on the Use of Electrical Energy. The authors of the report observe that where the terrain is level and there is a dense network of power transmission lines, electric traction is more economical than diesel traction when the freight intensity of the railroads is 15-20 million ton-kilometers net/kilometer a year. In mountainous regions with many curves and a sparse network of power transmission lines this threshold of freight intensity rises to 30-35 million [125].

The report goes into particular detail in its analysis of capital investment for electrification of railroads and the cost of their operation with electric traction under current conditions. Observing that expenditures for the purchase of electric engines constitute 25-35 percent of the total cost of electrification of a system, the authors argue that these expenditures will be reduced by one-half for electric traction because the service life of electric locomotives in the United States is 30-40 years, more than double the economically advisable service life of mainline diesel locomotives, which is now accepted to be 12-15 years.

Great Britain adopted a plan to reconstruct railroad transportation 20 years ago. This plan contemplated electrification of a significant part of the railroads. Nonetheless, the length of railroads working on electric traction today there is small. The railroad companies, in order to preserve their capital invested in the installation of steam traction, refused to electrify the railroads.

At the same time it should be observed that considerable capital has been invested in the reconstruction of British railroads in recent years.

In 1974-1978 1,013,000,000 pounds sterling was planned for this purpose: 674 million pounds for reconstruction of mainline systems and 339,000,000 for suburban lines [126]. The distribution of this capital investment by areas of expenditure is shown in Table 13 below.

Table 13, Distribution of Capital Investment in Reconstruction of British Railroad Transportation in 1974-1978.

Area of Expenditures	Trunk Lines Pounds Sterling	%	Suburban Lines Pounds Sterling	%
Passenger Rolling Stock	1,036,000	20.2	89,000,000	26.3
Passenger Station	34,000,000	5.0	40,000,000	11.8
Freight Stations	44,000,000	6.5	-	-
Track Reconstruction	144,000,000	24.6	47,000,000	13.9
Electrification of Roads	9,000,000	1.4	54,000,000	15.9
Signals and Communications	94,000,000	13.0	52,000,000	15.3
Other Work	191,000,000	28.4	57,000,000	16.8
Total	674,000,000	100.0	339,000,000	100.0

The largest part (43.8 percent) of all capital investment is going for reconstruction of the track and the purchase of passenger rolling stock, while only 6.3 percent is being used for electrification of the railroads.

Chapter V. Efficiency of Use of Fixed Capital

1. Monetary and Physical Indexes of the Use of Fixed Capital

The rapid growth and continuous improvement of the fixed capital of railroad transportation requires that a whole series of important problems related to improving its use be solved. Among these problems are: comprehensive introduction of new machinery and increasing the efficiency of capital investment; improving the technology of the shipping process and management in transportation; improving labor organization, dissemination of progressive know-how, and increasing the material interest of railroad workers in the results of their labor; employing techniques of planning, finance, and cost accounting that promote maximum growth in labor productivity, decrease in the prime cost of shipping, and improvement in the quality of work by all subdivisions of railway transportation.

The 25th CPSU Congress focused considerable attention on improving the use of fixed capital. It set down the challenge for the 10th Five-Year Plan: "Significantly raise the level of use of fixed capital. In sectors of the national economy and at enterprises and organizations work out and implement programs to raise the output-capital ratio" [5, p 168].

Production fixed capital, representing an enormous accumulation of past labor, has a major impact on the work of railroads and all enterprises participating in the shipping process. Improving the use of fixed capital makes it possible to convey freight and passengers with minimal expenditures of live and past labor, which provides growth in labor productivity and a decrease in the prime cost of shipping. The traffic and carrying capacity of the railroads, capital investment requirement, loss from obsolescence of fixed capital which is withdrawn from use ahead of time, and efficiency of the shipping process in railroad transportation depend on how fixed capital is used.

The socialist economic system has significant advantages over the capitalist system in creating conditions for most efficient use of the fixed capital of all sectors of the national economy, railroad transportation included. The introduction of new machinery on the railroads improves the technology of the shipping process and promotes better use of all fixed capital; this is achieved not by increasing the intensity of labor, but by better use of capacities and increasing the length of work of rolling stock, machinery, and equipment.

The socialist competition that has developed in railroad transportation for best use of fixed capital is revealing significant reserves for improving the quality of railroad operations. Putting these reserves into use makes it possible to handle the enormous volume of freight and passenger traffic which the national economy is giving to railroad transportation.

During the Ninth Five-Year Plan the planned volume of freight shipping was significantly overfulfilled. In the first year of the Tenth Five-Year Plan, however, railroad transportation was under great strain. To improve railroad work the CPSU Central Committee and USSR Council of Ministers adopted a decree which envisioned major steps to develop railroad transportation in 1976-1980. Implementation of these measures will insure an increase in the traffic and carrying capacity of the railroads and promote an improvement in the quality indicators of operations work and the technological processes of work by sidings and stations and an increase in the efficiency of use of production fixed capital.

Under the strained working conditions of railroad transportation today, improving the use of production fixed capital becomes exceptionally important. Raising the output-capital ratio of the railroads just one percent makes it possible to carry 36 million additional tons of freight and 35 million more passengers, to raise railroad income by 165 million rubles, and to receive almost 65 million rubles of additional profit.

The level of use of railroad fixed capital depends on many factors, foremost among which are the qualitative indicators of operations work, the degree to which the carrying and traffic capacities of systems are used, the extent of use of unit trains, the speed of freight and passenger delivery, and others. Most of these indicators are reflected in the output-capital ratio, which in railroad transportation is measured in physical terms, by the number of ton-kilometers and passenger-kilometers per ruble of production fixed capital, as well as a monetary expression, the amount of income per ruble of the same capital.

The output-capital ratio is also characterized to a significant degree by the indicator of profitability, that is, the amount of balance profit per ruble of production capital. Taken together, the physical and monetary indicators of the output-capital ratio describe the use of production fixed capital with satisfactory completeness.

It should be remarked that the physical and monetary indicators of the output-capital ratio used today are determined on the basis of the final output of railroad transportation as a whole and characterize the intensity of use of all railroad fixed capital. Such an evaluation will be inaccurate for a particular system because not all the units of its fixed capital participate equally in the creation of transportation output. Thus, the use of production fixed capital associated with the movement of freight and passengers, the so-called movement operation, is characterized adequately by the indicator of output-capital ratio measured by the figure for calculated ton-kilometers per ruble of average annual value of this capital. The use of production fixed capital involved with beginning and final operations, forming and breaking up trains, can be evaluated much more correctly by tons of freight shipped and arrived and number of passengers carried per ruble of this part of fixed capital.

It therefore seems advisable when evaluating the efficiency of use of the production fixed capital of the railroads and road sections to establish two physical indicators of the output-capital ratio: the number of calculated ton-kilometers per ruble of average annual value of fixed capital involved in moving operations; the number of tons of freight shipped and arrived and passengers carried per ruble of average annual value of fixed capital involved with beginning and final operations and forming and breaking up trains. These indicators should be determined separately for freight and passenger traffic.

In railroad work the various units of fixed capital are not used in isolation from one another, but rather together. Full use of rolling stock is especially important. The qualitative indicators of the use of locomotives and cars are important physical indicators of the use of production fixed capital.

The quality of use of locomotives is evaluated by such indicators as the section speed of train travel, the gross weight of the train, average daily run, auxiliary use, and locomotive productivity.

The section speed (speed of train travel including scheduled stops) is one of the most important indicators of road operations. When the section speed is greater, locomotives and cars will be turned around faster. Increasing section speed plays a large part in stepping up the delivery of freight to the customer. Section speed depends significantly on technical speed (speed excluding scheduled stops) and on reducing car downtime at intermediate stations.

The gross weight of a train is especially important for increasing the carrying capacity of systems and improving the use of locomotives. The more a train weighs, the more fully the locomotive's capacity is being used. At the same time, pulling heavier trains should not cause intensive wear and worsen the technical condition of the locomotives and their traction engines.

The greatest economic impact is achieved when shipments are organized by heavier trains for entire large divisions of the road, not for particular sections when frequent change in the weight of the train will cause an increase in expenditures for switching work to process the trains and greater car downtime at stations waiting for assembly, which reduces the benefit from increasing the weight of the train.

Organizing freight shipment in full-weight trains is especially efficient if it is combined with an increase in traveling speed. This maximizes the gain from both procedures.

The average daily run of locomotives is one of the basic indicators of their use. It depends on the speed of travel and locomotive downtime at stations. Reducing locomotive downtime at turnaround stations and shift change points allows a significant increase in the section speed of train travel and the average daily run of the locomotives. Reducing locomotive downtime for supplies and the related need to give engine crews break time is very effective in increasing the average daily run. Increasing the number of locomotives operating on extended circulation sections and operating them with shift crews are important reserves for increasing the average daily run.

The auxiliary use of locomotives, which includes distance traveled alone, with trains in double traction, pushing, and switching work, significantly affects their use. Operating locomotives in double traction and the pushing mode is usually useful because it makes it possible to move heavier trains through entire large divisions of a road at high speed, which increases the traffic and carrying capacity of the roads in these divisions. The other types of auxiliary use arise from specific operating conditions and increasing their scope worsens the indicators of locomotive use.

The productivity of a locomotive is a composite indicator which most fully characterizes the use of locomotives with respect to both capacity and time of useful work. For train engines this indicator is determined by the number of gross ton-kilometers performed by one train locomotive of the operating fleet in a day, month, or large period of time. The productivity of switch engines is determined by the actual number of cars processed by one switch engine in a day, month, or other time period.

Analysis of performance of a locomoitive's productivity assignment makes it possible to determine which indicators have caused its useful work to increase or decrease.

In addition to the indicators considered above, indicators of locomotive operating time between repairs and downtime for repair are important in evaluating their use. The further a locomotive can travel between repairs and the shorter its downtime for repair is, the more time it will have to perform useful work.

The important indicators of the efficiency of use of freight cars are: car turnaround time, average daily run, static and dynamic loads, percentage of empty runs, and car productivity.

Car turnaround is a composite indicator that reflects the quality of work by stations, road divisions, roads, and the railroad network as a whole. Car turnaround time includes the time that cars are at loading and unloading stations, on the road, and at intermediate, section, and classification stations. This indicator is influenced by the length of freight shipping, empty runs, speed of travel, and car downtime at stations.

The average daily run of cars is linked to the distance of the shipment and depends on the speed of travel and car downtime at stations. The distance which a car travels with freight and without freight during its full cycle is the full run of the car. Thus, the average daily run of the car is its full run in this day. Where other conditions are equal, the more that car turnaround time is reduced the more its average daily run will increase.

The static load of cars describes the degree of use of their freight capacity and depends on the structure of freight shipping. When the volumetric weight of the freight is less it will be more difficult to make full use of the car's freight capacity. It is very important in increasing static loads to deliver for loading the precise kind of car that will insure maximum use of its capacity for hauling the particular freight. For example, hard coal can be shipped in gondolas or flatcars. In such a case, however, the freight capacity of flat cars is only about 50 percent used. Therefore, it is inefficient to load coal on flatcars, and it is much more efficient to use gondolas for this purpose. Their load capacity will be used almost completely.

The dynamic load of loaded cars depends not only on the degree of use of their freight capacity and the structure of freight being shipped, but also on the distance which the car will travel with this particular load.

Thus, static load describes the use of car capacity when it is being loaded (dispatched), and dynamic load shows how the car capacity was used considering its trip while loaded. In practice, the indicator of dynamic load of a working car is often used. This indicator differs from the preceding one because it also takes into account car travel while empty.

Empty runs by cars depend on their type, size, and the composition of freight traffic in the road divisions. In large part this indicator reflects how well the freight shipping process was planned and the control of empty cars located at stations.

Car productivity is a composite indicator of car use. It is measured in operating net ton-kilometers performed by one car of the fleet being used in a day, month, or other period of time. Car productivity takes into account the effect of all the qualitative indicators of use of the car fleet.

The job of employees in all sectors of railroad transportation is to take all possible steps to improve the qualitative indicators of rolling stock use, make maximum use of all fixed capital, and perform a large volume of shipping work for each ruble of value of fixed capital.

A correct assessment of the impact of any particular indicator on improving the use of fixed capital requires that we determine the specific effect that this indicator has. First of all it is necessary to establish how the indicator is reflected in labor productivity, reducing operating costs for moving freight and passengers, saving on capital investment, and increasing the carrying and traffic capacity of the railroads.

2. Methodology for a Monetary Evaluation of the Indicators of Use of Rolling Stock

Monetary evaluation of the indicators of use of rolling stock has become widespread in railroad work. Under current conditions this evaluation is usually done according to the effect of these indicators on the profit and incomes of railroad transportation enterprises, and sometimes by their effect on the size of the payment for production fixed capital. The most concrete and complete evaluation, however, is evaluation of the indicators of use of rolling stock by their influence on operating expenditures (prime cost of shipping) and capital investment.

The problem of evaluating the effect of use of rolling stock on operating costs has always attracted the attention of investigators interested in the issues of the prime cost of railroad shipping. As far back as the 1920's Ye. V. Mikhal'tsev established a relationship between the operating cost of railroads and qualitative indicators of the use of locomotives and cars [78]. Ye. V. Mikhal'tsev's work provided the impetus to an investigation of these important issues of railroad economics. Evaluating the effect of indicators of the use of rolling stock on railroad operating costs was given significant treatment in the work of V. N. Orlov and A. S. Chudov [89, 94].

An important role in study of this problem belongs to the division of economics at TsNII MPS [Central Scientific Research Institute of the Ministry of Railroads]* and a number of educational institutions [24, 60] which, on the basis of work done earlier, have elaborated proposed methods of evaluation and promoted their introduction in practical railroad work.

It is most convenient to perform a monetary evaluation of the indicators of use of rolling stock by the method of expenditure rates which are set for accepted measures of operations work. After the expenditure rates are determined, it is determined how change in the indicators of rolling stock use being evaluated is reflected in the magnitude of the measures and, consequently, on the expenditures of the railroad or its production subdivision.

Indicators such as car turnaround time and average daily run, car downtime in repair, at stations, and en route are evaluated by measures that reflect time because the expenditures connected with these indicators are determined by time. Thus, the turnaround of freight cars, average daily run and downtime of cars at stations affect expenditures for repair and depreciation which depend on time, and therefore are measured by car-hours. One hour of actual car downtime is adopted for the evaluation. The consolidated measure of car-hours is also used to evaluate car downtime as a result of change in section speed.

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*In 1951 engineer N. P. Kornilov was the first to work out methodological instructions for a monetary evaluation of fulfillment of planned norms for use of rolling stock. In 1954 A.V. Izosimov's "Denezhnaya Otsenka Pokazateley Ekspluatatsionnoy Raboty Zheleznykh Dorog" [Monetary Evaluation of Indicators of the Operations Work of Railroads] was published as No 96 in the series of works of the TsNII MPS. No 218 of the series, "Ekonomicheskaya Otsenka Ekspluatatsionnykh Pokazateley Raboty Dorog" [Economic Evaluation of the Operations Indicators of Railroad Work] edited by A. G. Zakharov was published by TsNII MPS in 1961. In recent years a series of important studies has been carried out under the general direction of A. P. Abramov.

The average daily run of locomotives is also evaluated by a measure of time. This measure is the locomotive-hour, which includes all expenditures associated with the locomotive in operation: use of fuel and electricity, depreciation deduction related to replacement, and payment of locomotive crews. This measure is also used to evaluate locomotive downtime at stations, in the depot, and in repair.

The evaluation of a locomotive-hour, just like that of a car-hour, may differ depending on the conditions in which it is made. For example, if locomotive downtime at a station without a crew is evaluated, the costs of paying the crew should not be considered in determining expenditures for each hour of such locomotive downtime.

Switching work is evaluated by time spent by switch engines. In this case the measure of a switch engine-hour includes not only costs of depreciation and expenditures for maintenance and operation of the switch engine, but also the cost of paying train crews employed in switching work and certain other expenditures.

The section speed of travel reflects the time that the train is en route and is evaluated by the measure of train-hours. This measure is also used to evaluate train downtime for various reasons.

The other group of indicators is evaluated differently. These are the load and empty runs of cars, auxiliary use of locomotives, locomotive travel between repairs, gross weight of the freight train, and others. These indicators influence expenditures that depend on the run, and therefore they are evaluated by measures that reflect distance traveled.

Car loading has a significant impact on the operating costs of a road. With a constant volume of shipping increasing the car load decreases the number of car-kilometers. For this reason the measure of car-kilometers is used to evaluate the car load. Evaluating car loading with two measures, both car-kilometers and car-hours, makes the calculation somewhat more accurate but much more complex [117].

Reducing empty runs by cars, when accomplished by improving the planning of shipping in large sectors not by taking on additional freight shipments in the empty direction, is also evaluated in car-kilometers. In the case where the empty run of the cars is reduced by taking on additional shipping in the empty run directions, the economic impact is determined by a separate calculation.

Distance traveled by locomotives alone is measured in locomotive-kilometers of lone travel.

Because the number of train-kilometers performed changes with a change in the gross weight of a train, the evaluation of this index is done by a consolidated measure of train-kilometers.

Table 14 below gives a general picture of the relationship between the qualitative indicators of locomotive and car use and consolidated measures for their evaluation.

Table 14. Relationship of Qualitative Indicators of Rolling Stock Use to Consolidated Measures of Operations Work

Indicator of Rolling Stock	Measure by Which Evaluation Is Made
For Cars	
Turnaround and Average Daily Run of Freight Cars	Car-Hours
Static Load	Car-Kilometers of Freight Cars
Empty Run Distance	" " " " "
Passenger Car Load Factor	Passenger Car-Kilometers
Car Downtime for Repair	Car-Hours
For Locomotives	
Average Daily Run	Locomotive-Hours: Without Crews; With Crews
Auxiliary Run Distance (Travel Alone, Pushing, and Double Traction)	Locomotive-Kilometers of Auxiliary Use
Distance Run Between Rapiars	Locomotive-Kilometers
Downtime for Repair	Locomotive-Hours
For Trains	
Gross Weight of Freight Train	Train-Kilometers
Speed of Travel	Train-Hours
Switching Work	Switching Locomotive Hours
Train Downtime	Train-Hours

When evaluating the quality of use of rolling stock, indicators must be chosen so that they do not reflect changes in the same expenditures. For example, to avoid duplicate counting the change in car turnaround and average daily run cannot be evaluated at the same time. If several indicators change at the same time under the effect of a certain factor, it is better to evaluate them together by a separate calculation because there may be fairly significant error when evaluated by particular indicators because of failure to consider the mutual influence of the indicators on one another. Thus, for two simultaneously changing indicators error goes up 2.6 percent, while for three it goes up to 8.7 percent.

The use of a combined calculation makes it possible to receive a more accurate evaluation of the effect from introducing progressive methods of using rolling stock, which usually improves several indicators of railroad operations work at once, not just one. It is necessary first of all to establish indicators which are influenced by the method under consideration, and then to evaluate them, identifying the savings of operating capital and capital investment. For a correct determination of the economic impact it is advisable to establish the relative, not absolute change in operating indicators.

Moreover, an improvement in the use of rolling stock cannot be evaluated by certain indicators only, disregarding change in other indicators and existing operating conditions. For example, it is not permitted to evaluate an increase in the gross weight of a freight train only by number of train-kilometers saved because in this case the distance traveled by the locomotive alone in the empty direction may increase, which will decrease the economic benefit of organizing shipping in heavier trains. Operating such trains in just one section may cause a certain increase in the volume of switching work related to additional train processing. Therefore, when determining the efficiency of organizing shipping in heavier trains, it is essential to consider change in both the number of train-kilometers, the amount of locomotive travel alone, and the volume of switching work evaluated by the appropriate measures.

When indicators of the use of rolling stock are being evaluated, it is necessary to establish what factors cause them to change. Thus, the average daily run of a locomotive may increase because of reduced downtime at the depot without a crew or by reducing downtime at stations with a crew or increasing the technical speed of travel. The evaluation will differ in each of these cases.

Before determining unitary expenditure rates and setting consolidated rates for the measures in Table 14, net freight and passenger work must be separated. According to the operative "Methodological Instructions on Calculating the Prime Cost of Railroad Shipping" (Moscow, Transport Publishing House, 1977), this breakdown of expenditures is done by the road section who send their figures to the road administration. The administration puts all the data from the sections together for the road and determine the prime cost of freight and passenger conveyance.

When breaking down expenditures by types of conveyance the road sections classify one group of expenditures directly with passenger or freight traffic and divide the other part of expenditures up proportional to the particular measures envisioned by the "Methodological Instructions" of the Ministry of Railroads. The distribution of expenditures done for 1975 showed that 80.9 percent of all expenditures are related to freight traffic and 19.1 percent to passenger traffic.* In this case 41.6 percent of the expenditures were directly assigned to passenger or freight traffic and 58.4 percent was divided between the types of conveyance.

Railroad expenditures are broken down not only by types of conveyance but also by types of traction. This breakdown is also done using the "Methodological Instructions" of the Ministry of Railroads for Calculating the prime cost of rail conveyance. In this case one part of expenditures is assigned directly to the particular type of traction and the rest is divided up proportionally using measures established by the "Methodological Instructions." The results of the breakdown of expenditures by types of conveyance and types of traction are shown in Table 15 below.

Table 15. Railroad Expenditures for Freight and Passenger Conveyance with Different Types of Traction in 1975, percentage

Type of Traction	All Expenditures	Included in That Freight	Included in That Passenger
Electric, total	44.3	34.6	9.7
Included in Above:			
Electric Locomotives	40.9	34.6	6.3
Electric Trains	3.4	-	3.4
Diesel, total	54.1	45.0	9.1
Included in Above:			
Diesel Engines	53.2	45.0	8.2
Diesel Trains	0.9	-	0.9
Steam	1.6	1.3	0.3
Total	100.0	80.9	19.1

The expenditures distributed by types of conveyance and types of traction in the road sections are consolidated for the road as a whole. Then the general expenditures of road administration are added to them and total expenditures related to freight and passenger traffic are finally established with a breakdown by types of traction. The unitary expenditure rates for the measures of work adopted for the entire road are calculated on the basis of these data.

* The introduction of a new "Nomenclature of Expenditures for Basic Activities of Railroads" (Moscow, Transport Publishing House, 1975) on 1 January 1976 and new "Methodological Instructions for Calculating the Prime Cost of Railroad Shipping" (Moscow, Transport, 1977) may change the distribution of expenditures made for 1975 to some extent.

Another source of raw data used to determine the expenditure rates for measures of rolling stock work in freight and passenger traffic by types of traction is the report data of the railroad on fulfillment of measures of operations work and indicators of the use of rolling stock.

When evaluating the efficiency of use of rolling stock the following must be kept in mind. The larger the subdivision of railroad transportation whose report data is used to determine expenditure rates, the less accurate the evaluation result using them will be. The most precise evaluation is achieved when expenditure rates are determined for road sections and, if necessary, refined for specific sectors, divisions, and sectorial line enterprises.

Expenditure rates that vary by types of traction cannot be accurately determined for a current period on the basis of report data on railroad expenditures and measures of rolling stock work alone. This is because the actual report figures on expenditures reflect changes that have taken place in the report year with respect to wage rates and systems of road employees and changes in prices for fuel, electricity, materials, and the like. Therefore, the actual expenditures of the road are recorded for different price levels, wage rates, and other changed conditions. Moreover, there may be changes during the year in expenditures in connection with shortages of particular materials, unproductive expenditures, faulty work, and other factors. All this requires that expenditure rates calculated on the basis of report data be refined, and in some cases they must simply be determined from planning and normative figures only.

A number of books and booklets have presented the methodology of the monetary evaluation of indicators of railroad operations in detail [11, 49, 50, 117]. In addition, the division of economics of TsNII MPS together with the Economic Planning Administration of the Ministry of Railroads worked out "Methodological Instructions on Monetary Evaluation of Indicators of Railroad Operations" [Moscow, Transport Publishing House, 1973) which, with certain refinements [116], make it possible to evaluate indicators under current conditions. For this reason the methodology of calculating expenditure rates will not be presented in this book.

A somewhat distinctive feature of the expenditure rates given above as compared to the rates ordinarily used to evaluate indicators of the use of rolling stock by expenditure rates is that the expenditures for locomotive and car repair are broken into three measures that reflect time, distance run, and use of fuel or electricity. The author employed this breakdown to evaluate the indicators of use of rolling stock in earlier works, and it is recommended in work [10, p 126].

Table 16 and 17 give approximate expenditure for freight and passenger conveyance by railroads working with different types of traction.

Table 16. Expenditure Rates for Freight Shipping with Electric and Diesel Traction Based on 1975 Figures, kopecks

Measure	Type of Traction: Electric	Diesel
Car-Kilometer	0.32	0.32
Car-Hour	5.36	5.36
Locomotive-Kilometer	6.1	11.4
Train Locomotive-Hour	98.1	148.9
Kilogram of Standard Fuel	-	4.9
Kilowatt-Hour of Electricity	1.8	-
Gross Ton-Kilometer	0.017	0.017
Hours of Work by Guards [konduktory] on Trip, Pickup, and Boundary-Crossing Trains	107	107
Crew-Hour of Locomotive Crews (All Trains)	312	322
Included in Above:		
Transit and Trip Trains	314	327
Pickup and Boundary-Crossing Trains	264	277
Switch Locomotive-Hour:		
Diesel Engine	785	785
Steam Engine	986	986
Electric Engine	454	-
Ton Shipped	2.64	2.64
10 Net Ton-Kilometers	0.824	1.085

Note: When a "one-man" crew operates a diesel switch engine the expenditure rate for one diesel switch engine-hour is 680 kopecks.

Table 17. Expenditure Rates for Passenger Conveyance with Different Types of Traction Based on 1975 Figures, kopecks.

Measure	Type of Traction: Electric Locomotive	Electric Train	Diesel Locomotive	Diesel Train
Car-Kilometer	0.7	-	0.7	-
Car-Hour	25	-	25	-
Locomotive-Kilometer	5.9	-	9.8	-

[Table continued on next page]

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[Table 17 Continued]

Measure	Type of Traction Loco-motive	Electric Train	Loco-motive	Diesel Train
Train Locomitive-Hour	80.6		138	
Train Kilometer	-	12.6	-	19
Train-Hour	-	235.5	-	289
Kilogram of Standard Fuel	-	-	7.6	11.8
Kilowatt-Hour of Electricity	2.05	2.48	-	-
Gross Ton-Kilometer	0.017	0.017	0.017	0.017
Hour of Work by Pneumatic Baggage Delivery Unit on Trains	84	-	84	-
Crew-Hour of Locomotive Crews of Express, Long-Distance, and Local Trains	350	-	340	-
Same for Suburban Trains	330	313	318	303
Hour of Work by Guards [provodniki] of Passenger Cars of Long-Distance and Local Trains	89	-	89	-
Same for Suburban Trains	78	96	78	78
Switch Locomotive-Hour:				
Diesel	785	-	785	-
Electric	454	-	-	-
Steam	986	-	986	-
Dispatched Passenger	3.7	0.34	3.7	0.34
10 Passenger-Kilometers	2.538	2.311	3.610	4.158

Note: The expenditure rates per train-kilometer and train-hour were determined for an ER1 electric train with 10 cars in the case of electric traction and a four-car diesel train for diesel traction.

The expenditure rates calculated for average railroad working conditions can also be determined, when necessary, for road sections taking specific working conditions, type of rolling stock used, and traffic intensity into account.

3. Evaluation of Indicators of Car Use

Among the indicators that characterize how well cars are used, freight car turnaround occupies a special place. In a monetary evaluation evaluation of this indicator car turnaround time can be broken down into the following constituent parts.

1. The time that the car spends in loading and unloading operations. Every railroad has norms for car downtime for loading and unloading.

If one knows actual car downtime for loading and unloading and downtime according to the norm as well as the number of cars loaded and unloaded, it is possible to determine the savings or waste of car-hours at the station for a given period with respect to this element of car turnaround. In 1975 downtime for loading operations and stations accounted for 34.2 percent of freight car turnaround time. Mechanization of loading and unloading work and increasing the number of paired operations are important ways to reduce car downtime for loading and unloading.

2. The time that a car spends at technical stations which it passes through in one cycle depends on the length of car processing at these stations and the number of cars going through processing at the stations. Downtime at technical stations accounted for 34.9 percent of total freight car turnaround time in 1975. Reducing the number of cars that goes through stations with processing reduces the total time that cars are at technical stations. Organizing shipping by unit [marshrutnyy] trains is an important reserve that makes it possible to reduce the number of stations at which trains are processed, thus reducing the number of car-hours and accelerating car turnaround.

3. The time that a car is in motion is closely linked to the traveling speed of the trains and the full run of the car. The higher the technical speed of travel is and the shorter the full run, the quicker the car will be turned around. In 1975 the average car was in motion 22.2 percent of total turnaround time. The length of freight shipping and distance traveled by cars (empty) have a significant impact on the full run of the cars. Reducing the average distance of shipments and the distance traveled when empty are, in addition to increasing technical speed, important factors in accelerating car turnaround.

4. The time that a car is stopped at intermediate stations is the difference between the time that the car is en route and the time actually in motion. In 1975 the average car spent 8.7 percent of total turnaround time at intermediate stations. Reducing the number and length of train stops at intermediate stations increases the section speed and therefore accelerates car turnaround.

As we see, all the constituent parts of car turnaround time can be measured in car-hours.

At one time various investigators proposed several methods of evaluating the car-hour. They are all determined to a significant degree by the activities which are to be evaluated using this indicator. The present work considers just one of the possible methods of evaluating the car-hour to determine the efficiency of improving railroad operations.

When car-hours are saved expenditures for car repair and depreciation are reduced. Under average conditions of the system, the expenditure rate for one car-hour is 5.4 kopecks. If we know the total number of car-hours saved, it is always possible to determine the savings of operating capital obtained from accelerating car turnaround. The savings determined by the number of car-hours saved, however, is far from a complete characterization of the impact of accelerating car turnaround. For example, when car turnaround is accelerated it becomes possible to ship a larger number of loads. This impact cannot be fully evaluated in monetary terms on a national economic scale. But even for railroad transportation, to evaluate it at 5.4 kopecks per car hour is inadequate. Therefore, the method proposed way back in 1932 by V. N. Orlov and M. D. Gordon for evaluating car-hours has become quite popular in practice [89, p 203]. The evaluation is made based on the effect obtained from the larger volume of shipping made possible by accelerating car turnaround. A slowdown in car turnaround, by contrast, leads to the failure of railroad transportation to perform all freight shipping required of it and, consequently, hypothetical losses. In other words, according to this method the effect is evaluated by the amount of hypothetical savings of operating capital obtained from reducing the share of independent expenditures in performing additional shipments in cars made available by accelerating car turnaround.

Let us suppose that through the skillful work of station employees car turnaround has been accelerated saving 24 car-hours, and that the car freed is used for additional shipment. If we assume that the load of a working car under these conditions is 28 tons and the average daily run is 260 kilometers, the car will do 7,280 ton-kilometers of work in a day (28 × 260). Because the amount of independent expenditures does not change, the savings is six rubles (0.082 × 7,280, where 0.082 is the average share of independent expenditures in the prime cost of shipping for all types of traction). In other words, one car-hour will cost 25 kopecks (six rubles/24). The total money savings linked to one car-hour will be 30.4 kopecks (5.4 + 25).

In conditions where the railroads are experiencing a shortage of cars, this method of evaluating the car-hour is entirely applicable to determine the impact of accelerating car turnaround.

There are some who think [24, p 258] that when car turnaround is accelerated no such savings of operating capital is achieved because neither the depreciation deductions for replacement nor capital for current car repair included in the expenditure rate per car-hour changes for the fleet of cars remains to be seen (it is just used better). This proposition is correct only if the volume of shipping is unchanged. In reality, however, shipping is steadily growing and the cars made available by accelerating turnaround are used to meet this demand. If car turnaround were not accelerated it would be necessary to acquire more new cars to cover the growth in shipping.

Therefore, if car turnaround is accelerated depreciation deductions for replacement and expenditures for current repair will be less than if growth in shipping were handled entirely by newly delivered cars.

For the same reasons, the decrease in capital investment for the delivery of new cars should be taken into account in evaluating the acceleration of car turnaround. If there were no acceleration of car turnaround and consequently no additional cars were made available, more new cars would have to be bought to cover the growth in shipping and capital investment in the fleet of cars would increase.

Let us consider a concrete example of a reduction in capital investment for new cars to cover increased shipping. Suppose that a system is working at the level of 6,000 cars a day. If car turnaround time is 60 hours the working fleet will be 15,000 cars (6,000 × 60/24). If car turnaround is accelerated by one hour, the required size of the car fleet will drop to 14,750 (6,000 × 59/24). If the 250 cars freed are used to handle the growth in shipping it will not be necessary to order 250 new cars and the capital investment savings with an average car price of 6,120 rubles [56, p 48] will be 1,530,000 rubles (250 × 6,120), which is 70 kopecks [1,530 × 10^5/250 × 24 × 365)] per car-hour.

In addition, for a complete evaluation the influence of accelerating car turnaround on the turnover rate of physical assets in the shipping process must be considered. T. S. Khachaturov has proposed a technique for evaluating this influence [108, p 93].

The essence of the method is as follows. The total value of the freight C_o located in shipment each day is

$$C_0 = \frac{ЦPO}{365}, \qquad (15)$$

where P is the volume of freight shipping per year in tons; O is car turnaround in days; Ц is the average price of one ton of the freight being shipped in rubles; 365 is the number of days in the year.

When car turnaround is accelerated to O' days the physical assets M_{OB} freed from working capital in a day will be

$$M_{ов} = \frac{ЦP(O-O')}{365}. \qquad (16)$$

The value of the freight per car-hour can be determined from this. If the car load is taken as 45 tons, when car turnaround is accelerated one hour and the average price of a ton of freight is 190 rubles [56, p 22], physical assets worth 97.6 kopecks [(45 × 190 × 100)/(24 × 365)] will be freed for each car-hour in the course of the year.

Thus, the effect of accelerating car turnaround by one hour can be evaluated by a savings of operating capital of 30.4 kopecks, a reduction of 70 kopecks in capital investment for the car fleet, and 97.6

kopecks of physical assets freed from the shipping process. To make it easier to evaluate the use of cars, the physical assets freed, which are part of working capital, may somewhat arbitrarily be classified as capital investment.

The car-hour unit of measure is used for other indicators of use of the car fleet in addition to car turnaround. The principal ones are the average daily run of cars and car downtime for repair.

Because it is a generalizing indicator, car turnaround also reflects average daily run. Therefore, the indicator of average daily car run could be disregarded because a change in it will be reflected in car turnaround. In certain cases, however, a separate evaluation of change in the average daily run of cars is necessary. Let us assume that the average daily run of a car increases from 253 to 274 kilometers, that is by 21 kilometers. This causes an acceleration of car turnaround of (274 - 253) 24/253 = 2 hours. Thus, increasing the average daily run by one kilometer is equivalent to accelerating car turnaround by 0.09 hours (2/21).

It must be kept in mind that increasing the average daily run of a car does not always afford an identical savings in car-hours, which depends on the length of the average daily run and, consequently, will differ in size relative to an increase in it.

Car loading is another important qualitative indicator of the use of railroad cars. Increasing the load leads to a decrease in the distance run by cars and locomotives, gross ton-kilometers, and expenditures of fuel and electricity for shipping. In addition, there is a reduction in expenditures for repair, lubrication, depreciation of rolling stock, ongoing maintenance and depreciation of main routes, and payment of locomotive and train crews.

The savings from increasing car loading is most conveniently linked to the measure of "car-kilometers saved." Calculations made with a technique developed earlier [49] show that this savings depends on the type of traction and will be 2.2 kopecks for electric and 2.4 kopecks for diesel traction. In this case the amount of the savings related to one car-kilometer saved is practically independent of car loading and can be taken as constant for both types of traction.

Establishing the so-called "influence factors" of indicators of rolling stock use on railroad operating expenditures and the prime cost of shipping is highly interesting. The methodology for determining influence factors has been considered most fully by professor Ye. V. Mikhal'tsev [79, p 163]. According to his methodology all indicators of rolling stock use are broken into two groups according to their impact on expenditures: inverse factors, where expenditures decrease when the indicator increases; direct, where an increase in the indicator means an increase in expenditures.

If the change in operating expenditures (as a percentage) caused by relative increase in an indicator of rolling stock use γ (in fractions of one) is designated as Δ, the influence factor of this indicator on expenditures z for inverse indicators of rolling stock use can be represented in the form

$$z = \frac{\Delta (1+\gamma)}{\gamma}. \qquad (17)$$

Calculations show that when car loading is increased 10 percent the prime cost of 10 ton-kilometers moved by electric traction drops from 2.148 to 2.079 kopecks or 3.21 percent, so the influence factor of loading is

$$\frac{3.21\ (1 + 0.1)}{0.1} = 32.4\%$$

The corresponding calculation for diesel traction shows the influence factor of loading to be 31.1 percent.

Thus, when the car load is increased one percent the prime cost of shipping decreases 0.324 percent for electric traction and 0.311 percent for diesel. In other words, for practical purposes the relationship between the influence factor of loading and type of traction is negligible.

The number of car-kilometers saved is also used to evaluate a reduction in empty runs by cars achieved by better planning of shipments. When the proportion of empty runs to loaded runs for cars increases by one percent (absolutely) the prime cost of shipping for diesel traction increases 0.227 percent. Unlike car loading, the empty run indicator is a direct one, because when it increases railroad expenditures also rise. Therefore, the influence factor of the empty run indicator on the prime cost of shipping is determined by the formula

$$z = \Delta \div \gamma \qquad (18)$$

Let us suppose that the empty run distance of cars relative to the loaded run increased by one percent absolutely or 2.56 percent relatively. The prime cost of 10 ton-kilometers with electric traction rose from 2.148 to 2.153 kopecks as a result, an increase of 0.278 percent. The influence factor of the empty run indicator will thus be 0.278/0.0256 = 10.9 percent.

For diesel traction the influence factor of the empty run indicator on the prime cost of shipping will be 8.9 percent.

Evaluation of the average daily productivity of a car Π_B involves a generalizing indicator that depends on fulfillment of three indicators, namely: dynamic load of loaded car P^{r}_{α}, percentage of car distance run empty relative to distance run loaded α, and average daily run of cars S_B. This is determined by the following formula

$$П_в = \frac{П^г_д S_в}{1+\alpha}. \qquad (19)$$

The result of the evaluation depends on which particular indicators change to cause change in average daily car productivity. If the change comes from two of the above-mentioned indicators, the evaluation may be done by adding the impacts of the change in these indicators. Where all three indicators change and one or two of them may be worse, car productivity must be evaluated in a complex manner taking into account the mutual influence of the indicators. In this case, comparative calculations should be made of change in the prime cost of 1,000 net ton-kilometers under the old and new operating conditions and the effect of raising car productivity established for the entire volume of shipping done in the period during which the change in car productivity resulting from these indicators took place [49].

Evaluation of the indicator of car use in passenger traffic is also very important. Let us consider, for example, how improving such indicators as the coach loading factor and speed of travel of passenger trains affect the reduction of operating costs.

To determine the efficiency of increasing the coach loading factor of passenger cars, first of all we must calculate the expenditures per train-kilometer. Table 18 gives such a calculation.

The following figures were adopted for the calculation in Table 18: an express passenger train of 14 cars, including 11 passenger cars, one baggage car, one mail car, and one dining car; average road traveling speed of 54 kilometers an hour; average daily run of express passenger trains — 600 kilometers (the magnitude of this distance depends on many factors, in particular on the length of the train's trip, the amount of time it is down at turnaround points, and other factors*); coefficient of out-of-train work by guards and baggage handlers — 1.27; the same coefficient for locomotive crews — 1.48; expenditure of electricity per 10,000 gross tons-kilometer — 167 kilowatt-hours; weight of passenger train — 1,050 tons.

With an average coach load factor in long-distance travel of 32.8 persons a total of 361 passenger-kilometers will be performed in one train-kilometer (32.8 × 11). If the coach load factor is increased by four, 405 passenger-kilometers will be done (361 + 4 × 11) and expenditures per passenger-kilomter will decrease by 0.045 kopecks [148.68 × (1/361 - 1/405)].

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* Questions related to the use of passenger cars are considered in detail in [118].

Table 18. Expenditures per Train-Kilometer for an Express Passenger Train on Electric Traction (ChS2 Electric Engine).

Измеритель (a)	Расходная ставка, коп. (b)	Величина измерителя (c)	Общий расход, коп. (d)
(e) Вагоно-километр	0,7	14	9,8
(f) Вагоно-час	25	$\frac{14 \cdot 24}{600} = 0,55$	13,75
(g) Локомотиво-километр . .	5,9	1	5,9
(h) Локомотиво-час	90,6*	$1 : 54 = 0,0185$	1,68
(i) Час работы проводников вагонов	89	$\frac{(2 \cdot 11 + 2)\ 1.27}{54} = 0,564$	50,20
(j) Час работы приемо-сдатчиков багажа в поездах . .	84	$\frac{1 \cdot 2 \cdot 1,27}{54} = 0,047$	3,95
(k) Бригадо-час локомотивных бригад	350	$\frac{1 \cdot 1,48}{54} = 0,0274$	9,59
(l) Тонно-километр брутто . .	0,017	1050	17,85
(m) Киловатт-час электроэнергии	2,05	$\frac{167 \cdot 1050}{10\,000} = 17.51$	35,96
Итого (Total) .	—	—	148,68

Key:
(a) Measure;
(b) Expenditure Rate, kopecks;
(c) Amount of Measure;
(d) Total Expenditure, kopecks;
(e) Car-Kilometer;
(f) Car-Hour;
(g) Locomotive-Kilometer;
(h) Locomotive-Hour;
(i) Hour of Work by Train Guards;
(j) Hour of Work by Baggage Handlers on Trains;
(k) Hour of Work by Locomotive Crew;
(l) Gross Ton-Kilometer;
(m) Kilowatt-Hour of Electricity.

* The expenditure rate per locomotive-hour for the ChS2 electric engine, in kopecks.

Thus, the savings for each additional passenger-kilometer performed will be 0.045 × 405/44 = 0.41 kopecks.

When the load factor of suburban electric train cars is increased, the savings for each additional passenger-kilometer performed is 0.25 kopecks.

To determine the savings of capital expenditures from increasing the coach load factor of passenger cars it is necessary to establish the proportion of these expenditures used for one additional passenger-kilometer. According to calculations, the reduction in capital investment for one additional passenger-kilometer is 0.86 kopecks for long-distance passenger trains and 0.72 kopecks for suburban trains using motorcar traction.

Evaluation of the traveling speed of passenger trains, just like that of freight trains, can be done by the consolidated measure of train-hours.

Table 19 gives a calculation of expenditures associated with one hour of downtime for an express passenger train on electric traction. From the calculation we can see that one hour of express train downtime costs 31 rubles 99 kopecks. In suburban transportation expenditures for one hour of downtime of an ER1 electric train are seven rubles 40 kopecks.

Table 19. Expenditures for One Hour of Downtime of and Express Passenger Train with a ChS2 Electric Engine.

Measure	Expenditure Rate, kopecks	Amount of Measure	Total Expenditure, kopecks
Car-Hour	25	14	350
Locomotive-Hour	90.6*	1	90.6
Hour of Work by Train Guards	89	2×11+2=24	2,136
Hour of Work by Baggage Handlers	84	2×1=2	168
Hour of Work by Electric Locomotive Crews	350	1	350
Kilowatt-Hour of Electricity	2.05	51#	104.55
Total	-	-	3,199.15

* 90.6 is the expenditure rate for one locomotive-hour of the ChS2 electric engine, in kopecks.

51 is electricity used for one hour of downtime by a ChS2 electric engine in working condition, kilowatt-hours.

In the above examples of evaluting the use of passenger cars losses associated with delaying passengers en route were not determined. Evaluating passenger time savings is one of the most complex problems and requires independent study.

4. Evaluation of Indicators of Locomotive Use.

One of the most important indicators of locomotive use is the gross weight of the train. An increase in this indicator has a large impact on reducing operating costs for shipping. When the weight of a train is increased, there are savings related to amounts spent for locomotive repair and depreciation, fuel and electricity to pull trains, expenditures for locomotive and train crews, and ongoing maintenance and depreciation of trunk lines and artificial structures.

The saving achieved by increasing the gross weight of a train may be linked to the measure of train-kilometers. The greater the weight of the train is, the smaller the number of train-kilometers will be for a constant shipping volume. Knowing the savings for each train-kilometer eliminated, it is possible to determine the total savings from increasing train weight. Let us suppose that the gross weight of a train in a circulation sector of 1,500 kilometers is increased from 3,000 to 3,600 tons, an increase of 20 percent. The number of train-kilometers will then decrease from 1,500 to 1,250, which means that 250 train-kilometers will be saved. To establish the extent to which increasing train weight reduces operating costs, we will determine the amount of savings for each train-kilometer saved.

The methodology for calculating expenditures associated with performing one train-kilometer is given in [89, p 191]. When the weight of a train increases, however, not all expenditures which are usually related to this measure are reduced. Some of them do not change in amount and, therefore, should not be considered in determining the savings linked to train-kilometers. For example, the sum of expenditures for car repair, lubrication, and depreciation will not change depending on the weight of the train, so no savings occurs there.

Other expenditures, for fuel and electricity to pull trains, locomotive repair, paying locomotive crews, and ongoing maintenance and depreciation of track installations increase in delayed fashion, not directly proportional to the increase in train weight. Therefore, when shipments are made in trains of increased weight the savings of operating capital occurs in precisely these expenditures and this must be considered in evaluating train weight.

The savings for each train-kilometer eliminated differs by type of traction and averages 71 kopecks for electric traction and 84 kopecks for diesel traction.

The weight of the train is one of the inverse indicators; in other words, when it increases operating costs decrease. Therefore, the influence factor of train weight on expenditures may be determined by formula (17).

According to calculations, the influence factor of train weight on expenditures is 21.1 percent for electric traction and 22.4 percent for diesel traction. Thus, when the gross weight of a train is increased one percent the prime cost of freight shipping decreases about 0.22 percent.

Increasing the gross train weight by q tons with a given weight norm for the train of Q, a trip distance of 1, and the same type of locomotive produces a savings in shipment Э of

$$Э = E\left(l - \frac{Ql}{Q+q}\right), \qquad (20)$$

where E is the savings obtained for one train-kilometer saved in rubles and $1-Q\ /Q+q_1$ is the number of train-kilometers saved.

As we can see, the quantity E is very important in formula (20). Studies [49] show that the savings per train-kilometer saved differ significantly for types of traction, but depend little on train weight; they depend much more on the type of locomotive. For approximate calculations the quantity E may be taken as the average for types of traction without differentiation by type of locomotive.

In addition to a savings of operating capital, increasing the gross weight of a train reduces the required size of the operating fleet of locomotives, and therefore also capital expenditures. The reduction in capital expenditures for each train-kilometer saved depends on the type of traction, and also on the cost of the locomotive. On the average it is 92 kopecks for VL8 electric engines, one ruble 62 kopecks for $VL80^k$ electric engines, one ruble 50 kopecks for TE3 diesel engines, and two rubles 10 kopecks for 2TE10L diesel engines.

The average daily run of locomotives depends on their traveling speed and downtime at crew change points and turnaround points. When the traveling speed increases the locomotives pass through circulation sectors faster and, if downtime is constant at initial and terminal turnaround points, the average daily run increases.

This increase may be a result of an increase in technical speed or of reducing downtime at intermediate stations. If the growth in average daily run occurs through an increase in technical speed, there is usually an additional requirement for fuel or electricity, but the savings in money for paying locomotive crews, depreciation of rolling stock, and other expenditures is noticeably reduced. Where the increase in average daily run is achieved by reducing locomotive downtime at intermediate stations and at crew and locomotive change stations, the savings is maximal.

Analysis of the daily time budget shows that electric and diesel engines are in motion about half of the day. The rest of the time goes for downtime at intermediate stations and crew change stations and at primary and turnaround depots. Thus, reducing locomotive downtime at stations is a major reserve for improving their use.

Increasing the average daily run of locomotives makes it possible to perform more shipping work with the same stock of locomotives. If the volume of shipping does not change, an increase in the average daily run saves locomotive-hours, which leads to a decrease in operating costs and a reduction in the number of locomotives required. Therefore, the savings from increasing the average daily run of a locomotive can be evaluated by the consolidated measure of hours of locomotive downtime. The evaluation can be done either for hours of locomotive downtime for a locomotive with crew or without the crew, depending on the particular case.

Table 20 below gives a calculation of expenditures associated with one hour of downtime for the VL8 electric engine.

Table 20. Expenditures for One Hour of Downtime for a VL8 Electric Engine and Crew.

Measure	Expenditure Rate, kopecks	Magnitude of Measure	Total Expenditure, kopecks
Locomotive-Hour	103.9*	1	103.9
Locomotive-Kilometer	6.1	1	6.1
Hour of Work of Locomotive Crews	312.0	1	312.0
Kilowatt-Hours of Electricity	1.8	102	183.6
Total	-	-	605.6

* The expenditure rate for one hour for the VL8 electric locomotive.

Where the downtime of the VL8 electric engine with crew is reduced one hour its average daily run will increase by 23.8 kilometers (571.1/24) and the savings of operating capital per kilometer of increase in average daily run will be 25.4 kopecks (605.6/23.8). When the downtime of an electric engine without crew is cut one hour the savings will be 293.6 kopecks and the increase in the average daily run from this will make it possible to reduce operating costs 12.3 kopecks per kilometer.

Similar calculations made for TE3 diesel engines show that the savings of operating capital for each kilometer of increase in average daily run by reducing the downtime of a locomotive with crew is 37.6-49 kopecks, while without a crew it is 21.1-32.5 kopecks.*

*The lower figure is for downtime of a TE3 diesel engine in working condition with the engine set on zero position of the controller; the larger figure is for an engine working on position VII. The fuel expenditure per hour of diesel engine downtime for these positions was taken as 49 and 94.5 kilograms respectively [92, p 273].

With an increase in average daily run there is not only a savings of operating capital, but also a decrease in capital investment because the required size of the locomotive fleet is reduced. Thus, if the average daily run of a VL8 electric engine is increased by one kilometer, if this engine costs 159,600 rubles and has an average daily run of 571 kilometers, 76.6 kopecks of capital investment is released to purchase new engines. Increasing the average daily run of a TE3 diesel engine, which costs 228,900 rubles, by one kilometer releases one ruble 33 kopecks of additional capital for the national economy.

When the section speed of freight trains is increased a savings of operating capital is formed by reducing expenditures to pay for locomotive crews and for locomotive and car repair and depreciation. Increasing section speed by reducing train downtime at stations also provides a savings of capital for fuel and electricity for the locomotives. The savings of operating capital may be determined by the measure of train-hours. Table 21 shows a calculation of expenditures related to train downtime for one hour.

Table 21. Expenditures for One Hour of Downtime for a Freight Train with a VL8 Electric Engine.

Measure	Expenditure Rate, kopecks	Magnitude of Measure	Total Expenditure, kopecks
Car-Hour	30.4*	53.6**	1,629.4
Electric Locomotive-Hour	103.9	1	103.9
Electric Locomotive-Kilometer	6.1	1	6.1
Hour of Work by Electric Locomotive Crew	312	1	312.0
Kilowatt-Hour of Electricity	1.8	102***	183.6
Total	-	-	2,235.0

* 30.4 is the expenditure rate for one car-hour considering savings of independent cost, in kopecks.

** 3,600/67.2 × 1 = 53.6 (67.2 is the gross weight of a car in tons arbitrarily adopted for the calculation).

*** 102 is the electricity used in one hour of downtime in working condition for a VL8 electric engine, in kilowatt-hours.

Expenditures related to one hour of downtime for a freight train with a TE3 diesel engine are 23 rubles 62 kopecks-25 rubles 85 kopecks (see footnote previous page).

The savings of operating capital formed with an increase in the section speed of train travel by reducing downtime at stations may be determined by multiplying train-hours saved by the expenditure rate established for the corresponding locomotive.

The measure of train-hours can also be used to evaluate indicators related to train downtime. For example, this measure can be used to evaluate losses from forced train stops en route and at closed entry signals of stations, from delay in dispatching trains, from an increase in train stops at intermediate stations, and other factors.*

The influence factor of the section speed of freight trains on operating expenditures, and therefore also on the prime cost of shipping, is 8.5 percent for electric traction and 9.9 percent for diesel. Thus, when section speed is increased one percent under average conditions for the rail system the prime cost of shipping will decrease 0.09 percent.

In cases where the section speed of train travel increases owing to increase in technical speed, the savings of operating capital is reduced by the additional expenditure of fuel and electricity to pull the trains. Thus, whereas a savings of fuel and electricity occurs when the weight of the train is increased, when the technical speed is increased the specific expenditure of fuel and electricity usually rises.

Table 22 below shows the change in expenditure of fuel and electricity for 10,000 gross ton-kilometers depending on train weight and traveling speed for different types of locomotives [92, p 293].

Table 22. Change in Specific Expenditure of Fuel and Electricity for Increase in Traveling Speed and Weight of a Freight Train, in percentage.

Indicator	Type of Locomotive: Electric			Diesel		
	VL8	VL23	VL80	TE3	2TE10	TE10
Decrease in Specific Expenditure of Fuel and Electricity when Gross Train Weight Is Increased One Percent	0.185	0.230	0.270	0.170	0.162	0.170
Increase in Specific Expenditure of Fuel and Electricity when Train Speed Is Increased One Kilometer/Hour	0.98	0.92	0.85	0.98	0.97	0.99

*In these cases the additional losses of fuel and electricity for acceleration and slowing down must be taken into account.

The influence factor of section speed on the prime cost of shipping when it changes owing to technical speed is 2.5 percent for electric traction and 3.3 percent for diesel traction.

The indicator of auxiliary use is also important for evaluating the use of locomotives. Certain types of auxiliary uses of train locomotives, for example running in double traction and pushing mode and performance of switching work by locomotives of composite trains are essential and generally promote better use of rolling stock. But other types of auxiliary uses, travel alone and conditional use which reflect locomotive downtime in working condition at depots and stations, are essential only within certain limits that depend on the nature of freight flows and the system of locomotive operation. It is the job of railroad workers to reduce the time spent by locomotives traveling alone and waiting at stations and depots.

Locomotive travel time alone can be evaluated by measurement in kilometers, while downtime can be measured in hours with and without a crew depending on the concrete conditions. The procedure for evaluating locomotive downtime was considered above. A change in the distance traveled by locomotives alone leads to growth or decrease in expenditures for fuel, repair, and lubrication of the engines, payment of locomotive crews, and so on.

Table 23 gives an example of calculating expenditures per kilometer of time traveled alone by electric engines.

As can be seen from table 23, reducing the distance traveled alone by a VL8 engine by one kilometer permits a savings of 27.7 kopecks of operating capital.

Expenditures associated with one kilometer run alone are determined in a similar manner for other types of locomotives. They are 35.3 kopecks for the TE3 diesel engine.

The use of railroad switch equipment depends greatly on time spent processing cars at stations. The use of improved methods of switching work makes it possible to save the working time of switch engines and crews and releases locomotives and cars.

The savings of capital related to maintaining switch engines and operating them must be taken into account to evaluate the economic impact of reducing the volume of switching work. This savings can be determined most simply by multiplying the number of switch engine hours saved by the expenditure rate calculated for one switch engine hour.

The expenditure rate for one switch engine hour given in Table 16 above includes expenditures for operation, maintenance, and repair of switch

Table 23. Expenditures per Kilometer of Distance Traveled Alone by a VL8 Electric Engine.

Measure	Expenditure Rate, kopecks	Magnitude of Measure	Total Expenditure, kopecks
Electric Locomotive-Kilometer	6.1	1	6.10
Hour of Work by Electric Locomotive Crew	312	$\frac{1+0.48*}{60*}$=0.0247	7.71
Kilowatt-Hour of Electricity	1.8	5 **	9.00
Gross Ton-Kilometer for Electric Engines	0.017	184 ***	3.13
Electric Locomotive-Hour	103.9	1/60=0.0167	1.74
Total	-	-	27.68

* 0.48 is the coefficient of auxiliary work by electric locomotive crews and represents the ratio of time spent by crews at crew change stations and locomotive turnaround points to the time that they work with trains in the circulation section; the speed of travel of an electric engine alone is taken as 60 kilometers an hour.

** 5 is the expenditure of electricity per kilometer of travel alone by a VL8 electric engine going 60 kilometers an hour, in kilowatt-hours.

*** 184 is the weight of the VL8 engine in tons.

engines and to pay train crews employed in switching work. When 23.5 diesel switch engine hours are released (0.5 hours goes for supplying), it is possible to reduce the fleet by one diesel switch engine and the savings of operating costs will be seven rubles 85 kopecks × 24 = 188 rubles 40 kopecks.

The savings of capital investment from freeing one switch engine hour are six rubles six kopecks for TEM1 diesel engines.

Like car productivity, the indicator of locomotive productivity should be evaluated depending on which particular indicators of locomotive use cause it to change.

The monetary evaluation of qualitative indicators of the use of rolling stock is given in summary form in Table 24 below.

Table 24. Monetary Evaluation of the Qualitative Indicators of Use of Railroad Rolling Stock.

Indicator	Consolidated Measure	Savings or Overexpenditure per Unit of Measure, kopecks: Operating Capital	Savings or Overexpenditure per Unit of Measure, kopecks: Capital Investment
Car Turnaround	Car-Hour	30.4	167
Car Loading:			
Electric Traction	Car-Kilometer	2.2	2.0
Diesel Traction	Car-Kilometer	2.4	2.2
Distance Run by Empty Cars	(This indicator is evaluated in the same way as car loading using the measure of the car-kilometer.)		
Coach Load Factor of Passenger Cars:			
Express Passenger Train with Electric Traction	Passenger-Kilometer	0.41	0.86
Suburban Electric Train	Passenger-Kilometer	0.25	0.72
Average Daily Run:			
VL8 Electric Engine	Locomotive-Kilometer	12.3-25.4*	77
TE3 Diesel Engine	Locomotive-Kilometer	21.1-37.6*	133
Downtime with Crew:			
VL8 Electric Locomotive	Locomotive-Hour	606	1,822
TE3 Diesel Engine	Locomotive-Hour	736	2,613
Downtime at Depot without Crew:			
VL8 Electric Locomotive	Locomotive-Hour	294	1,822
TE3 Diesel Engine	Locomotive-Hour	414	2,613
Gross Train Weight with:			
VL8 Electric Locomotive	Train-Kilometer	71	92
TE3 Diesel Engine	Train-Kilometer	84	150
Section Speed of Freight Trains for:			
VL8 Electric Locomotive	Train-Hour	2,235	6,070
TE3 Diesel Engine	Train-Hour	2,585	6,440
Section Speed of Passenger Trains with ChS2 Electric Locomotive	Train-Hour	3,199	8,727

[Continued on next page]

Indicator	Consolidated Measure	Savings or Overexpenditure per Unit of Measure, kopecks: Operating Capital	Capital Investment
Same for ER1 Electric Train	Train-Hour	740	4,285
Lone Travel Time:			
VL8 Electric Locomotive	Locomotive-Kilometer	28	77
TE3 Diesel Locomotive	Locomotive-Kilometer	35	133
Work of Special TEM1 Diesel Switch Engines	Switch Engine-Hour	785	606

* The lower figure represents the increase in average daily run by reducing locomotive downtime at stations without a crew, while the larger figure is with a crew.

The figures in Table 24 on monetary evaluation of indicators or the use of rolling stock can be employed to establish an approximate evaluation of the efficiency of use of locomotives and cars for an entire system, its sections, and sectorial line enterprises.

In cases where more than two indicators of the use of rolling stock change at the same time, it is wise to determine the economic result of their change in a complex manner, that is, taking into account the mutual influence of the indicators. Moreover, in many cases it is completely impossible to consider the result of simultaneous change in several indicators because it may be counted twice. For example, one cannot record the economic impact of reducing locomotive downtime at stations and simultaneously the resulting effect on increase in average daily run of locomotives.

Fullest possible use of locomotives and cars, increasing the traveling speed of trains, outstanding maintenance of permanent railroad installations, above all track structures and signal and communications units, create all necessary conditions for safe, fast performance of freight and passenger conveyance.

Correct organization of the work of railroad workers, improving the quality of operations work, and developing socialist competition for fullest use of locomotives and cars and for economy with materials, fuel, electricity, and spare parts, reduce operations expenditures and the material-intensiveness of shipping and raise the profitability of work by railroad transportation.

Organizing evaluation of the work of shops, shifts, crews, and individual workers in all production subdivisions of the railroads will make possible better organization of socialist competition to reduce the prime cost of shipping. It is important here that the economic impact of fulfilling qualitative work indicators be told to the workers themselves in time.

In practice, there are often difficulties with evaluating the quality of work by railroad workers. Dispatchers, station duty personnel, locomotive engineers, rolling stock and track repair workers, car inspectors, and other employees must know what effect their work has on production and financial results of the activities of the entire enterprise and the railroad as a whole. The monetary evaluation of indicators of the use of locomotives and cars considered above should help the railroads, road sections, and line enterprises make correct evaluations of the quality of operations work and fulfillment of indicators for use of the fixed capital of railroad transportation.

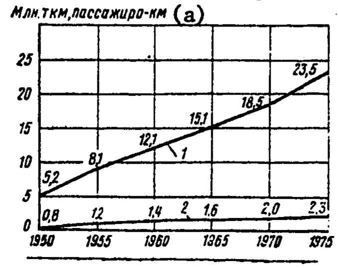
5. Improving the Use of Permanent Structures

The technical condition of permanent railroad structures is very important for fuller use of rolling stock. The indicators that characterize the use of permanent structures are measures of operations work: locomotive-kilometers, gross ton-kilometers, train-kilometers, and others figured per unit of measure of the permanent structure. For example, the intensity of use of railroad track is determined by freight intensity in gross ton-kilometers per kilometer of trunk track length; the catenary system by number of current collectors (trolleys) passed per kilometer of length of the mainline catenary system; communications and signal units by the number of train-kilometers and locomotive-kilometers of lone travel per kilometer of operating length of track equipped with the particular devices, and so on.

For each type of permanent railroad structure, therefore, there is a particular indicator with which the intensity of its use can be judged. In their turn, the measures of operations work and other indicators that characterize the use of permanent structures are closely related to the volume of transportation output. Therefore, the intensity of use of all permanent railroad structures can also be characterized by the volume of shipping in tons or ton-kilometers and passenger kilometers per unit of measure of the structure.

Figure 9 below shows the growth in density of freight and passenger traffic in recent years. As can be seen, the average density of freight (freight intensity) and passenger (passenger intensity) per kilometer of operating railroad is increasing each year. Compared to 1950 the intensity of use of permanent railroad structures in 1975 was 4.5 times greater for freight shipping and almost three times greater for passenger conveyance. The figure rose particularly during the Ninth Five-Year Plan. Thus, in 1975 the growth in average freight intensity of the railroads compared to 1970 was 25.9 percent, while for passenger intensity the rise was 15 percent.

Figure 9. Growth in Shipping Density per Kilometer of Operating Line:



Key: (1) Freight Shipping (millions of net ton kilometers);
(2) Passenger Conveyance (millions of passenger-kilometers);
(a) Millions of ton-kilometers or passenger-kilometers.

The high intensity of use of permanent railroad structures, above all the track, is even more apparent if it is measured in gross ton-kilometers per kilometer of total length of mainlines. According to calculations by Professor G. M. Shakhunyants, roughly half of the railroad network performs about 85 percent of the shipping work. On 1 January 1971 the average freight intensity of the railroads was almost 30 million gross ton-kilometers per kilometer of total length of mainline track per year, while the maximum freight intensity was 150 gross ton-kilometers [37, pp 3-4]. In the Ninth Five-Year Plan the average freight intensity measured in millions of gross ton-kilometers per kilometer of total length of mainline track increased almost 26 percent.

If the output-capital ratio in gross ton-kilometers per ruble of value of track structures in 1965 is taken as 100 percent, in 1970 it was already 125 percent, and in 1975 140 percent, which characterizes the extremely high intensity of use of the fixed capital of the track system. For this reason improving the technical condition of track structures, which create the essential conditions for fullest and most efficient use of locomotives and cars, is very important.

Track structures are kept in good condition by supplying track units with modern mechanized equipment. At the present time the track system uses more than 70 different types of special track machines. Reliable devices have been built to monitor track condition. Full use of track machines for repair and ongoing maintenance of the track makes it possible to repair the track quickly and well and keep it in good condition.

In addition, the use of machinery in the railroad track system makes the labor of workers easier and raises their productivity. Planning machine work to minimize the movement of machinery from one region to another is very important to improve the use of the machinery and equipment of track machine stations. Prolonged transfers of track machine stations cause a decrease in the time that machinery and equipment is used productively.

Road foremen, brigade leaders, and track installers who maintain the railroad in outstanding condition thereby promote better use of the track. Like the rolling stock, the track of USSR railroads is used much better than the railroad track of the capitalist countries. The freight intensity of one kilometer of railroad track in the Soviet Union is roughly seven times greater than that of the United States.

With high freight intensity it becomes especially important to prevent and quickly eliminate malfunctions and to increase the service lives of all elements of the track. The employees of many track units, for example Dzerzhinsk, Ilanskiy, Kalach, and Kamyshlov, are performing this job well. On the best track units planned preventive jobs are performed consistently for each kilometer of the track according to schedule. Organizing ongoing track maintenance in this way makes it possible to get full use of track machinery and mechanisms.

The collective of the Kalach unit of the West Siberian Railroad maintains its track outstandingly. The workers of this unit are maintaining a section with high freight intensity. All track work is done according to plans developed annually on the basis of fall track inspections. These plans include medium repair and track-lifting jobs and replacement of individual elements of the superstructure; the plans are modified where necessary after the spring track inspection. The system of planned preventive work adopted in the Kalach unit is based on the necessity of prolonging the service life of rails, ties, and other track elements, systematically monitoring their condition, and providing constant, outstanding maintenance.

Owing to outstanding track maintenance, the workers of the unit are significantly increasing the service lives of rails and fastenings, switches, ties, and crossbeams.

Timely repair and skillful use of wooden packing reduce wear and increase the service life of ties, which is now 15 years. With current techniques of treatment and repair the service life of ties can be raised to 25 years, which will make it possible to reduce annual replacement of ties from six percent to four percent. Prolonging the service life of ties by just one year makes it possible to reduce the operating expenditures of railroads by almost 8 million rubles and to save more than 150,000 cubic meters of first-grade lumber.

The track machine stations play an important part in outstanding track maintenance. They perform most of the capital, medium, and track-lifting repair jobs and lay new rails and reinforced concrete ties.

Analysis shows that the use of track machines for the system as a whole has improved. In 1975 the output of the VPO-3000 machines, gravel-cleaning machines, track strippers, and electrical ballasters was 10-12 percent higher than in 1970. Further improvement in the use of track machines requires broad introduction of sliding schedules for their work in several sections. When track in heavily used freight sections is being repaired it is wise to concentrate the track machines of several track machine stations in order to do the job more quickly.

Improving the use of track machines makes it possible to perform track repair quickly and well, reduce the number and length of shutdowns for repair, and promote faster movement of freight passengers by rail. The level of use of track machines depends greatly on how highly qualified the service personnel are, whether the equipment is repaired reliably when necessary, and how supply of materials and spare parts is organized.

Outstanding ongoing maintenance and repair of power supply structures is very important for uninterrupted and safe movement by trains at high speed on electrified railroads. High-quality maintenance of the catenary system and traction substations, which are the key elements of electric traction, creates the essential conditions for uninterrupted operation of electrified lines and raises the level of use of electric engines and trains.

The operating reliability of signal, centralization, and blocking devices and communications equipment is also important. The railroads are constantly receiving improved signal and communications equipment and it is an important job of the workers who operate this equipment to keep it in outstanding condition.

The quality of railroad operations work also depends on how productively mechanized classification humps, supply and loading-unloading devices, production buildings, and various station structures are used. The mechanized humps available in the rail system are used, very intensively. The mechanized humps at the Sverdlovsk Classification, Yasinovataya, Perm', Chelyabinsk, and other stations process large numbers of cars.

Maintaining the permanent structures of railroad transportation in conformity with established norms is an important way to improve their use.

6. Changes in Output-Capital Ratio and the Efficiency of Capital Investment

The output-capital ratio in railroad transportation rose especially fast in the first years after the war. As freight and passenger traffic on the railways grew, however, existing reserves of carrying and traffic capacity were increasingly limited. During the Seventh, Eighth, and especially Ninth five-year plans railroad transportation began to experience marked difficulty in handling shipping because its reserves of carrying and traffic capacity were exhausted in certain rail sectors. The growth in shipping volume passed growth in operating length of railroad, which led to an increase in traffic intensity and demanded an increase in available fixed capital.

To clarify the changes that have taken place in the output-capital ratio and establish the correspondence between increasing available railroad capital and growth in freight and passenger shipping between 1950 and 1975 we must first express the production fixed capital of railroad transportation in 1967 prices and reproduction conditions, which were used for the re-evaluation based on conditions as of 1 January 1972. This conversion of fixed capital was done using the methodology and data from a similar conversion made after the re-evaluation of fixed capital on 1 January 1960 in prices that had existed since 1 July 1955 [52]. In the recalculation the growth in fixed capital for each year was adopted considering expression in 1967 prices.

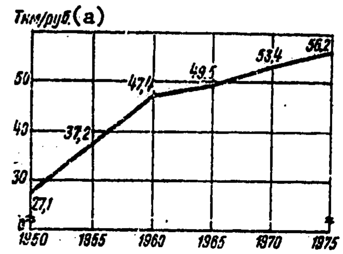
Because the value of fixed capital was determined for purposes of calculating the output-capital ratio, fixed capital put out on lease or not participating in shipping was excluded from the total amount.

To determine the amount of fixed capital for each year before and after the re-evaluation in uniform prices, it is not correct to use a constant evaluation adjustment coefficient obtained for the moment at which the re-evaluation was made. As research has demonstrated, evaluation adjustment coefficients of production fixed capital for different years are not the same; they are equal to the ratio of replacement cost obtained in the 1 January 1972 re-evaluation to the balance cost as of this date. The evaluation adjustment coefficients calculated for earlier years show a tendency to increase: 1970 — 1.30; 1965 — 1.36; 1960 — 1.42; 1955 — 1.48; 1950 — 1.54. For later years, by contrast, they decrease.

Figure 10 shows that the output-capital ratio in calculated ton-kilometers per ruble of production fixed capital (the physical indicator of output-capital ratio) rose from 27.1 in 1950 to 47.4 ton-kilometers in 1960, an increase of 75 percent, but in 1975 it was 56.2 ton-kilometers, a further increase of just 18.6 percent in 15 years.

The slow growth in the output-capital ratio in recent five-year plans is linked to technical reconstruction of the railroads and the resulting substantial increase in the value of the fixed capital of railroad transportation. The construction of new, more expensive

Figure 10. Change in the Output-Capital Ratio in Railroad Transportation (fixed capital and comparable prices).



Key: (a) Ton-Kilometers per Ruble.

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items of fixed capital and purchase of powerful rolling stock, capital investment to raise the quality and reliability of shipping, and construction of new railroads in remote regions have played significant parts in this.

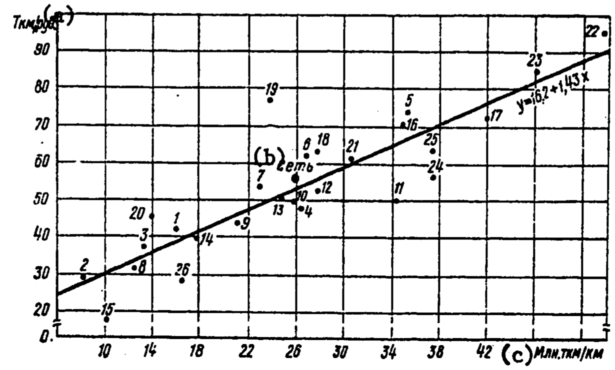
The output-capital ratio has also changed significantly during this period for the particular railroads (see Figure 11 below). The higher the road's freight-intensity is, the greater the output-capital ratio per ruble of value of production fixed capital will be. This indicator, however, is also greatly influenced by the volume of loading and unloading operations on the road, the magnitude of transit shipments, the nature and scope of passenger conveyance, climatic and geological conditions of the terrain through which the road runs, and other factors.

Therefore, one still cannot tell on the basis of the data given in Figure 11 which roads use production fixed capital better or worse. To establish this, a careful analysis of the conditions in which the roads work is required. But despite this, the indicators given in Figure 11 make it possible to get a general picture of the output capital ratio of the particular road and use of its production fixed capital.

The monetary indicator of output-capital ratio determined as the amount of income per ruble of production fixed capital was 26.6 kopecks in 1975, an improvement of 10.7 percent over 1970 in comparable prices.

Another monetary indicator that represents the ratio of profit to the value of production fixed capital and also describes the output-capital ratio was actually somewhat lower in 1975 than in 1965 and 1970. But this indicator, unlike the indicator of income per ruble of production fixed capital, is much more strongly influenced by

Figure 11. Use of Fixed Capital on USSR Railroads in 1975.



Key:
- (a) Ton-Kilometers per Ruble;
- (b) Network;
- (c) Millions of Ton-Kilometer, per Kilometer;
- (1) October;
- (2) Baltic;
- (3) Belorussian;
- (4) Moscow;
- (5) Gor'kiy;
- (6) Northern;
- (7) Southwestern;
- (8) L'vov;
- (9) Odessa-Kishinev;
- (10) Southern;
- (11) Dnepr;
- (12) Donets;
- (13) North Caucasus:
- (14) Azerbaijanian;
- (15) Transcaucasian:
- (16) Southeastern;
- (17) Kuybyshev;
- (18) Volga;
- (19) Kazakh;
- (20) Central Asian;
- (21) Sverdlovsk;
- (22) South Ural;
- (23) West Siberian;
- (24) East Siberian;
- (25) Transbaikal;
- (26) Far Eastern.

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change in wage rates and norms for expenditures in prices of materials, fuel, and electricity.

Whereas the indicator of railroad income reflects only change in the structure of freight traffic, rates, and the level of additional charges, the indicator of profit additionally reflects the impact of change in expenditures for shipping. The fact that the indicator of profit per ruble of production fixed capital has dropped somewhat in recent years is indeed the result of the increase in operating costs during these years in connection with the raising of norms for depreciation deductions on track structures and the increase in prices for diesel fuel and the wage rates of railroad transportation workers.

If the indicator of profit per ruble of fixed capital is figured in comparable conditions, it will turn out that it has not decreased, but has actually risen since 1970.

The slow growth in indicators of output-capital ratio and railroad transportation attracts attention. The primary explanation for this is that during the Eighth and Ninth five-year plans there was intensified reconstruction of fixed capital and the increase in shipping volume by railroad only slightly exceeded growth in production fixed capital, whose rate of growth was close to the growth rate of transportation output. Thus, in 1975 the volume of shipping in calculated ton-kilometers increased by 28.6 percent over 1970, while production fixed capital grew 22.6 percent; as a result, the output-capital ratio in calcuated ton-kilometers rose only 5.2 percent. But this is just an external manifestation of the causes of low growth in the output capital-ratio. The matter requires deeper consideration.

It is very important for timely and complete fulfillment of a steadily growing volume of freight and passenger conveyance to have an appropriate increase in the carrying and traffic capacity of the railroads, which by the mid-1970's was in significant part used on most of the busy freight sectors. This led to some difficulty in handling shipping and caused a worsening of certain qualitative indicators of the operations work of the railroads.

Significant capital investment has been made in recent years to overcome these difficulties and create reserve traffic and carrying capacity for the development of railroad transportation. In the Eighth Five-Year Plan 9.4 billion rubles was invested in railroad transportation, but in the Ninth Five-Year Plan the figure was almost 12.9 billion rubles. The material-technical base of railroad transportation has been changed substantially by various major steps. The technical reconstruction of traction has been basically completed on the railroads. At the present time almost the entire rail system works on electrical and diesel traction. A significant increase in the length of electrified lines is envisioned in the future.

The railroad track has been improved and signal and communications devices replaced with new ones to create conditions for highly productive use of rolling stock. The capacity of the road superstructure has been increased on the most freight-intensive roads and lines which also have heavy passenger traffic. Other types of fixed capital have also been replaced with the acceleration of scientific-technical progress.

The growth in fixed capital does not, however, insure an equal growth in shipping volume in all cases. This depends significantly on the area of capital investment and its effectiveness.

The impact of capital investment in the development of railroad transportation on the output-capital ratio is best evaluated separately for new railroad construction and reconstruction of the existing rail system.

The efficiency of building new railroads, considered from a national economic point of view, is very high. New railroad lines bring out-of-the-way parts of the country into economic life and offer an opportunity for rapid development of their natural wealth, construction of industrial enterprises, and development of agriculture. The efficiency of railroad construction is also high in those cases where new lines are laid to intensify the operating rail network, streamline transportation links, and therefore reduce transportation expenditures for shipping.

If the construction of new railroads is considered from the standpoint of the impact on the output-capital ratio of production fixed capital, it can be established that newly built roads have a different impact. Thus, straightened railroad lines built to improve transportation links rationalize the existing rail network and reduce the number of ton-kilometers and also passenger-kilometers performed on the road and in the network as a whole. At the same time, the number of tons and passengers carried may not increase significantly.

The construction of railroads to open up new regions usually leads to an increase in the number of tons and passengers shipped and increases the volume of transportation output performed by the railroad. But this increase, especially in the first years of operation of the road, is much smaller than the growth through introduction of production fixed capital. Thus, in cases where new railroad lines are not immediately loaded at a level that exceeds the average for the system, or when they are straightening roads, which is to say they rationalize the existing transportation network, a reduction in the output-fixed capital ratio occurs in the first years of their operation.

Capital investment used for reconstruction and intensification of the fixed capital of operating railroads (for construction of second tracks, electrification of lines, installation of automotic blocking and dispatcher centralization, reconstruction of stations and locomotives and car structures, introduction of new automation, remote control, and communications equipment, purchase of improved machinery and equipment for repair and ongoing maintenance of the railroad track and rolling stock, and the like) is used primarily to intensify the carrying and traffic capacity of the railroads, improve train safety, reduce the cost of shipping, and improve the working conditions of employees of railroad transportation. This capital investment usually promotes performance of larger volumes of freight and passenger conveyance, improves their quality, reduces transportation expenditures, and increases the efficiency of the shipping process.

The impact of reconstruction projects on the output-capital ratio of operating fixed capital also varies and depends on the purpose for which the work is done. Activities intended to intensify existing fixed capital for the purpose of performing a growing volume of shipping lead to an increase in transportation output. But this increase, especially in the initial period of introduction of the measure, is often less than the growth of fixed capital. Therefore, the increase in the output-capital ratio is not achieved immediately, but occurs as newly built fixed capital is incorporated and receives its optimal loading.

Steps taken for the purpose of improving train traffic safety, improving working conditions, preserving the quality and quantity of freight being shipped, improving the conditions of passenger travel, and lowering shipping costs lead to a drop in the indicator of output-capital ratio in physical terms, that is, the quantity of ton-kilometers and passenger-kilometers per ruble of production fixed capital. But in this case the quality of shipping will rise: the speed and safety of train traffic increases, freight losses en route are cut, and the goods being shipped keep their value. Many of these steps which affect the finance indicators of railroad work are reflected in the monetary indicator of output-capital ratio.

Thus, the use of production fixed capital of railroad transportation depends largely on how the fixed capital is developed and the purpose pursued in this. In the case where fixed capital grows through construction of second tracks, installation of automatic blocking, and dispatcher centralization, that is through technical measures taken for the purpose of increasing shipping volume, the output-capital ratio rises if the shipping volume increases more than fixed capital and is dropped if shipping increases less than fixed capital.

If fixed capital grows through delivery of new, more comfortable passenger cars or more economic locomotives and freight cars, the volume of shipping does not usually change and the output-capital ratio in physical terms decreases inversely proportional to the increase in fixed capital. In this case the indicator of the output-capital ratio in monetary terms does not decrease, but in all likelihood will increase, depending on the economy of the new locomotives and cars being introduced. Moreover, the quality of shipping will improve; freight and passengers will be moved more cheaply and quickly, which characterizes a growth in efficiency of the shipping process.

This means that capital investment spent to carry out very technical measures on the railroads has an absolute efficiency measured by the number of ton-kilometers and passenger-kilometers, while in monetary terms it can be put in amounts of income per ruble of capital investment, which is reflected differently in the output-capital ratio. In cases where the absolute efficiency of capital investment is less than the output-capital ratio of operating fixed capital, there is a decrease in the latter indicator and, conversely, if capital investment is used to take steps which have higher efficiency indicators the output-capital ratio increases.

Therefore, the efficiency of use of fixed capital is to a significant degree determined by the efficiency of capital investment. In selecting technical steps to develop railroad transportation and determining the distribution of capital investment for them, therefore, it is essential to strive to see that each technical project raises the efficiency of the operating production fixed capital. This means, for example, that when designating a railroad to open up a new region, maximum return of transportation output per ruble of capital investment must be the goal. When a new railroad line is being built, the route must be chosen so that the newly introduced fixed capital will be loaded up quickly. For straightened roads measures should be envisioned concurrently to provide additional load for the sectors that are losing traffic.

When reconstruction projects are undertaken to intensify the traffic and carrying capacity of railroads, special attention should be devoted to raising the return from the new fixed capital quickly to the amount which it had before the particular project.

It is very important to take a comprehensive approach in the development of the fixed capital of all sectors of the railroad system. This means above all that the various forms of fixed capital when used fully should insure the same carrying and traffic capacity for entire sections of railroads and make it possible to use all fixed capital to the maximum.

7. Ways To Improve the Use of Fixed Capital

All of the many procedures and techniques for improving the use of production fixed capital can be grouped into two large categories:

1. Ways to insure an increase in the length of work of fixed capital and reduce downtime for various causes;
2. Ways involving increasing the intensity of use of fixed capital per unit of time.

The rapid growth in the production fixed capital of railroad transportation that is occurring under the influence of scientific-technical progress and broad introduction of new technology places great challenges before railroad workers to improve the use of this capital. Improving the use of the active part of operating fixed capital, above all rolling stock, is especially important (see Table 25 below).

Table 25. Change in Indicators of Use of Rolling Stock During the Ninth Five-Year Plan

Indicator	1970	1975	1975/70(%)
Gross Weight of a Freight Train, tons	2,574	2,732	106.1
Average Daily Run of Locomotive in Freight Traffic, kilometers	499.5	510.1	102.1
Traveling Speed of Freight Trains, kilometers/hour:			
Technical	46.4	46.5	100.2
Section	33.5	33.4	99.7
Freight Car Turnaround, days	5.57	5.84	104.8
Car Time, hours:			
For One Loading Operation	20.74	22.67	109.1
At One Technical Station	4.15	4.29	103.4
Average Daily Run of Freight Car, kilometers	255.5	248.3	97.2

From the figures in Table 25 it is apparent that some indicators of the use of locomotives and cars were better in 1975 than in 1970, but others were somewhat worse or approximately the same.

The indicators of use of rolling stock reflect in large part change in the conditions of operations work on the railroads. The conditions have become more complicated in recent years, especially because of the increase in the volume of freight and passenger traffic. Whereas freight traffic in railroad transportation increased 29.7 percent during the Ninth Five-Year Plan, the operating length of railroads increased just 2.3 percent. As a result, the average freight intensity rose in 1975 to 23.5 million ton-kilometers and the density of passenger traffic increased to 2.3 million passenger-kilometers per kilometer of operating line. Although a substantial program was carried out during the five-year plan to introduce second tracks, extend station tracks, and equip roads with automatic blocking and centralized dispatching equipment, the rate of development of the material-technical base of railroad transportation was inadequate when compared with the growth in freight and passenger traffic.

The turnaround indicator for freight cars increased very slightly during the period under consideration. To some extent this can be explained by an increase in the average distance of freight shipments. This indicator is significantly influenced by the time that cars stand at freight stations and customers' places for loading and unloading operations; this time continues to be very substantial. Between 1970 and 1975 the average car time spent for one loading operation increased 9.1 percent.

Reducing car downtime for loading and unloading offers major reserves for improving car use. Where precisely organized interaction between railroads and industrial enterprises is established and uniform work procedures for industrial sidings and station tracks have been developed and put into practice, the indicators of freight car use are usually good. The collectives of industrial enterprises in Chelyabinskaya Oblast and the Southern Urals Line offer an example of such cooperation in work.

In May 1978 the CPSU Central Committee adopted the decree "Organizational Work by the Chelyabinskaya Oblast Committee of the CPSU to Reduce Car Downtime for Loading Operations and Insure Car Security at Industrial and Railroad Enterprises of the Oblast." The decree observes that the metallurgical combine, calibration plant, and cement plant in Magnitogorsk, the Chelyabinskugol' Production Association, and the Chelyabinsk Metallurgical Plant, in cooperation with the Southern Ural Railroad and under the leadership of the Chelyabinskaya Oblast party organization, are doing a great deal of work to reduce car downtime for loading and unloading and in to insure car security. These enterprises have taken concrete steps to mechanize loading and unloading operations, adopted measures to raise the level of technical equipment available in the transportation system, introduced uniform technological processes at railroad stations and sidings, and employed new, more progressive methods of loading work on a broad scale.

As a result of these steps car downtime for loading operations has been cut significantly at these enterprises in recent times, the security of the car fleet has been improved, and almost 100,000 cars have been released for additional loading.

The working experience of the industrial and railroad enterprises of Chelyabinskaya Oblast to reduce car downtime for loading operations is important for the national economy. The decree of the CPSU Central Committee points out that broad dissemination of these practices will promote a further increase in the efficiency of use of means of transportation and fuller satisfaction of national economic shipping needs.

Reducing car downtime at technical stations is a significant reserve for accelerating car turnaround. In the Ninth Five-Year Plan the length of time spent by cars at one technical station rose 3.4 percent.

Broad dissemination of progressive methods of loading cars is an essential condition for improving the use of freight cars. The principal areas for improvement are delivering for loading those types of cars which can make maximum use of their freight capacity, loading cars running in empty directions to reduce the empty run distance, and applying various new loading techniques.

The static loading of cars has increased through the application of new loading methods. The coefficient of use of car freight capacity was 80.9 percent in 1970 and rose to 82.3 percent in 1975.

Broad use of container and stack shipping offers significant opportunities for better use of car freight capacity. Significant capital investment was directed to the development of the container fleet in the Ninth Five-Year Plan.

Change in particular qualitative indicators of the use of freight cars is reflected in the generalizing indicator of car productivity, which was almost three percent higher in 1975 than in 1970.

During the period under consideration definite advances were also made in the use of locomotives. Thus, the average gross weight of a freight train increased 158 tons between 1970 and 1975, which was 6.1 percent. Improving this indicator depends greatly on broad dissemination of progressive methods of operating trains, replenishing the fleet of locomotives with more powerful electric and diesel engines, and reducing the number of trains running at less than full weight. The number of such trains was reduced from 2.5 to 2.1 percent of the total number of freight trains by the end of the Ninth Five-Year Plan.

Increasing the average daily run of locomotives is very important for improving locomotive use. During the Ninth Five-Year Plan this indicator rose two percent on the average for all locomotives. But there are significant reserves for a further increase. As an analysis of the use of the daily time budget of locomotives demonstrated, electric engines are in motion roughly half the time on the average, and diesel engines just 44 percent. Locomotive downtime at intermediate stations has hardly been decreased at all. Inadequate growth in the average daily run of locomotives can be explained to a large extent by significant downtime at primary depots and only slight increase in the technical speed of train travel.

Raising the gross weight of a freight train, reducing engine use for pushing and double traction, where it is efficient, and cutting the distance locomotives travel alone, plus decreasing the share of steam traction in shipping have brought about growth in locomotive productivity. The productivity of locomotives in freight traffic between 1970 and 1975 rose by more than nine percent on the average.

The organization of locomotive use on extended circulation sectors plays a significant part in improving locomotive use. Since the very beginning of widespread introduction of electrical and diesel traction, traction arms have been steadily joined into extended sectors. During the Ninth Five-Year Plan 123 traction arms were joined into 58 extended circulation sectors. The operation of locomotives on extended sectors makes it possible to reduce downtime at stations and increase traveling speed and average daily run. The average length of circulation sectors is constantly growing; it is 450 kilometers for electric engines today and 470 kilometers for diesels. According to studies made at TsNII MPS, the optimal length of locomotive circulation sectors is 800-1,000 kilometers [47].

Improving the schedule of train traffic is an important reserve for improving locomotive use.

Where the traffic capacity of the roads is being used to a high degree, it becomes important to find new ways of moving trains through to increase their traveling speed.

Growth in locomotive productivity depends greatly on improving the quality of repair work and on the reliability of the basic parts and assemblies. Work to raise the operating reliability and longevity of locomotives should begin from well-founded service lives for them because it is advisable to insure the necessary level of reliability within this limit. This is the only approach that determines the economic efficiency of expenditures for measures to increase the reliability and longevity of means of transportation, machinery, and equipment. Low reliability generally leads to a situation where these types of fixed capital often need repair, that is, they are out of use for long times. By contrast, raising reliability leads to an increase in time between repair jobs and reduces downtime for repair.

An important characteristic of the fixed capital of railroad transportation is its close interdependence, where the use of fixed capital as a whole depends on the use of each particular type. For example, the level of use of rolling stock predetermines the degree of use of the track superstructure, artificial structures, power supply units, signal and communications equipment, and other permanent structures and installations. In its turn, the technical condition of the permanent structures on railroads creates the necessary conditions for most efficient use of locomotives and cars. Therefore, the use of the different types of fixed capital in railroad transportation must be considered in light of their close interrelations, not in isolation.

It is not possible to make full use of the traction force of locomotives and run full-weight trains at a high speed if the workers in all sectors of railroad transportation have not created the essential conditions for this. This means above all maintaining all permanent structures and installations in outstanding condition, which makes it possible to use them fully.

The efficiency of use of locomotives and cars depends significantly on the qualifications of the locomotive crews, skillful management of train traffic and switching work by dispatchers, the qualify of work by freight and baggage handlers, and on the workers at freight stations and sidings.

The use of rolling stock is determined in large part by locomotive power and the quality of rolling stock designed and the reliability of the permanent road structure, which depends on the quality of work by employees of the services engaged in repair and ongoing maintenance of all fixed capital of railroad transportation, primarily track and power supply structures and signal and communications units.

Increasing the amount of useful work by locomotives, cars, machinery, and equipment in the course of a day is an important reserve for improving the use of the active part of fixed capital. This is promoted by reducing locomotive and car downtime at stations and depots, increasing (related to the preceding) the average daily run of rolling stock, increasing the number of shifts that machinery and equipment work, reducing the time spent by fixed capital in repair, and stepping up the introduction of newly built fixed capital.

Introducing progressive labor methods in all sectors of railroad transportation is a major reserve for improving the use of fixed capital.

Railroad employees, building up socialist competition and making broad use of existing reserves, are working hard to improve the qualitative indicators of rolling stock use and perform freight shipment for the national economy as fully as possible at the right time.

It is especially important for improving the use of fixed capital and raising the output-capital ratio on the railroads to disseminate the know-how, approved by the CPSU Central Committee, of the collective at the Lyublino Classification Station of the Moscow Line for most efficient use of means of transportation and raising labor productivity and the collectives of the Leningrad transportation center concerning labor cooperation among maritime, railroad, motor vehicle, and river workers. They have achieved precise and coordinated work on the basis of mutually reconciled continuous schedule-plans aimed at a uniform production process.

Employees of the Lyublino Classification station took a creative attitude toward their production process, introducing new ways to step up classification work. At the same time they figured on a future increase in the volume of car processing. To achieve the highest qualitative indicators station facilities at "tight" spots were reinforced and elaborated: train-forming units were equipped with uniform relay centralization which made it possible to control switches and signals from a single console and portable Tyul'pan radios and pneumatic message transmission were introduced. The introduction of new equipment made it possible to employ the progressive method of dispatcher management of train formation and breaking up proposed by Hero of Socialist Labor N. N. Kharitinov, train formation worker at the station.

Thanks to the use of improved work procedures, highly productive use of station equipment (above all classification humps and switch engines), and the precise, coordinated work of employees in all subdivisions participating in car handling, the downtime of transit cars for processing at the Lyublino Classification station decreased from 5.7 hours at the beginning of the Ninth Five-Year Plan to 4.6 hours at the end. The average daily productivity of the classification humps increased by 500 cars, while the time required to form each train was reduced by 15 minutes.

The introduction of improved procedures for forming trains made it possible to free 32 percent of the employees engaged in switching operations, reduce switch engine downtime, and decrease the number of switch engines needed. The annual savings of operating capital from this was more than 70,000 rubles [86, p 7].

The method of work at the Lyublino Classification station has spread widely at railroad classification stations. The downtime of transit cars on the average for the rail system has been cut by 0.12 hours by introduction of this method. Two hundred-eighty stations have introduced the "one-person" train-forming system [86, p 9].

The general principles and practices of work at the Lyublino Classification station are also being employed at enterprises of other sectors of railroad transportation, that is, at freight stations, locomotive and car depots, road units, and the like. Under concrete working conditions the progressive method of improving the use of fixed capital and raising labor productivity employed at the Lyublino Classification station is being creatively refined and enhanced with efficient new procedures that greatly increase its efficiency.

Improving the organization of car flows is very important for improving rolling stock use. Shipping costs depend not only on how economically cars are processed, but also on how often this is done and how far cars travel between technical stations. Increasing the use of unit-train shipping helps reduce the volume of car processing at technical stations. During the Ninth Five-Year Plan the proportion of unit-train shipping rose from 39.2 percent in 1970 to 46.1 percent in 1975, which made it possible to increase the distance run by cars without processing and reduce the volume of classification work. Raising the transit coefficient of car flows is a major reserve for improving railroad operations work.

The organization of train processing and inspection of car axle box assemblies at technical servicing points is very important for moving trains rapidly along the railroads. It is important here to disseminate the method of detecting concealed malfunctions in the sliding axle boxes of freight cars as proposed by M. P. Batin, senior inspector at the Moscow-Classification-Ryazan' Station of the Moscow Road [35, p47].

The method is based on determining the level of lubrication in the axle box and the time the bearings have been used depending on the condition of the babbit layer. Introducing the M. P. Batin method improves train traffic safety, especially in long circulation sectors and at high speeds.

Employees in many road sections and locomotive depots are making major advances in highly productive use of locomotives. This refers above all to the dispatchers of the Georgiu-Dezh section and the locomotive crews at the Rossosh' and Georgiu-Dezh depots of the Southeastern Road. By stepping up supply operations, combining technical inspection with the turnover and acceptance of locomotives, and skillfully using the locomotives in long circulation sectors, they have developed broad socialist competition to reach the goals of 1,000 kilometers of locomotive travel and 1,000 minutes of useful work by locomotives per day [35, p 33]. At the present time this competition has become widespread on many roads, which has promoted a significant increase in locomotive productivity.

Establishing an optimal structure of fixed capital and timely replacement and introduction of more progressive and economical types of equipment are important steps for raising the efficiency of use of fixed capital. Delay in replacing rolling stock, machinery, and equipment retards scientific-technical progress and worsens the operating and economic indicators of railroad work. Labor productivity with outdated equipment averages one-third to one-half lower than for up-to-date equipment.

New norms for depreciation deductions were introduced on 1 January 1975. The norms for rolling stock, machinery, and equipment are determined based on shortened service lives, which makes it possible to reduce the total number of capital repairs performed. At the same time, the norms of depreciation deductions for replacement of these types of fixed capital have been increased and envision the accumulation of large amounts of capital to replace them with new equipment. It is very important to replace the active part of fixed capital at the right time and prevent obsolete equipment, machinery, and rolling stock from being used.

Improving the technology of the shipping process and repair work by introducing new machinery promotes better use of rolling stock. Performing shipping work with technically improved rolling stock and using progressive designs for buildings, permanent structures and installations, and machinery and equipment saves live and embodied labor, thereby raising the efficiency of the shipping process. Only where there is a savings of overall social labor and a reduction in expenditures of social labor per unit of transportation output does scientific-technical promote a rise in the efficiency of the shipping process and growth in the output-capital ratio in railroad transportation.

Material incentive for railroad workers plays an important part in improving the use of fixed capital. At the present time all of the railroads are using the system of planning and economic stimulation introduced in 1967-1969. This system envisions creating economic stimulation funds from which road workers receive bonuses for high work indicators. It is very important to choose indicators for the formation of economic stimulation funds that will give employees of the roads, sections, and sectorial line enterprises an interest in improving the use of rolling stock, raising labor productivity, reducing the prime cost of shipping, and increasing savings.

For this reason, the indicators of calculated profit, labor productivity, and prime cost of shipping are used to form material incentive funds on railroads and road sections. The material incentive fund at sectorial line enterprises is modified according to the fund-formation indicators stipulated in the "Statute on Cost Accounting of a Railroad Section and Sectorial Line Enterprises under the New Conditions of Planning and Economic Stimulation," ratified by the Ministry of Railroads on 28 November 1977. These indicators are: preventing overexpenditure of operating capital compared to "rightful" expenditures, overfulfillment (underfulfillment) of the plan for labor productivity, and increase (decrease) in profit from subsidiary activities compared to the plan. In addition, fund-formation indicators that reflect the specific working conditions of each enterprise have been established for certain sectorial line enterprises.

Bonus payments to employees for better use of rolling stock and outstanding maintenance of railroad track and other permanent structures are used extensively in the railroads.

Engineers and their assistants at locomotive depots receive bonuses for fulfillment of the indicator of locomotive productivity, handling heavy trains, increasing the speed of travel while observing norms for expenditure of fuel and electricity, and achieving average daily locomotive runs of 1,000 kilometers and more where such distances are systematically performed for a month.

Locomotive crews engaged in switching work receives bonuses for reducing norms of downtime of transit cars for processing and, at some depots, also for increasing car processing at the station compared to the norm, that is, for raising the productivity of the switch engines.

Employees of track units, signal and communications units, power supply sectors, and other sectorial line enterprises receive bonuses for good maintenance and uninterrupted operation of the track, artificial structures, catenary system, signal, centralization, and blocking devices and communications equipment, and other types of railroad structures and equipment.

The indicators of bonus payments to employees of railroads, sections, and line enterprises should be mutually reconciled and stimulate best use of fixed capital and more efficient shipping. Work to improve the indicators of bonus payments is carried on continuously and vigorously on all railroads with due regard for their concrete operating conditions. The experience of the Moscow road with improving bonus payments to workers under the time-rate and bonus system, considering concrete conditions and degree of intensity of workers in different occupations when determining bonus sizes, and solving other complex questions of bonus payments deserves attention.

Formulating an efficient system of material incentive for railroad workers to use rolling stock most productively and maintain all structures and devices in outstanding condition is a major reserve for raising the output-capital ratio in railroad transportation.

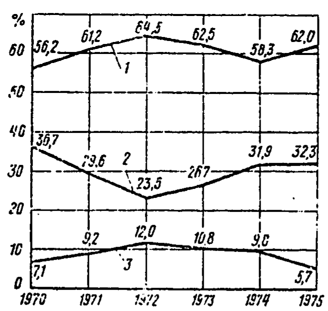
A number of steps are being taken in railroad transportation to give roads and sectorial line enterprises a greater interest in improving the use of rolling stock. Among these measures are the application of depreciation deductions to freight cars and containers proportional to the working fleet; introducing accountability for the use of refrigerated rolling stock, for timely return of locomotives to the road owner when they are operating on long circulation sectors, for incorrect guidance of car flows, and the like.

Introduction of the payment for production capital is an important factor in stimulating better use of fixed capital. The payment for capital was established to stimulate fulfillment of the assigned volume of shipping with minimal fixed capital and working capital. The amount of the payment for capital influences the amount of calculated profit, and the economic stimulation funds depend on this latter sum. For railroad transportation the normative payment for capital has been set at six percent of the value of production fixed capital and norm-controlled working capital. The payment norm for railroads and sections is varied depending on their profitability.

In 1975 in connection with the re-evaluation of fixed capital and introduction of new norms for depreciation deductions, principally in connection with the lack of differentiation by particular roads for the depreciation norm for the superstructure, system-wide norms for the payment for capital "were computed based on insuring approximately equal relative sums of the payment for production capital in the balance profit of the railroads reduced by the amount of other planned uses of the profit of each road" [61]. As a result of the fact that the norms of the payment for capital were used to even out the amounts of balance profit, which was necessary owing to the lack of differentiation in the norm of depreciation deductions for track superstructure by particular roads, the purpose of the norms for payment for capital changes significantly and they increasingly play an uncharacteristic role. At the present time, the norms of the payment for capital range from 0.5 to 10 percent for different railroads.

The effectiveness of the payment for capital depends on how significantly it affects calculated profit and profitability, on which the economic stimulation funds depend, when the amount of production capital changes. Until the present time, however, the payment for capital has not played its proper role in stimulating better use of fixed capital. The reason is that the payment for capital still does not make up the predominant share of profit, which it should. At the present time the share of the payment for production capital is just 58.3 percent of railroad profit, an inadequate figure although it has risen since 1968. The still significant amount of free balance profit nullifies the impact of small fluctuations owing to change in the payment for capital (see Figure 12 below).

Figure 12. Distribution of Railroad Profit Paid to the Budget.



Key: (1) Payment for Capital;
(2) Free Balance Profit;
(3) Other Payments.

Many scholars working in the fields of price formation, cost accounting, capital investment, and fixed capital have studied questions of payment for capital. For example, L. A. Vaag proposed raising the norm of the payment for production capital; in his opinion, it should be set separately for new capital at the level of the normative efficiency factor (about 15 percent a year) [30]. P. G. Bunich, pointing out that setting the payment for capital too low weakens the material accountability of enterprises for efficient use of production capital, also suggests that two rates be established for the payment for capital: one for old and one for new capital. He believed that the payment should be figured on the balance value, not full value, of fixed capital [29].

Thus, the problem of payment for capital has not yet been resolved and three steps are necessary to raise the efficiency of use of the payment for capital in railroad transportation:

1. Develop economic substantiation of the size of the norm of the payment for capital for railroad transportation, taking into consideration the distinctive features and structure of its production capital within which permanent rail structures with long service lives occupy a significant proportion;

2. Substantiate the necessity of differentiating the norms of the payment for capital by railroads and establish the principles of such a differentiation based on the purposes being accomplished by introduction of the payment for capital;

3. Determine the advisability of differentiating norms of the payment by types of production capital, taking into account the purposes of introducing payment for capital and also the fact that improving the use of certain types of the active part of fixed capital (for example locomotives, cars, and the like) may also be stimulated by establishing a direct relationship between material incentive funds and the degree of use of these types of fixed capital.

In addition, certain refinements are needed in the list of fixed capital not subject to the payment. It should be considered here that releasing certain types of newly built fixed capital from the payment does not stimulate rapid loading and full use of this capital. Therefore, it seems advisable to significantly shorten this list, including in it structures that are designed to decontaminate water and air basins and objects withheld by decision of the government. There should also be thorough investigation of the impact of the payment for production capital on the process of replacing obsolete equipment in railroad transportation.

At the present time the indicator of output-capital ratio in railroad transportation does not consider and is not planned to permit monitoring the use of production fixed capital and identifying causes of decrease or retarded growth of this indicator. Considering the importance of raising the efficiency of use of production fixed capital, it is advisable to organize record-keeping and planning for the indicators of output-capital ratio of production fixed capital in the Ministry of Railroads, on the particular roads, and in sections and sectorial line enterprises.

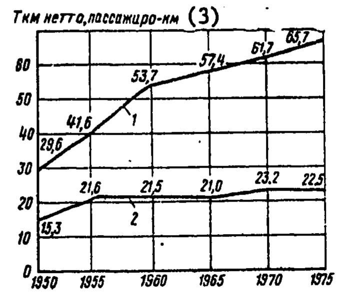
In this case the indicators of output-capital ratio for sectorial line enterprises should be set with due regard for the distinctive features and nature of the operations they perform in the shipping process. Indicators of output-capital ratio in physical terms should reflect the volume of output per ruble of production fixed capital, while in monetary terms they should consider expenditures of live and embodied labor or the operating capital necessary to perform shipping operations, also per ruble of production fixed capital. The general indicators of output-capital ratio should be complemented by qualitative indicators of operations work and the use of rolling stock and the railroad track.

Careful factor analysis of the output-capital ratio is very significant for identifying reserves for raising this important indicator. Such analysis makes it possible to establish the factors that have influenced its change during the report period. During analysis of the output-capital ratio figured in calculated ton-kilometers per ruble of average annual value of production fixed capital, it should be kept in mind that the ratio would also be higher for transit systems than for systems that perform a large volume of loading and unloading and train formation and breaking up work. For this reason, it seems advisable when analyzing fulfillment of the indicator of output-capital ratio in physical terms on particular roads to consider the number of calculated ton-kilometers per ruble of fixed capital involved with moving operations and the number of tons of freight shipped and received and passengers carried per ruble of fixed capital related to initial and terminal operations and train formation and breaking up operations separately.

In addition, when analyzing the output-capital ratio it is essential to consider change in the structure of transportation output, which consists of passenger-kilometers and net ton-kilometers. Calculations have shown that under contemporary conditions the capital-intensiveness (an indicator that is the inverse of the output-capital ratio) of one net ton-kilometer is approximately one-half of the intensity of one passenger-kilometer (the average passenger-kilometer for all types of travel). In its turn, the capital-intensiveness of one passenger-kilometer for all types of travel varies significantly. It is much higher for long-distance travel than for suburban travel. Thus, the output-capital ratio by road depends also on the structure of transportation output, which can be seen from Figure 13 below.

Change in the share of passenger conveyance in transportation output is reflected in the systemwide figure for the output-capital ratio. In 1975 compared to 1970, for example, freight traffic grew 29.7 percent and passenger traffic 17.8 percent. This led to a decrease in the share of passenger conveyance and transportation output from 9.6 to 8.8 percent, and this was reflected by a drop in the output-capital ratio for passenger conveyance from 23.2 to 22.5 passenger-kilometers per ruble of fixed capital. At the same time, the output-capital ratio for freight shipping rose from 61.7 to 65.7 ton-kilometers per ruble of fixed capital. As a result, the overall output-capital ratio rose 2.8 calculated ton-kilometers, which included an increase of 2.9 ton-kilometers for freight shipping and a decrease of 0.1 passenger-kilometers in passenger conveyance.

Figure 13. Output-Capital Ratio for Railroad Conveyance per Ruble of Production Fixed Capital (in Comparable Prices).



Key: (1) Freight Shipping (net ton-kilometers);
(2) Passenger Conveyance (passenger-kilometers);
(3) Net Ton-Kilometers, passenger-kilometers.

Change in the share of passenger conveyance in transportation output is reflected not only in the physical indicator, but also in the monetary expression of the output-capital ratio, which depends on the ratio of income rates per 10 ton-kilometers and 10 passenger kilometers. Where passenger conveyance rose more slowly the total sum of income, and therefore also the output-capital ratio, decreased compared to the amount that would be received if the growth rates of freight and passenger traffic were the same.

8. The Use of Railroad Fixed Capital in the Capitalist Countries

Bitter competition between railroads and other forms of transportation in the capitalist countries in recent years has made it necessary to carry out a significant amount of work to modernize the existing rail network and provide more new types of locomotives and cars. Technical progress and the reconstruction of railroad transportation associated with it in the capitalist countries requires considerable capital investment and leads to a growth in fixed capital.

Table 26 (next page) shows changes in the fixed capital and output-capital ratios of the railroads of the economically most developed capitalist countries in recent years.

It can be seen that in most of these countries the fixed capital of the railroads is increasing. Between 1960 and 1975 the appraisal of railroad fixed capital rose 3.1 times in France, two times in West Germany, 4.1 times in Italy, 1.2 times in the United States, 1.3 times in Canada, and 4.6 times in Japan. This growth reflects the enormous inflation that has occurred in almost all countries and the results of re-evaluations of railroad fixed capital, on the one hand, and to a lesser degree, the cost of work done to modernize railroads and deliver rolling stock, on the other. In Great Britain the fixed capital of railroad transportation is decreasing in connection with

Table 26. Change in the Output-Capital Ratio of the Railroads of the Developed Capitalist Countries.

Страна (Country)	Единица измерения основного капитала (a)	1960 г. Основной капитал (b)	1960 г. Транспортная продукция, млрд. приведенных ткм (c)	1960 г. Фондоотдача, ткм/ед. основного капитала (d)	1965 г. Основной капитал (b)	1965 г. Транспортная продукция, млрд. приведенных ткм (c)	1965 г. Фондоотдача, ткм/ед. основного капитала (d)	1970 г. Основной капитал (b)	1970 г. Транспортная продукция, млрд. приведенных ткм (c)	1970 г. Фондоотдача, ткм/ед. основного капитала (d)	1975 г. Основной капитал (b)	1975 г. Транспортная продукция, млрд. приведенных ткм (c)	1975 г. Фондоотдача, ткм/ед. основного капитала (d)
(1) Великобритания (Британские железные дороги)	млн. ф. ст. (e)	2 076	65,2	31,4	1 989	55,3	27,8	1 464	55,0	37,5	1 258	51,5	40,7
(2) Франция (Национальное общество французских железных дорог)	млн. фр. франков (f)	12 399	92,0	7,42	20 414	106,0	5,19	27 073	113,0	4,17	37 649	116,0	3,08
(3) ФРГ (Федеральные железные дороги)	млн. марок ФРГ (g)	35 403	96,0	2,71	49 348	98,6	2,00	59 264	109,9	1,85	72 142	93,4	1,29
(4) Италия (Итальянские государственные железные дороги)	млрд. лир (h)	878,2	44,3	0,050	1 597,3	42,9	0,027	2 343	51,5	0,022	3 547	51,8	0,015
(5) Канада (Канадская Тихоокеанская и Канадские национальные железные дороги)	млн. канад. долл. (i)	6 127	99,2	16,2	6 687	132,0	19,7	7 284	150,5	20,7	7 950*	177,3*	23,3*
(6) США (железные дороги I класса)	млн. амер. долл (j)	30 675	869,7	28,4	32 063	1047,0	32,7	34 534	1134,1	32,8	37 000	1115,9	30,2
(7) Япония (Японские государственные железные дороги)	млрд. иен (k)	1 460	178,5	0,122	2 204	230,4	0,105	4 417	252,1	0,057	6 738	261,9	0,039

* 1974 Figures.

Key: (a) Unit of Measure of Fixed Capital;
(b) Fixed Capital
(c) Transportation Output, Billions of Calculated Ton-Kilometers;
(d) Output-Capital Ratio, ton-kiometers per unit of fixed capital);
(e) Millions of Pounds Sterling;
(f) Millions of French Francs;

[Key continued on next page]

Key (continued):
- (g) Millions of West German Marks;
- (h) Billions of Lira;
- (i) Millions of Canadian Dollars;
- (j) Millions of American Dollars;
- (k) Billions of Yen;
- (1) Great Britain (British Railway);
- (2) France (National Society of French Railroads);
- (3) West Germany (Federal Railroads);
- (4) Italy (Italian State Railroads);
- (5) Canada (Canadian Pacific and Canadian National Railways);
- (6) United States (Class I Railroads);
- (7) Japan (Japanese National Railroads).

Note: The table was compiled on the basis of figures published in the statistical year books of the International Railroad Union "Statistique international des chemins de fer — Statistique des Reseaux Anne," Paris, 1960, 1965, 1970, 1975.

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expansion of the trunk system, shutting down low-traffic lines and stations, eliminating additional tracks, and other such steps.

In the United States and Canada where the fixed capital of the railroads has not been re-evaluated, its growth is significantly less and reflects chiefly the technical reconstruction that is taking place, which involves the introduction of automation equipment, improved signal and communications, and new types of machines, other equipment, and rolling stock.

If a re-evaluation of the fixed capital of U. S. railroads were to be made, the figure would be much higher. According to an estimate by the Organization for the Establishment of a Rational Transportation System in the United States, the amount of railroad fixed capital in 1970 was 60 billion dollars.

According to calculations made by the author, the fixed capital of all U. S. railroads, considering re-evaluation, was more than 63 billion dollars in 1962 [51], and 96 billion dollars in 1974. According to calculations made by L. I. Vasilevskiy, the fixed capital of U. S. railroads based on replacement value was 110 billion dollars in 1970, while its balance appraisal was 38 billion dollars [104].

As the figures given in Table 26 show, the output-capital ratio of railroads in most of the capitalist countries is dropping. The ratio is increasing for the railroads of Canada, but this is largely because the fixed capital there was taken without re-evaluation, that is, its magnitude was determined under earlier conditions for railroad construction and purchase of rolling stock. If current conditions for reproduction of railroad fixed capital in Canada are taken into account, its figure for 1974 rises to roughly 19.7 billion Canadian dollars and the output-capital ratio is just nine calculated ton-kilometers per dollar. This level of output-capital ratio indicates a very low level of use of the fixed capital of Canadian railroads.

The situation is almost the same on the U. S. railroads, whose fixed capital considering re-evaluation was about 90 billion American dollars in 1975, which corresponds to an output-capital ratio of 13 calculated ton-kilometers per dollar.

Thus, the production fixed capital of USSR railroads is used almost 4.5 times as intensively as the fixed capital of U. S. railroads and six times as intensively as that of the Canadian railroads. As Table 27 below shows, the railroads of the most highly developed European capitalist countries have low indicators for use of rolling stock [44, pp 242-243]. Cars are used somewhat better on the Japanese railroads. The productivity of a two-axle freight car in Japan is almost twice as high as the figure for the railroads of the European countries, and approaches the level of car productivity on U. S. and Canadian railroads. Compared to the USSR railroads, however, the use of freight cars in Japan and in the other capitalist countries is quite weak.

Car turnaround, one of the most important indicators of use of the car fleet, was 22.3 days on U. S. railroads in 1975.

The locomotive fleet is not used as well in railroad transportation in the capitalist countries either. Thus, the average daily run of diesel engines on U. S. railroads in 1975 was one-third less than on USSR railroads.

Many of the capitalist countries have recently begun devoting more attention to working out steps to improve the use of rolling stock. For example, among the measures proposed to step up car turnaround in West Germany are more extensive use of unit-train shipping and organizing loading-unloading work on days off and at night. In the United States many actions are being taken to step up car turnaround. Among them we should note the agreement among railroad companies to consolidate the fleet of enclosed freight cars, the use of the systemwide information system Train II to reduce empty car runs, and formation of multigroup trains that pass small stations without processing.

The intensity of use of railroad track structures in the economically developed capitalist countries, just as in the USSR, is characterized by shipping volume per kilometer of operating length (see Table 28 below).

Table 27. Indicators of the Use of Railroad Rolling Stock in the Developed Capitalist Countries in 1973 [44, pp 242-243].

	Indicators					
	A	B	C	D	È	F
Great Britain (British Railways)	N/A	14.9[1]	20.1	120[2]	16[2]	10.0
France (National Society of French Railroads)	820	36/16[3]	27.8	715	55	12.1
West Germany (Federal Railroad)	837	35.6	21.6	573	59	5.4
Italy (Italian State Railroads)	667	N/A	16.6	381	43	10.1
Canada (Canadian Pacific and Canadian National Railways)	3,224	37.0	47.2	1,332	100	15.4[2]
United States (Class I Railroads)	3,519	32.0	51.6	1,183	93	18.5
Japan (Japanese National Railroads)	626	24.6[4]	19.5	1,170	95	4.4[2]

Key: (A) Gross Train Weight, tons;
(B) Section Speed, kilometers/hour;
(C) Static Car Load, tons;
(D) Productivity of Two-Axle Car, ton-kilometers;
(E) Average Daily Car Run, kilometers;
(F) Car Turnaround, days.

[1]Figures for 1960.
[2]Figures for 1965.
[3]The numerator is for fast freights; the denominator is for slow freights.
[4]Figures for 1968.

It can be seen from the figures in Table 28 that the railroads of the capitalist countries, with the exception of Japan, have low freight intensity, which indicates low intensity of railroad track use (compared to USSR railroads). The freight intensity of the railroads, defined by gross ton-kilometers per kilometer of total length of trunk lines, confirms this conclusion even more strongly. In the United States, the most highly developed capitalist country, the average freight intensity of railroads in 1975 was 7.1 million gross ton-kilometers per kilometer of total length of trunk lines, less than one-fifth of the intensity figure on USSR railroads.

Table 28. Freight Intensity of the Railroads of the Developed Capitalist Countries, millions of calculated ton-kilometers per kilometer of operating length.

Countries	1950	1960	1970	1975
Great Britain (British Railways)	2.2	2.2	2.9	2.8
France (National Society of French Railroads)	1.7	2.4	3.1	3.4
West Germany (Federal Railroad)	2.0	2.7	3.3	2.9
Italy (Italian State Railroads)	1.5	2.0	2.6	2.6
Canada (Canadian Pacific and Canadian National Railways)	1.5	1.5	2.3	2.7
United States (Class I Railroads)	2.5	2.5	3.4	3.5
Japan (Japanese National Railroads)	6.3	8.7	12.1	12.4

Chapter VI. Wear and Service Lives of Structures and Rolling Stock

1. Physical Wear and Obsolescence

The withdrawal of railroad transportation fixed capital from operation results from various factors, one of the foremost of which is physical or material wear.

The physical wear of fixed capital is primarily linked to its use. Locomotives and cars traveling over railroad track cause wear on the rails, ties, and ballast layer and they themselves wear out. The contact wire on roads with electric traction wears out owing to the action of the trolleys (current collectors) of moving electric locomotives and trains as they slide along the wire.

The intensity of use of fixed capital determines how quickly it wears out. The degree of impact of use intensity on physical wear depends on the designation of the fixed capital and the functions which it performs in the transportation process. When the volume of shipping on roads is increased, which leads to more intensive use of their fixed capital, it is the railroad track, locomotives, and cars that wear out most rapidly. Long ago, K. Marx observed that "the objects subject to the greatest wear are the rails and rolling stock" [1, Vol 24, p 190].

There is a close relationship between locomotive and car wear and the condition of the track. The rubbing parts of the spring suspension and axle box assembly of the rolling stock wear out more quickly when used in sectors where the track is in poor condition.

But fixed capital does not wear out only during the process of use. It also wears out while being held in reserve or not used at all. Indeed, thanks to timely repair and proper maintenance fixed capital in use often has an even longer period of usability than fixed capital which does not participate in the shipping process. As K. Marx observed, "This preservation, arising from use in the process of labor, is a free gift from the nature of live labor" [1, Vol 24, p 194].

Fixed capital also wears out under the impact of natural conditions: precipitation, wind, temperature, air humidity, and the like. Their effect is particularly great on rolling stock, the roadbed, bridges, tunnels, track superstructure, signal and communications equipment, and other structures that are operated in the open air. Natural conditions cause steel to rust and wooden structures to rot and they weather and break down the building materials from which items of fixed capital are constructed.

The nature of wear on fixed capital owing to the above-mentioned factors varies. Wear caused by natural forces is relatively even. But when fixed capital is used in the shipping process wear depends significantly on how intensively it is used. For example, the track superstructure wears out more quickly on segments with heavy train traffic (especially for heavy trains) and when the trains travel at high speed. It should be observed that locomotives, cars, track and construction machines, track superstructure, the catenary system, and certain other types of railroad transportation fixed capital wear out more rapidly mainly because they are greatly affected by the mechanical forces of friction, physical impact, and loading.

Intensity of use has a much less significant effect on the wear of such fixed capital as the roadbed, tunnels, metal, stone, and reinforced concrete bridges and culverts, stone and reinforced concrete buildings, and freight and passenger platforms. The wear of these structures, buildings, and installations depends more on atmospheric precipitation, wind, air temperature and humidity, and saturation with various gases and vapors.

Observations of installed rails show that their wear depends primarily on shipping volume. In addition, it depends on the quality of rail manufacture, the axial loads of rolling stock, the plan and profile of the track, and other factors. Work [12] considers the effect of these factors on individual retirement of rails and their service lives.

After passing a certain threshold tonnage of traffic the physical wear on rails increases sharply and the rails are completely changed to avoid large-scale replacement of individual rails. For example, under average operating conditions R65 rails have a traffic capacity of 500 million gross tons. With a freight intensity level of 50 million gross ton-kilometers per kilometer a year the service life of this type of rail is 10 years on main lines (500/50). Where freight intensity increases to 60 million gross ton-kilometers per kilometer R65 rails serve only eight years on main lines (500/60).

Thus, where other conditions are equal the wear of a particular type of rail is greater when the freight intensity of the segment where the rails are laid is greater.

Among the other factors on which physical wear of fixed capital depends we should note:

1. conditions of fixed capital maintenance — the qualifications of employees, the quality of ongoing maintenance and care, the system of scheduled preventive repair work and its quality;

2. conditions of use of fixed capital — length of work in a day, speed employed, nature of work (physical impacts, overvoltages, overheating, overloading, and the like), and others;

3. design and reliability of fixed capital — type of material from which fixed capital has been manufactured, care taken in building, correctness of assembly or installation, and others.

As physical wear mounts the efficiency of productive use of fixed capital decreases. Ultimately, when the wear of objects of fixed capital is significant and capital repair cannot restore their former qualities, continued productive use of the objects becomes impossible and they are withdrawn from use.

All types of fixed capital in railroad transportation are subject to physical wear, but it takes different forms. For lathe-type equipment physical wear involves abrasion of rubbing parts, while for electrical machines it is the aging of the insulation of the wires, for overhead communications lines it is the rusting of steel wires, for wooden construction components it is rotting and mechanical destruction, and so on.

The general indicator that characterizes the physical wear of fixed capital is the duration of their functioning in the shipping process or the service life. The service life is that crucial indicator which reflects the longevity of objects of fixed capital depending on their physical wear, the time that they are used reliably and productively. Outstanding ongoing maintenance and timely, high-quality repair make it possible to increase service life and improve the use of rolling stock, machines, equipment, structures, and the like.

Where the speeds of travel of trains on railroads and the intensity of use of fixed capital are increasing, it becomes exceptionally important to extend their service lives. Increasing the longevity of the fixed capital of railroad transportation reduces the need for capital investment to replace fixed capital being withdrawn.

Study of the patterns of physical wear of fixed capital is a highly complex problem. The difficulty of determining the degree of increase in wear of fixed capital during the operations process is linked to the existence of many different factors that affect it. Moreover, the factors that affect wear interact with one another, which makes it even more difficult to establish a precise mathematical dependence for this influence.

In addition to physical wear, railroad transportation fixed capital is subject to what is called nonphysical wear (obsolescence). Obsolescence is the economic aging of fixed capital that occurs owing to scientific-technical progress. Its impact is seen in the fact that obsolete fixed capital, even though it is still physically usable, no longer provides a high rate of growth in labor productivity and the necessary, plan-dictated decrease in the prime cost of output and, consequently, is retarding the development of production. Therefore, fixed capital loses its value and becomes uneconomical as the result of obsolescence. In most cases it is advantageous to replace it before it is fully worn out physically.

All types of railroad transportation physical capital experience obsolescence. It comes especially fast for those objects which make up the active part of fixed capital and are implements of labor. Foremost among them are the rolling stock and various machines, mechanisms, lathes, and tools. These are the objects of fixed capital which are most frequently judged to be obsolete and replaced by new, more economical and productive models. In most instances this replacement takes place long before full physical wear has occurred.

The obsolescence of buildings, the roadbed, artificial structures, the track superstructure, and other permanent railroad structures is much slower.

The impact of scientific-technical progress on the average length of the service life of railroad transportation fixed capital manifests itself in two directions. On the one hand, the service life increases because of scientific-technical progress; this occurs both through improvement in the design of fixed capital and the use of more wear-resistant materials and by improvement in the quality of repair work on repairing even machines or structures that have been subject to great physical wear. On the other hand, service life decreases owing to the effect of scientific-technical progress and the obsolescence associated with it because more economical means of labor appear.

The action of obsolescence takes two forms. The first is where, with the passage of time and improvement in production technology, better labor organization, and the use of new, less expensive materials, the cost of replacement of fixed capital in use is reduced. This means that, at a given moment, the manufacture of a machine of a particular design requires fewer labor, material, and monetary inputs than at the time when the machine was first manufactured. In such a case the cost of the machine will decrease more when the time from its original construction or the time between re-evaluation until another new evaluation is made is greater. The second form of obsolescence is where, owing to scientific-technical progress, new, more sophisticated and productive machines appear and make existing ones less valuable.

"In both cases," K. Marx observes, "no matter how new and vital a machine may be, its value is no longer determined by the work time it actually embodies; rather it is determined by the work time necessary now to reproduce the machine itself or a better one. Therefore, it loses its value to one degree or another" [1, Vol 23, p 415].

With the first form of obsolescence there is no need to replace operating fixed capital ahead of schedule because it is as good as its potential replacement and affords the same labor productivity and shipping conditions. Therefore, there is no reason to replace operating fixed capital with identical new fixed capital until the old capital has attained an economically advisable service life. The necessity of replacing operating fixed capital arises only where new, more productive means of labor appear and the second form of obsolescence occurs.

The most obsolete types of fixed capital in railroad transportation today are isothermic cars with ice-salt cooling, passenger cars with wooden bodies, and certain types of lathes and tools. The introduction of electric and diesel traction made both steam locomotives and structures designed to repair and service them such as stoking pits, coal-supply scaffolds, and installations to wash steam boilers obsolete.

The use of obsolete machines, equipment, and rolling stock in the fixed capital of railroad transportation involves great losses which show themselves in the high prime cost of shipping. These losses may be reduced by systematic re-evaluation of operating fixed capital (for the first form of obsolescence) and by setting service lives that consider obsolescence and timely withdrawal of obsolete and uneconomical types of fixed capital from operation and replacement with new, improved models (for the second type of obsolescence).

Under capitalism the obsolescence of railroad fixed capital involves great losses for the owners of railroad enterprises,who can no longer get the maximum profit norm with old means of labor but will be made bankrupt by a lower profit norm. To avoid this the capitalists are forced to replace physically usable but obsolete means of labor with more economical and productive forms. Thus, while means of labor may, on the one hand, be kept in production for a long time based on their condition, "on the other hand, the competitive struggle, especially during decisive changes in technology, forces them to replace old means of labor with new ones before their natural death. Disasters and crises are the principal things that compel premature replacement of enterprise equipment on a broad social scale" [1, Vol 24, p 191].

The possibility of replacing outdated equipment with new equipment ahead of schedule depends on the capacities and competitive capability of railroad enterprises. Small, uncompetitive enterprises that cannot replace outdated equipment with new equipment at the proper time are ruined. In their pursuit of a maximum profit norm the owners of enterprises who have old equipment offer great resistance to the loss of value of their fixed capital. They delay the introduction of new technology and create obstacles to its practical application. In this way, the railroad owners, attempting to preserve their fixed capital, retard scientific-technical progress.

But the tendency to retard scientific-technical progress does not, of course, mean that transportation machinery in the capitalist countries is not developing. Engaged in desperate competition with other forms of transportation, railroad enterprises try to reduce shipping costs and increase their own profit by employing new equipment and making various kinds of technical improvements. For example, U. S. railroads have introduced diesel traction, laid heavy rails on most mainlines, and introduced automatic blocking, centralized dispatching, the use of computers and calculators, and remote control of switch engines, switches, and signals on a broad scale.

To avoid losses from replacement of old equipment ahead of time, obsolescence is taken into account in determining service lives. The book "Economics of Transportation," published in the United States, observed that "the obsolescence of all types of transportation equipment occurs rapidly; therefore, charges to the customer must contain a certain amount for depreciation of investment during the probable service life of the equipment so that costs are applied to the output of this equipment during its service life, not to the output of the equipment which replaces it" [127, p 715]. At the same time the difficulty of determining the possible service life of equipment is emphasized. "It does not follow, however, because the problem is difficult that it should be dodged" [127, p 715].

In a socialist economy obsolescence makes it necessary to replace outdated equipment ahead of schedule. This gives rise to losses from incomplete depreciation of obsolete machinery. To reduce the losses that occur when obsolete and uneconomical equipment whose cost has not yet been fully transferred to output is withdrawn from production, service lives must take obsolescence into account. It has the strongest impact on reducing the service life of locomotives, cars, machines, and mechanical and energy equipment and causes them to be replaced before they are physically worn out.

The average service lives of fixed capital are decreased owing to continuous scientific-technical progress, which results in improved types and designs of rolling stock, machines, and mechanisms. Therefore, to avoid delaying the introduction of new types of fixed capital the service lives should correspond to the pace of scientific-technical progress. Service lives that are too long cause physically wornout and obsolete equipment to be used for an extended time.

Thus, obsolescence leads to a reduction in the service lives of fixed capital based on physical wear. This reduction will be greater when the pace of scientific-technical progress quickens and industry has more realistic possibilities of quickly replacing obsolete equipment.

It would be a mistake, however, to think that we should try to minimize service lives in every case to avert obsolescence. As will be demonstrated below, in cases where the service life of fixed capital based on physical wear is less than the service life determined from conditions of obsolescence, it is necessary to increase the length of service of objects based on physical wear. The most economical effect is achieved when the service lives established by physical wear and obsolescence coincide.

An increase in service life based on physical wear where it is less than the service life based on obsolescence is very important because it makes it possible to save capital investment and reduce depreciation deductions transferred to output. An increase in the service life is especially efficient within the limits of the depreciation, which is that service life, taking obsolescence into account, which is adopted as the basis for working out norms of depreciation deductions.

Analysis of the withdrawal of railroad transportation fixed capital shows that there is significant retirement of fixed capital from use ahead of schedule owing to great physical wear, which results in incomplete depreciation of fixed capital and the occurrence of losses. In 1975 alone, depreciation deductions not transferred to transportation output owing to premature withdrawal of fixed capital and withdrawal of certain types of equipment that are included in composite inventory objects was more than 172 million rubles. Insuring highly reliable work by fixed capital through the entire depreciation period will make it possible to reduce these losses, improve qualitative indicators of their use, and decrease expenditures for ongoing and capital repair.

2. Withdrawal of and Writing Off Fixed Capital

The fixed capital that is withdrawn from use owing to physical wear or obsolescence is subject to writing off. According to the "Instructions on Procedures for Writing Off Unusable Fixed Capital from Enterprise and Organization Balances," equipment, means of transportation, tools, and inventory items that are obsolete, wornout, and unsuitable for further use may be written off.

Fixed capital is written off when the crucial assemblies and parts reach thresholds of wear where restoring them by repair is either not technically feasible or economically unwise. Equipment and rolling stock are also written off in those cases where they have obsolete, imperfect designs and further use of them, even with significant modernization, is inefficient. Equipment and means of transportation damaged in natural disasters and accidents are also subject to writing off if crucial assemblies and large parts of them have been completely destroyed or have punctures, cracks, breaks, and buckling that cannot be repaired.

The withdrawal of railroad transportation fixed capital in recent years has been significantly linked to technical reconstruction of the railroads and introduction of new equipment; in other words, it is explained by the action of obsolescence.

The buildings and structures of railroad transportation are written off in connection with reconstruction and demolition related to the construction of new facilities and also when they become dilapidated.

The suitability of various types of fixed capital for further use and the possibility and wisdom of reconstruction repair are determined by permanent commissions formed at railroad transportation enterprises and organizations. These commissions make on-the-spot inspections of the objects planned for writing off, determine the causes of writing off and the possibility of restoration and further use of the entire object, make an evaluation of the condition of particular parts and assemblies of the objects being written off, and compile writing off affidavits using form FOU No 13.

In conformity with the "Statute on Procedures for Planning, Computing, and Using Depreciation Deductions in the National Economy" (Moscow, Ekonomika, 1974), losses from writing off fixed capital that has not been fully depreciated are classified with the results of the economic activity of enterprises and organizations, except for those cases where fixed capital is liquidated according to a ratified plan in connection with the introduction of new equipment and reconstruction of cities and railroads. In this case the losses are applied to reduce the statutory capital of the enterprise. It is proper to make a more careful review of the reasons for ahead-of-schedule withdrawal of fixed capital that had not been fully depreciated. The losses should be related to the results of economic activity only in those cases where fixed capital is written off ahead of schedule for reasons that depend on the employees of the particular enterprise.

Work [48] reviews the question of regulating the results of premature withdrawal of fixed capital in detail.

The withdrawal of fixed capital in railroad transportation increases each year, related to an increase in the intensity of its use and greater physical wear. Moreover, with the acceleration of scientific-technical progress the withdrawal of obsolete fixed capital is rising. If all railroad fixed capital withdrawn in 1960 is taken as 100 percent, withdrawal in 1965 was 146 percent, in 1970 it was 215 percent, in 1975 — 281 percent, and in 1977 — 290 percent.

3. Determining the Average Service Lives of Rolling Stock, Machines, and Equipment.

Determination of the average service lives of various types of fixed capital is one of the most complex problems. The reason for the complexity is the fact that service lives are closely tied to wear which, as demonstrated above, depends on many factors.

Different methods are used to determine the service lives of fixed capital. One of them is based on analysis of statistical data on the withdrawal of fixed capital from use.

"We know from experience," K. Marx wrote, "how long a given means of labor, for example a certain type of machine, can exist on the average" [1, Vol 23, p 215]. Determining service lives on the basis of statistical data makes it possible to give fullest consideration to all factors that affect them. But the use of this method to establish service life for future periods demands additional consideration of new factors that may appear. Establishing the impact of the factors on change in average service life is made more complicated by the fact that it is also necessary to predict their appearance itself.

It should be observed that it is not always possible to use the method of determining service lives on the basis of statistical data because the necessary information is not available. Moreover, organization of sampling surveys to obtain data on withdrawal of fixed capital from use is complicated and labor-intensive work that requires well laid-out records of the introduction and withdrawal of fixed capital.

The service lives of fixed capital may also be determined by special engineering calculations that take account of the impact of the most important, but not all, factors on wear [physical wear and obsolescence], which also means on service life. In most cases these calculations are highly complex.

Correct determination of the service lives of objects is closely linked to the development of classifications of repair jobs and determining the inter-repair periods on which the number and volume of periodic repair jobs and the volumes of repair work done during ongoing maintenance of objects depend.

In practice the determination of average normative service life for particular types of fixed capital is very important. The average normative service life of an object is not the number of years during which it maintains its full capacity, productivity, and efficiency. It is natural that at a certain moment in time after its launching in use, and especially in its final period of use, an object cannot keep all its technical and operating qualities. The term average normative service life should mean the average number of years that pass until further use of the particular object of fixed capital is not technically feasible or is economically unwise owing to substantial physical wear or obsolescence.

The most important characteristics that define this moment are the following: (1) when basic parts, details, and assemblies of the objects reach threshold norms of physical wear at which the objects should be removed from operation because it is plainly impossible to use them for their designated purpose or to insure the necessary safety of operations (for example, for internal combustion engines this norm is the allowable wear on cylinder walls); (2) significant drop in the productivity, speed, precision, pressure, stability, strength, or other characteristics of fixed capital given in their factory passports where capital repair and even modernization cannot restore these characteristics to the original level; (3) significant increase in expenditures for operation, repair, and ongoing maintenance (loss of economic feasibility).

All of these characteristics must be established in the concrete operating conditions of the particular type of fixed capital.

The average service life of objects includes all the norm-controlled interruptions in their operation, the time needed for repair work, cleaning, inspections, and the like. Past experience with use of the objects taking into account intensity of use and progressive methods of repair and ongoing maintenance must be considered when determining the average service life.

Because the objects of different types of railroad transportation fixed capital differ in designation and the complexity of the functions they perform, their normative service lives are determined by different procedures. But all of these procedures must be based on wear.

The average service life of railroad rolling stock based on physical wear may be determined from the service lives of the most important, expensive, and long-lasting parts. For example, for many years the service life of railroad cars was determined by the longevity of the frame, and the life of locomotives was based on the service life of the frame or body. The development of repair technology, however, made it possible to repair and restore both small parts and assemblies of the objects, and also their principal parts, whose service lives had been used to determine the lives of entire objects. For this reason it was proposed that the average service life of an object based on physical wear be determined not by the service life of some one principal part, but rather by the service life, weighted by value, of particular parts and assemblies.

The service lives of parts and assemblies necessary for this may be determined on the basis of replaceability (for parts and assemblies that are withdrawn because of metal cracking and fatigue, wood rotting and the like) and by special calculations (for parts that work by abrasion, mechanical wear and the like).

Table 29 below gives an example of determining the average weighted service life of an ER2 electric car based on cost of constituent elements [54].

Table 29. Determination of the Service Life of an ER2 Electric Car

Design Elements of Car	% of Cost of Elements in Total Cost of Car	Service Life, Years	Number of Percent-Years (Col. 2 × Col. 3)
Body	8.79	40	351.60
Wires and Cost of Installing Them in Body	2.02	15	30.30
Frames of Trucks	6.89	35	241.15
Brake Leverage and Spring Suspension	7.46	30	223.80
Wheel Pairs with Axle Boxes	16.71	15	250.65
Traction Electric Motors	20.13	35	704.55
Electrical Equipment, Fittings, and Other Devices	12.74	20	254.80
Braking Equipment (Engineer's Brake Valve, Air Distributors, and the Like)	0.80	25	20.00
Other Elements	24.46	20	489.20
Totals	100.0	25.7	2,566.05

Application of the procedure for determining the service life of an object based on the service lives of its particular parts and assemblies is made more complicated by the fact that any part or assembly today can be repaired and thus the use of the object can be extended for practically any necessary time. Therefore, the effect of physical wear on withdrawal of fixed capital from operation is significantly mitigated and is essentially determined not by the possibility, but rather by the economic advisability of repairing objects and the scope of the losses associated with the use of obsolete objects.

Like many other sectors of the national economy, railroad transportation uses the method of determining what are called economically advisable service lives. It was first proposed for steam engines in 1925 by engineer V. O. Vasil'yev and was derived from the ratio of depreciation deductions to replacement and expenditures for current, medium, and capital repair financed from means of operation. The minimum of these expenditures, determined by the graph method, corresponded to the most advantageous service life of steam locomotives at that time, which was 21 years [31, p 24]. The graph method of determining economically advisable service lives for locomotives was later elaborated in the works of other Soviet scientists, principally K. I. Dombrovskiy and N. G. Kabenin [42, 57]. This method is also used in studies by American scientists [121].

The determination of economically advisable service lives of locomotives by the graph method begins with the assumption that as the locomotive grows older expenditures for repair and ongoing maintenance increase. Growth in the cost of repair and ongoing maintenance, which eliminate accumulating wear, will differ for electric and diesel locomotives even where they are used in the same way because it depends on locomotive design. It will be greater when a design has more moving parts and assemblies that are subject to mechanical wear and when locomotives are used more intensively.

According to studies by M. N. Belen'kiy, the increase in the cost of repair and inspection as the locomotives grow old is less significant for electric locomotives, owing to their simpler design, than for diesels [23, p 110]. The method under consideration begins from the general proposition that the shorter the service life of the locomotive is, the smaller annual expenditures for repair and ongoing maintenance will be. Depreciation deductions for full replacement will be greater with a short service life, however, because replacement of locomotives will have to be done more often in this case. Therefore, the locomotive service life taken as economically advisable is that period for which annual depreciation deductions for full replacement and expenditures for repair and ongoing maintenance are minimal.

In 1953 N. G. Kabenin used the method of analytical calculation of the service life of steam locomotives by minimum expenditures for repair and depreciation. This method was based on the equation below for average annual expenditures C_{ap} according to depreciation and repair of steam engines

$$C_{ap} = \frac{K_{п}}{T} + a_{п} + \frac{a_{в}(T+T^2)}{2T}, \qquad (21)$$

where K_{π} is the cost of a steam engine in rubles, T is the service life of the engine in years, a_{π} is the permanent part of annual repair expenditures in rubles, and a_b is the increasing part of repair expenditures per year in rubles.

The quantity $a_B \frac{(T+T^2)}{2T}$ shows change in average annual repair expenditures for the entire service life of the steam locomotive depending on the annually growing share a_B.

Expression (21) can be written differently:

$$C_{ap} = \frac{K_{п}}{T} + a_{п} + \frac{a_{в}}{2} + \frac{a_{в}T}{2}. \qquad (22)$$

By equating the first derivative of expression (22) to zero we find service life T for which average annual expenditures for repair and depreciation will be minimal,

$$\frac{dC_{ap}}{dt} = \frac{d}{dT}\left(\frac{K_{п}}{T} + a_{п} + \frac{a_{в}}{2} + \frac{a_{в}T}{2}\right) = 0. \qquad (23)$$

From this it follows that

$$T = \sqrt{\frac{2K_{п}}{a_{в}}}. \qquad (24)$$

The economically advisable service life of a steam locomotive calculated by N. G. Kabenin using formula (24) was 33 years. Considering that the scheduled official inspection period for the steam boiler is 40 years, he considered it possible to increase the service life of the entire locomotive to 40 years.

Somewhat later the question of determining economically advisable service lives was thoroughly investigated by Yu. N. Vinogradov, who analyzed repair expenditures for electric engines on the railroads of the Urals and Siberia. Using the same methodology of calculations and higher norms for distance traveled between repairs he came to the conclusion that the optimal service lives of electric engines should be 25–30 years [33].

The graph and analytic methods of establishing economically advisable service lives of fixed capital have become widespread for determining the service lives of various types of machinery and equipment [66].

It should be remarked that both of these methods have shortcomings. One of them is that the expenditures that depend on service life are not continuously changing. At the moment of capital repair there is a break in functions and therefore the differentiation of equations obtained is not entirely correct. Another shortcoming is the assumption of linear growth in expenditures for repair and ongoing maintenance of the objects under consideration throughout their entire service lives. Moreover, a precise determination of the magnitude of increase in these expenditures with the passage of time is extraordinarily complicated.

To eliminate these shortcomings R. N. Kolegayev proposed that the service lives of machines be determined by these methods by multiples of the number of repair cycles. Moreover he substantiated methodologically the linear growth of changing expenditures within the limits of each repair cycle and the increase in the level of these expenditures as the number of repair cycles increases [65].

It should be observed that the methods of determining economically advisable service lives do not fully account for the influence of scientific-technical progress and the obsolescence associated with it. Many scientists who have studied questions of service lives have pointed out this fact. For example, in 1955 A. S. Konson, determining the economically advisable service life of the DIP-200 machine tool by the graph method, took the decrease in its value owing to technical progress into account. "A significant shortcoming of this method," A. S. Konson emphasized, "is that it does not reflect the impact of the introduction of new, improved designs of machines with better operating parameters on the value of machines launched in operation at earlier times" [66, p 87].

In 1963 A. Ye. Gibshman proposed a method of determining the economically advisable service life of locomotives taking into account change in expenditures for repair and full replacement in time [38], that is, considering the postponement of capital investment, using a coefficient of postponement $K_o = 1/(1+E_H)^t$ (where E_H is the normative coefficient of economic efficiency and t is the service life of locomotives).

In addition to the effect of postponing expenditures, A. Ye. Gibshman considered obsolescence in determining the optimal service lives of locomotives. To this he determined the decrease in operating expenditures and capital costs with the introduction of improved locomotives and on the basis of analysis and logical conclusions adopted a period of 10-12 years for the appearance of new diesel locomotive designs and 10 years for new designs of electric engines.

In his studies of the effect of postponing capital investment on full restoration of locomotives and the factor of the appearance of new designs, A. Ye. Gibshman reached the conclusion that the optimal service life for electric locomotives should be 24 years, while for diesels it should be 18 years [38].

In 1971 S. Ye. Kantorer proposed determining the optimal service lives of construction machines by the minimum sum of expenditures for repair and depreciation deductions, expanding the group of expenditures that change depending on the age of the machines [58]. In this group he included expenditures for not only ongoing maintenance, repair, and depreciation of machinery but also fuel, lubricants, and materials that depend on the service life. He also took the drop in machine productivity with increasing age into account.

Emphasizing that when obsolescence is taken into account the service lives of construction machines decrease in connection with the appearance of more productive and economical models, S. Ye. Kantorer proposed that the optimal service lives of machines be determined by stages. In the first stage the economically advisable service lives of machines are established according to minimum operating expenditures, while in the second they are determined according to conditions of obsolescence. In the third stage steps are taken to converge service lives based on physical wear and obsolescence. As a result of following the first three stages the economically advisable service lives of machines are established with due regard for the combined influence of physical wear and obsolescence. In the fourth and fifth stages a determination is made of what service lives will yield a minimum of essential fixed capital and working capital and a minimum of capital investment in the production of machinery and spare parts for this capital. Finally, in the sixth stage the economically advisable service lives obtained are compared and the most optimal is selected.

In addition to the methods considered above for determining economically advisable service lives of means of transportation, machinery, and equipment, it is also proposed that these periods be determined by maximum profit obtained during the use of these types of fixed capital [64].

Similar methods of determining optimal service lives are used in certain foreign railroads. In 1970 W. Doering, working for the Ministry of Transportation of the German Democratic Republic, developed a methodology for determining the optimal service lives of railroad freight cars [125]. This methodology was based on the proposition that during its working life, from the moment it is put into use until it is written off, a car will require certain expenditures and bring in income; the most advantageous service life for the car corresponds to maximum profit. To simplify the calculations, however, W. Doering then establishes just one relationship, between the service life of cars and the magnitude of expenditures. The time during which the sum of expenditures for servicing, ongoing maintenance, and repair of cars and for depreciation deductions and energy costs for train traction are minimal is taken as the optimal service life of a car.

Obsolescence is considered by including expenditures for the cars being replaced in the calculation. This accounts for the effect of design, technological, organizational, and other improvements associated with new cars. After determining the minimal expenditures and the economically advisable service life of a car corresponding to them, W. Doering finds the annual cost savings from the introduction of promising types of cars. Taking the decrease in total expenditures owing to the introduction of new, improved cars into account he also determines the optimal service life of a car that corresponds to the new expenditures. W. Doering does not give the optimal service lives of cars which he obtained, but he points out that these periods depend largely on the degree of increase in car wear as they grow old.

In 1971 R. Guetter of East Germany used an analytic-graph method to determine the optimal service life of locomotives by minimum expenditures for depreciation, repair, and operation. He arrived at an optimal service life for locomotives of about 17 years.

In the Federal Republic of Germany the determination of optimal service lives of railroad cars begins from the fact that the steadily growing pace of scientific-technical progress causes cars to age rapidly. "Therefore," observed K. Raab, "long service lives for cars are no longer necessary if the railroads want to compete successfully with other forms of transportation. Because short service lives for cars increase the requirement for capital investment to replace them, however, it is essential to cut expenditures for repair and ongoing maintenance by strengthening the design of the car so that the period between capital repairs for it can be doubled, from four to eight years. On this basis, the service life of cars may be taken as 16 years for one overhaul, 24 years for two, and so on. In other words, it is a multiple of the repair cycles" [128, p 777].

Studies made in the FRG in 1979 showed that the optimal service lives correspond to minimal expenditures and are as follows: 40 years for flatcars, 32 years for passenger cars and enclosed freight cars, and 25 years for gondolas [128, p 776]. These same service lives are given in later works. For example, in a report at the International Railroad Congress in Bologna in September and October of 1975 devoted to reviewing change in the structure of the fleet of freight cars of West German railroads, W. Stelter gave the average service life of freight cars at 25-30 years.

This brief survey of methods of determining optimal or economically advisable service lives shows that their significant shortcoming is a failure to take full account of scientific-technical progress and the obsolescence associated with it. It is noteworthy here that certain investigators distinguish the concepts of "economically advisable service life" and "optimal service life."

In the opinion of these investigators the difference between these two concepts is that the optimal service life does not have to consider the concrete conditions that determine the length of service of objects of fixed capital, while the economically advisable service life must begin from the real possibilities of replacement of the objects for which it is being established. This distinction between the concepts is to a significant degree arbitrary because the economically advisable service life established for concrete conditions always takes into account actual prices for fuel and materials, the level of wages, prices for new machinery, its productivity and economy, repair costs, and other factors operative in the given time frame. Therefore, for the particular period of time the economically advisable service life is also the optimal service life.

As for the possibilities of replacement of machinery in the given period of time, they can limit the economically advisable or optimal service life of fixed capital depending on the purposes for which the service life was established. Thus, the depreciation period of fixed capital applied to calculate norms of depreciation deductions must take into account real possibilities of replacement of old machinery. A service life intended for future planning of new enterprises to produce new machinery should begin from optimal, economically advisable service lives for the given time frame with a certain correction factor for possible reduction in the future.

Extremely long service lives were used for rolling stock in USSR railroad transportation for a long time; during these periods of service locomotives and cars would go through numerous overhauls. For example, in an average service life of 35 years the TE3 diesel engine would travel almost 6.5 million kilometers and go through nine capital repairs with a total cost of 450,000 rubles when the price of the engine (two sections) was 228,900 rubles; the VL8 electric locomotive with a service life of 40 years traveled 8 million kilometers and went through 12 capital repairs with a total cost of 620,000 rubles where the price of the engine was 159,600 rubles.

Large amounts were spent for factory repair of freight and passenger cars, track machines, and the equipment of locomotive and car depots. For example, while a four-axle gondola car cost 5,700 rubles, total expenditures for factory repair in its service life of 40 years were twice this price. Repair expenditures were very high for specialized railway cars, in particular refrigerator cars.

It is inefficient to spend large amounts for capital repair of rolling stock because over a long service life locomotives and cars not only become greatly worn physically, they also become obsolete. Under such conditions it is much more advantageous to buy new, improved locomotives or cars than to repair old ones that have been in use for a long time.

Long service lives for rolling stock presuppose a large number of capital repairs at high cost and make it necessary to organize plants to produce spare parts and repair rolling stock and to develop repair shops at the depots, in addition to having locomotive and car building plants. The inadequacy of repair facilities for railroad rolling stock is being felt today and steps are being taken to expand it. This makes it particularly important to determine the service lives of locomotives and cars correctly. The service lives of rolling stock, which are still very long, must be shortened and the number of expensive and inefficient repair jobs on old equipment has to be reduced, replacing the equipment more rapidly.

In an article [119] G. Yakovlev proposed establishing a norm of one capital repair for most types of machines, while increasing the length of work until capital repair 1.5-2 times by strengthening weak parts and assemblies and increasing the wear resistance of the fastest-wearing parts and assemblies. Because prices for railroad rolling stock are significantly higher than the expenditures for one capital repair, the proposal to establish the service life of locomotives and cars figuring on just one capital repair is unacceptable. At the same time, however, 9-12 capital repairs during the service life is excessive and during the revision of depreciation norms in 1972 the number was reduced.

Thus, the optimal service lives of rolling stock, equipment, and machines used in railroad transportation should be determined with due regard for physical wear and obsolescence, the comparative efficiency of expenditures for capital repair and modernization, prospective balances of rolling stock and equipment, and the real possibility of replacing the equipment being withdrawn.

4. Taking the Effect of Obsolescence on the Service Lives of Rolling Stock, Machines, and Equipment into Account

Establishing progressive average service lives makes it possible to replace obsolete, wornout equipment with new, improved models at the proper time and also to avoid expensive and inefficient capital repair.

The extent of the influence of obsolescence on service life depends on how economical the equipment which will be substituted for operating equipment is. If the machine presently in use and the new machine design differ little in technical and economic indicators, obsolescence will be small and the service life of the machine in use will not change significantly because of it. But if the new machine is markedly more economical, it causes the machine in use to be obsolete and requires its rapid withdrawal from production. Thus, the greater the obsolescence of a machine is, the more quickly it should be taken out of use and the smaller the losses associated with its use in practical operations.

Let us consider in greater detail how the influence of obsolescence on reducing the service life of machines, rolling stock, and various types of equipment in use in railroad transportation can be evaluated quantitatively.

We will adopt the following designations: $T_Э$ is the service life of the machine being used in years; T_M is the decrease in the service life of the machine in use owing to obsolescence, in years; K_1 and K_2 are the prices of the machine in use and the new machine, respectively, in current conditions, in rubles; $Э_1$ and $Э_2$ are annual current costs using the present and new machines respectively, in rubles; H_B is the norm of depreciation deductions to replace the machine in use, as a percentage; E_H is the normative coefficient of the economic efficiency of capital investment, which according to the standard methodology for determining the economic efficiency of capital investment is taken as 0.12.

We will assume that a new, more economical machine has been built which lowers the value of the existing machine, reducing its service life.

The savings of operating capital received from use of the new machine is an important condition that determines whether to withdraw a machine from operation and, therefore, also its service life. This savings must be adequate, first of all, to repay the possible increase in capital investment for the new machine compared to the one in use, that is $K_1 - K_2$. But if the savings from introduction of the new machine is sufficiently large, this machine can be used even earlier, without waiting for the time when the machine in use has fully served its service life, that is, to repay a certain additional part of the still-undepreciated cost of the machine in use. In this case the total sum that should be repaid by the savings from use of the new machine will be

$$C_э = K_2 - K_1 + 0{,}01 K_1 H_в T_м. \qquad (25)$$

Let us determine the reduction owing to obsolescence in the service life of a machine in use, figuring that within the normative repayment time the savings from use of the new machine will repay the increase in expenditures for purchase of the new machine indicated in formula [25] and part of the undepreciated cost of the machine in use related to the reduction in its service life by T_M, in other words

$$\frac{K_2 - K_1 + 0{,}01 K_1 H_в T_м}{Э_1 - Э_2} = \frac{1}{E_н}. \qquad (26)$$

From this we obtain

$$T_м = \frac{Э_1 - Э_2 - E_н (K_2 - K_1)}{0{,}01 E_н K_1 H_в}. \qquad (27)$$

Thus, the reduction in the service life of a machine in use owing to the appearance of an improved machine depends on the amount of savings which the new machine can provide and on the cost of this machine.

Formula (27) considers the impact of both the first and second forms of obsolescence on reducing the service life of fixed capital. The impact of the first form of obsolescence is taken into account in the form of a decrease in the cost of building the obsolete machine that is being used; this cost is determined for the same conditions of production organization as applied to the newly built machine. In comparison with the original cost of the machine being used its new cost may differ owing to improvements in production technology and labor organization, a rise in labor productivity, the use of new materials, changes in prices for fuel, electricity, and materials, and changes in the level of wage rates, overhead expenditures, and the like.

It must be observed that the decrease in the replacement cost of means of transportation, machinery, and equipment in use owing to the first form of obsolescence will be less than the decrease which formula (1) recommends taking into account when re-evaluating obsolete fixed capital according to the methodology of the USSR Central Statistical Administration; this decrease takes into account the reduction in the output or productivity of these machines compared to current ones.*

Obsolescence of the second form is considered an expression (27) in the form of the annual savings $Э_1 - Э_2$ which is lost each year and continues to accumulate as long as the obsolete equipment is used.

The service life of a machine taking into account both forms of obsolescence T_H is determined by the formula

$$T_н = T_э - T_м = T_э - \frac{Э_1 - Э_2 - E_н (K_2 - K_1)}{0{,}01 E_н K_1 H_в}. \qquad (28)$$

The relationship between the service life of diesel locomotives and the economy and price of new locomotives is shown in Figure 14 below.

The methodology presented above was used to determine the service lives of railroad transportation rolling stock, machinery, and equipment taking obsolescence into account. It should be observed that in those cases where new equipment does not provide an adequate impact

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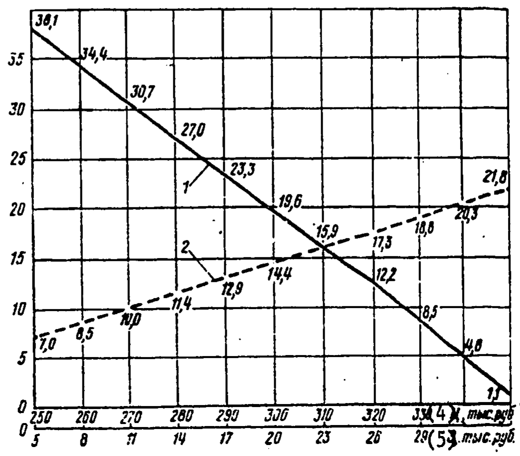
*"Instructions on Re-Evaluation and Determination of Wear of the Fixed Capital of Economically Accountable State, Cooperative (Including Kolkhozes), and Public Enterprises and Organizations Based on Conditions as of 1 January 1972," Moscow, Statistika, 1970, pp 29-30

Figure 14. Change in the Average Service Life of Diesel Locomotives Taking Obsolescence into Account



Key: (1) Depending on Economy Э;
(2) Depending on the Price Ц of the New Locomotive;
(3) Years;
(4) Ц, in thousands of rubles;
(5) Э, in thousands of rubles.

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compared to existing equipment there may be no reduction in the service life of the existing equipment owing to obsolescence. In certain cases T_M may in fact be a negative quantity, which indicates the advisability of increasing, not reducing the service life of the existing equipment. For example, when new car retarders were compared with existing ones it was found that the new ones are less efficient and the quantity T_M came out negative in the calculations [93].

Calculations made at the Central Scientific Research Institute of the Ministry of Railroads using this methodology demonstrated that newly built locomotives of improved designs make the locomotives in use on railroads today less valuable, reducing their service lives. For example, AC electric engines with commutatorless traction motors and power output of 1,200-1,500 kilowatts per axle limit the service life of VL80 electric locomotives to 16 years because of obsolescence. The use of diesel engines with more economical diesels, improved transmission, and more reliable parts and assemblies devalues the TE3 diesel engines now in use, reducing their service life to 15 years owing to obsolescence. These service lives have not been adopted at the present time, however, because other factors, above all the modernization of existing locomotives that is underway, make it possible to increase service lives and adopt the following figures for current conditions: 30 years for electric locomotives and 25 for diesels.

Table 30 below compares the service lives of railroad rolling stock and track machines in effect until 1 January 1975 and the new average service lives that were ratified for that date.

Table 30. Average Service Lives of Railroad Rolling Stock and Track Machines Adopted for Depreciation Norms.

Types of Rolling Stock	Average Service Life, years: 1963 Norms	1975 Norms	Decrease in Service Life, years
Mainline Diesel Locomotives	35	25	10
Diesel Switch Engines:			
With Electric Drive	35	30	5
With High-Speed Diesels	35	25	10
Diesel Trains and Cars	30	25	5
Electric Locomotives	40	30	10
Electric Trains	50	35	15
All-Metal Passenger Cars, except Dining Cars	54	40	14
All-Metal Dining Cars	54	30	24
Enclosed Freight Cars	40	40	-
4-, 6-, and 8-Axle Gondola Cars	40	25	15
Oil Tanker Cars	40	35	5
Acid Tanker Cars	40	10	30
Dosing Hoppers, Ballast Cars	40	30	10
Refrigerator Trains, Sections, and Cars with Mechanical Cooling	32	28	4
Isothermic Cars with Ice-Salt Cooling	32	20	12
Tie-Installing and Packing Machines	18	15	3
Track-Laying Machines and Rail-Layers	24	20	4
Rotary Snow Plows	40	32	8
Snow and Earth Clearing Machines	30	20	10

The decrease in the service life of locomotives and cars, machinery, and equipment aims at replacing the active part of fixed capital quickly and supplying railroad transportation with better, more economical models of new equipment that create the essential conditions for reducing the prime cost of shipping and raising labor productivity.

5. Service Lives of Railroad Structures

The major railroad structures such as the roadbed, bridges, tunnels, the track superstructure, and the catenary system, which make up a large part of the value of the production fixed capital of railroad transportation, have varied service lives.

Some structures serve for very long times, almost forever, and a finite service life for them can only be adopted arbitrarily; other structures can be classified as long-term only on the basis of their continuity of use.

The track superstructure and catenary system of electrified railroads are often included in the second group of structures. They do not require depreciation deductions for replacement to be made new because this occurs when they undergo capital repair. The development of a methodology for establishing average service lives, time period between repairs, and norms of depreciation deductions for specific types of transportation structures with indefinitely long service lives is exceptionally important.

This problem has become especially timely with rapid scientific-technical progress and a high rate of renewal of fixed capital in railroad transportation. Whereas for rolling stock and various types of machinery and equipment that represent the active part of fixed capital we should under these conditions try to establish a decrease in service life because obsolescence comes much faster for them, for railroad structures it is not usually very important to reduce the service life.

A decrease in service life and correspondingly an increase in the norms of depreciation deductions for full replacement of transportation structures leads to growth in these deductions and a decrease in the need for capital repair and modernization. But because the renewal of such major structures as the track superstructure, stone bridges, tunnels, and the like takes place during their capital repair, the capital for these repair jobs is usually inadequate. This is because it is figured only for capital repair norms and depreciation deductions, which should also be used for repair work such as full replacement of rails, ballast, and ties, are spent for other purposes not directly related to replacing wornout elements of the superstructure. Under conditions of highly intensive use of fixed capital, a shortage of depreciation deductions for capital repair of track structures causes a worsening of their technical condition and a decrease in the speed of train travel and the carrying and traffic capacities of railroad lines.

Service lives for railroad transportation structures have been determined based on physical wear and obsolescence taking account of statistical records of their withdrawal from use. As analysis of these data shows (Table 31 below), the withdrawal of railroad structures from use is negligible and results less from physical wear than from reconstruction, the necessity of changing the route of railroads, and other circumstances that are more closely related to obsolescence.

Table 31. Withdrawal of Railroad Fixed Capital in 1972, percentage of total.

Type of Fixed Capital	Total Withdrawn	Of that, with reconstruction and introduction of new equipment
Production Buildings	2.7	1.7
Structures	10.5	8.6
Old Superstructure Materials	27.3	-
Transmission Devices	1.8	1.4
Machines and Equipment	18.8	6.7
Means of Transportation	34.5	5.0
Other Fixed Capital	4.4	-
Total	100.0	23.4

The physical wear of the major railroad structures involves the weathering of building materials, rusting of steel components, rotting of wooden ties, contamination of the ballast, warping of rails and contact wire, and the like. The intensity of physical wear of a structure, and therefore also its service life depend on the reliability of the design, the strength of the material from which it is made, and operating conditions.

As an example Table 32 below gives the service lives of catenary grid towers forecast on the basis of an analysis of the condition of the towers in use and statistical data on their replacement and repair under normal operating conditions with all protective measures taken [96, p 195].

Table 32. Service Life of Catenary Grid Towers of Electrified Railroads, years.

Description of the Region	Tower: Metal	Tower: Reinforced Concrete Conical Centrifuged
Heightened Atmospheric Aggressiveness, ground with aggressive soil waters	25-30	15-20
Heightened Humidity, sharply continental climate, average atmospheric aggressiveness	30-40	20-25
Normal Conditions	50	40

Although it does not occur as rapidly as with rolling stock, machinery, and equipment, obsolescence in railroad structures has a very significant impact on the indicators of labor productivity and prime cost of shipping. At the present time roadbeds with inadequate width, bridge spans not designed for rolling stock with large axial loads, and linked track on wooden ties with light and unhardened 12.5-meter rails are obsolete.

Jointless track is the progressive superstructure design. It has a number of advantages over the linked design. Thus, norms for labor expenditures to maintain jointless track with reinforced concrete ties are 25 percent lower and individual retirement of rails is much less, which also means that their service lives are greater. Jointless segments of R65 rails on reinforced concrete ties can carry a freight load of 550-600 million gross tons. The service lives of other superstructure elements are 15-30 percent greater for jointless track. In addition, jointless track decreases the basic specific resistance to train movement by 10-20 percent (depending on operating conditions) compared to linked track [98, p 61].

In recent years rail tempering and hardening has been used extensively. A savings of 800-1,000 rubles a year is expected for each kilometer of track where body-tempered and surface-tempered rails are used [98, p 40]. For this reason a track superstructure design with untempered rails is even more obsolete.

The physical wear of railroad track structures is eliminated during the process of capital repair. At the same time modernization is carried on, which overcomes the continuously growing obsolescence. Thus, full renewal of the entire structure is accomplished during capital repair by parts. Therefore, it is not advisable to set any specific service life for the long-lasting structures of railroad transportation, as is also true for various similar structures in other sectors of the national economy which are classified as structures of indefinitely extended use. During development of the norms of depreciation deductions in 1971-1972, however, the service lives of the roadbed, railroad tunnels, and track superstructure were limited and taken as 500 years based on the belief that in this time new forms of transportation will appear and railroads will become completely obsolete.

6. The Efficiency of Modernization of Fixed Capital

Modernization of fixed capital is very important to comply with the adopted average service life and prevent losses from obsolescence. For this reason railroad transportation is continuously carrying on significant work to modernize its rolling stock and track and construction machines and to reconstruct the track superstructure and signal, centralization, blocking, and communications equipment. For example, the modernization of freight cars envisions reinforcing the body and replacing wooden planking with metal sides for gondola cars; replacing belt trucks with trucks that have cast side members; outfitting enclosed cars with self-sealing doors; replacing old styles of brakes with improved ones; equipping freight cars with roller bearings, and so on. Modernization of passenger cars includes work to improve the lighting system, installation of alkaline storage batteries in cars with air conditioning, improving electric heating, and so on.

Reconstruction of the track superstructure encompasses work to bring its capacity and design into line with the requirements of the growing freight intensity on the railroads.

Key design elements of objects of fixed capital are frequently modernized, which involves large expenditures of capital. Therefore, each time when the volume of modernization is determined it is necessary to establish whether it is economically wise. This refers especially to large-scale modernization which is economically efficient only if it makes it possible to substantially raise labor productivity, reduce the prime cost of shipping, and with the money saved by this reduction quickly repay money spent to the state. Thus, modernization of rolling stock and equipment is economically efficient if the capital spent for it is repaid quickly, for example in 4-5 years for equipment and 8-10 years for rolling stock.

The payback period for expenditures for large-scale modernization is determined according to the formula

$$T_{OK} = \frac{K_M}{(c_1 - c_2) Q_\Pi}, \qquad (29)$$

where T_{OK} is the payback period of expenditures for modernization, in years; K_M is capital expenditures for modernization, in rubles; c_1 and c_2 are the prime cost of producing a unit of output before and after modernization, in rubles; and Q_π is the annual volume of output after modernization.

The efficiency of modernizing particular assemblies of equipment, rolling stock, signal, communications, and automation equipment, and other objects is not determined if the modernization is aimed at insuring compliance with the accepted service life of the object as a whole defined according to its basic design components.

Table 33 shows changes in expenditures for modernization of rolling stock and reconstruction of track structures and signal and communications devices paid for from depreciation deductions for capital repair and on the basis of the capital investment plan.

As can be seen, modernization of rolling stock was initially carried out through capital repair funds, but in recent years has been done more on the basis of the capital investment plan. To some extent this can be explained by the inadequacy of depreciation deductions for capital repair. The growth in expenditures for reconstruction of

Table 33. Expenditures for Modernization and Reconstruction of Railroad Fixed Capital, percentage.

Expenditures	1963	1965	1970	1975
Capital Repair				
Modernization of Rolling Stock	22.1	22.2	10.8	6.7
Included in above:				
Locomotives	3.3	3.5	3.4	2.3
Freight and Passenger Cars	18.8	18.7	7.4	4.4
Reconstruction of Track, signal and communications devices, and the like	53.3	51.4	47.2	56.1
Total	75.4	73.6	58.0	62.8
Capital Investment				
Modernization of Rolling Stock and Equipment	24.6	26.4	42.0	37.2
Total	100.0	100.0	100.0	100.0

track structures and signal, centralization, blocking, and communications devices deserves attention. As a result the total volume of reconstruction work done according to the plan for capital repair of these structures and devices has risen substantially in recent years.

7. Service Lives of Fixed Capital on Foreign Railroads

Given capitalist production relations and bitter competitive struggle, railroad and other transportation enterprises shorten the service lives of equipment, rolling stock, and transportation structures, striving to employ methods of accelerated depreciation of fixed capital. For example, the following service lives for rolling stock and permanent structures have been established for the National Railway Society (SNCF) of France by the General Tax Board [124]:

	Service Life, years
Electric Locomotives	25
Diesel Locomotives	20
Electric Trains	20
Diesel Trains	15
Passenger Cars	20
Freight Cars	15
Track Machines and Other Mobile Equipment	10
Buildings	50
Artificial Structures . . .	50

	Service Life, years
Station Yards and Railroad Track	20
Electrification Structures	20
Signal, Communications, and Warning Devices	15
Crossings	20

Establishing economically sound service lives for locomotives, cars, and railroad structures receives considerable attention in the Federal Republic of Germany. At the present time the following service lives have been adopted for determining depreciation deductions on federal railroads [122]:

	Service Life, years
Rails	25-40
Wooden Ties and Beams	25-30
Steel and Reinforced Concrete Bridges	60
Massive Bridges	90
Buildings:	
Administrative and Service	30-90
Terminals	60-80
Production	40-90
Power Supply	40-80
Residential	80-100
Enclosed Platforms and Landings	70
Electrical Engineering Equipment	15-40
Mechanical Equipment	6-40
Electric Locomotives	40
Diesel Locomotives	25-30
Motorcars	30-35
Passenger Cars	32
Freight Cars	25-30

The service life of electric and diesel locomotives on British railways has been set at 25 years, while for the catenary system the service life is 33 years and for the equipment of traction substations it is 30 years.

The Japan National Railways adopt shorter service lives for railroad structures and rolling stock than are used in the countries of Western Europe and the United States. Some Japanese service lives are shown below:

	Service Life, years
Diesel and Steam Locomotives	20
Electric Locomotives	18
Electric Cars:	
New Tokaido Line	10
Lightened Designs	13
Other	18
Diesel Trains	11
Passenger and Freight Cars	20
Equipment of Traction Substations	20
Reinforced Concrete Station Buildings	53
Track Superstructure	17
Steel Bridges	40
Reinforced Concrete Tunnels and Other Railroad Structures	60

In the United States the following service lives for railroad rolling stock are considered economically sound [120]: 30-40 years for electric locomotives, 12-15 years for diesel locomotives, and 25-30 years for freight cars. When these periods run out the locomotives and cars must be replaced with new ones or rebuilt. In practice, however, these service lives are not observed and the diesel locomotive fleet of U. S. railroads, according to the figures of American economists, has become outdated and needs modernization and a significant infusion of new locomotives.

The car fleet of U. S. railroads also includes a significant number of obsolete types of freight cars. Of the 1,721,000 freight cars on hand in 1975, 103,000 were between 31 and 40 years old and 28,000 were more than 41 years old. According to statistical data on the car fleet, 26 years is the age at which 50 percent of the cars need to be replaced.

The service lives for the buildings and structures of U. S. railroads have been set at roughly the same level as in the Western European countries: 40-60 years for artificial structures, 60-80 years for production buildings, and 15-27 years for the track superstructure. These structures are, to a significant degree, old and greatly worn. The critical condition of the railroad track can be judged, for example, from figures published in the American press about the Pennsylvania Central Railroad. Limitations on the speed of train travel have been instituted on roughly 40 percent of the track of this road because the track is in poor condition. The total amount of capital necessary to put the road in normal operating condition is, according to calculations by American economists, 800 million dollars [123].

According to calculations by the Organization for the Establishment of a Rational Transportation System in the United States, 36.4 billion dollars is needed to reconstruct railroads in 1970-1980. Of this amount 18.6 billion dollars is necessary to modernize the car fleet, 6.0 billion dollars is required for renewal of locomotives, and 11.8 billion dollars is needed to strengthen the track superstructure and other structures.

Thus, despite the relatively short service lives of rolling stock and structures adopted in the capitalist countries, railroad fixed capital is greatly worn and requires considerable expenditures for renewal. The reason is that the service lives adopted are not generally observed, but are intended only to establish high depreciation deductions. In this way the railroad owners conceal part of their profit and evade taxes on it.

A great deal of work is being done in the railroads of the socialist countries to determine economically advisable service lives for fixed capital. The following service lives have been adopted in the German Democratic Republic for railroad rolling stock:

	Service Life, years
Steam Locomotives	37
Electric Locomotives . . .	30
Diesel Locomotives	25-30
Diesel Trains	20
Passenger and Baggage Cars.	25

In 1974 new norms of depreciation deductions were introduced on the railroads of the Polish People's Republic. They are figured on the basis of the following service lives [130].

	Service Life, years
Locomotives	25
Freight and Passenger Cars.	25
Self-Unloading Cars	20
Rail Cars and Trailers for Them	8
Load-Hoisting Cranes . . .	10
Production and Service Buildings	70-100
Standard and Narrow Gage Railroad Track	100
Track Construction.........	100

	Service Life, years
Communications, Signal, Centralization, and Blocking Equipment	20

The new service lives adopted on Polish railroads are significantly shorter than earlier ones for equipment, machinery, and rolling stock; for buildings and track structures they are longer.

Chapter VII. Depreciation Deductions in Railroad Transportation

1. Norms of Depreciation Deductions

As it gradually becomes worn, the fixed capital of railroad transportation demands considerable capital to eliminate the effects of the accumulating wear.* The wear can be partially eliminated during the servicing of fixed capital and performance of technical inspections and ongoing repair. The expenditures incurred in this are included directly in the estimate of annual operating costs.

But only minor wear is eliminated during technical inspections and ongoing repair. Fixed capital that has been in use for a long time and has undergone significant physical wear and obsolescence requires either replacement with new fixed capital or capital repair and modernization, which involves considerable material, labor, and monetary expenditures. Therefore, it would be incorrect to carry out full replacement, capital repair, and modernization of fixed capital out of the estimates of annual operating costs because in this case the actual expenditures for performance of these jobs would be applied against the output of just one year, whereas the wear would be cancelled over an extended time interval. The same thing applies to medium repair work which is done at periods of greater than one year.

Nonetheless, some investigators [27, p 91] suggest that it is advisable to finance capital repair out of the estimates of annual operating costs. But most economists believe it is more correct to allot the expenditures for replacement, capital repair, and modernization of fixed capital carried out concurrently in equal shares to the output produced with it over the entire service life.

In the USSR and some other countries full replacement, capital repair, and modernization carried out concurrently, as well as medium repair of fixed capital done at periods of greater than one year and, in its economic essence, representing a variation of capital repair, are financed through special deductions from the value of the fixed capital.

* [Russian word for wear, "iznos," includes both physical wear and obsolescence, and is used in this way here.]

This part of the value of the fixed capital is called depreciation deductions.

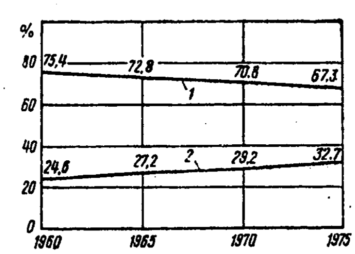
The methods of calculating depreciation deductions depend on how these deductions are determined according to the years of the service life of the fixed capital. A distinction is made between the even (straight-line or classical) method of calculating depreciation and uneven, usually accelerated, methods. In the USSR and most of the other socialist countries and in certain capitalist countries, the straight-line method is used. In this case the annual depreciation deductions are equal shares over the entire service life of the fixed capital.

Thus, depreciation deductions are a definite share of the initial cost of the fixed capital that is gradually transferred to output as the fixed capital becomes worn. One part of depreciation deductions is designated for full replacement of wornout fixed capital; the other is used to finance capital repair and concurrent modernization.

Under conditions of accelerated scientific-technical progress depreciation deductions are becoming vastly more important owing to their intensified role in renewal of operating fixed capital on a contemporary technical basis. As the rate of technical progress accelerates the impact of obsolescence becomes increasingly acute. This causes a reduction in the service lives of fixed capital and an increase in depreciation deductions designated to create a fund for full replacement. At the same time, depreciation deductions for capital repair and concurrent modernization have a tendency to decrease as service lives decrease. All this is reflected in the amount of depreciation deductions for full replacement and capital repair; the ratio between them is changing significantly (see Figure 15 below).

Figure 15. Structure of Depreciation Deductions Based on Primary Railroad Activities

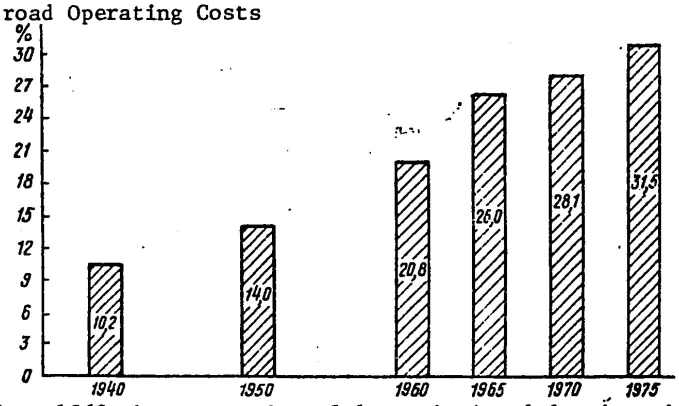
Key: (1) For Capital Repair;
(2) For Full Replacement.



The pace of scientific-technical progress has increased to such an extent today that it is not wise to perform more than one or two capital repairs for many types of machinery and equipment used in railroad transportation. Given continued scientific-technical progress in the future the average service lives of rolling stock, machines, and equipment will become even shorter and the norm of depreciation deductions for capital repair for them will decrease or become completely unnecessary.

Depreciation deductions make up a significant share of the prime cost of shipping. As the diagram given in Figure 16 below shows, their share of railroad operating expenditures is steadily increasing, which is related to scientific-technical progress and the growth of railroad transportation fixed capital. The share of expenditures for fuel, electricity, and materials and for wages is decreasing correspondingly.

Figure 16. Share of Depreciation Deductions in Railroad Operating Costs



From 1950 to 1960 the proportion of depreciation deductions in operating costs rose 50 percent, and in 1975 it was 2.3 times greater than in 1950. However, shipping grew even faster. Between 1950 and 1960 it increased 2.4 times and by 1975 it was 5.2 times greater than in 1950. This led to a decrease in the share of depreciation deductions in the prime cost of shipping from 0.74 kopecks in 1950 to 0.66 kopecks in 1960. The introduction of increased norms for depreciation deductions in 1963 caused a certain increase of this share. In 1965 it was 0.75 kopecks, and in 1970 it was 0.74. As a result of the re-evaluation of fixed capital and introduction of new, even higher norms for depreciation deductions, their share in the prime cost of shipping in 1975 had risen to 0.89 kopecks.

At the present time the share of depreciation deductions in railroad operating costs is almost 32 percent. The share of depreciation deductions in the operating cost for shipping is also significant for other types of transportation. In river transportation, for example, it is 28.5 percent and for air shipping it is 28.9 percent. The relative magnitude of depreciation deductions in expenditures to produce output is less in other sectors of the national economy. The average for industry in 1977 was 6.9 percent, which included 25.5 percent for electric power production, 15.8 percent in the fuel industry, 9.7 percent in ferrous metallurgy, 6.0 percent in machine building and metalworking, 3.1 percent in the food industry, and 1.4 percent in light industry [82, p 141].

Norms for depreciation deductions should be set at such a level that the amounts of depreciation received using them correspond to the wear of fixed capital. Computing too-large amounts leads to an unjustified increase in the prime cost of shipping. But if depreciation deductions are less than the expenditures necessary to compensate for wear of fixed capital, the capital will be "eaten up" and normal reproduction will be upset. Establishing correct, economically sound norms for depreciation deductions is very important to reinforce cost accounting and keep fixed capital in good condition.

The first studies of the necessity for and amounts of norms of depreciation deductions for replacement of fixed capital in USSR railroad transportation go back to 1925. One of them was the work of professor M. M. Filonenko-Borodich on theoretical issues of depreciation of railroad fixed capital [105].

A norm of depreciation deductions in railroad transportation was first used in 1927. It was established only for full replacement of fixed capital and was set at 2.5 percent of the cost of the capital. In 1930 this norm was raised by 2.2 percent in connection with the establishment of depreciation deductions for capital repair. Thus, the total norm of depreciation deductions was 4.7 percent.

The norm was set at this level on the basis of an analysis of railroad reports for a number of years and this norm was used to plan depreciation deductions system-wide. It was not possible to use it to determine deductions for replacement and capital repair of particular types of fixed capital and for various technical-economic calculations.

In 1938 a decree of the USSR Soviet of People's Commissars recognized the advisability of separating out a norm for capital repair from the overall norm of depreciation deductions in order to increase the accountability of economic managers for timely capital repair. According to the official instructions of the USSR State Bank entitled "Procedures for Financing and Monitoring the Use of Capital for Capital Repair," which was ratified by the Economic Council of the USSR Soviet of People's Commissars on 15 April 1938, the use of capital designated for capital repair to accomplish other purposes was prohibited. Since that time the planning, computation, and use of depreciation deductions for capital repair of fixed capital has been done separately from deductions for full replacement.

In 1939 the norm of depreciation deductions for capital repair was raised to three percent in connection with the increase in the cost of capital repair for railroad transportation fixed capital, owing chiefly to the inclusion of expenditures to replace ties, rails, and ballasts; at the same time the norm of deduction for full replacement was decreased to 1.7 percent. Thus, the total amount of the norm remained unchanged at 4.7 percent.

Because this norm was established applicable to the structure of railroad fixed capital in 1930, as railroad transportation was increasingly supplied with new equipment it became progressively less appropriate to the changing structure of fixed capital. Depreciation deduction norms differentiated by types of fixed capital were required to eliminate this discrepancy. In addition, such norms were needed for correct computation of depreciation, determination of the prime cost of freight and passenger conveyance by railroad, and for various types of technical-economic calculations involved in designing new equipment and determining proper conditions for most efficient use of fixed capital.

During the general inventory of fixed capital in 1940 brigades of engineer-specialists formed by sectors of railroad transportation worked out new depreciation deduction norms differentiated by types of fixed capital. This project was being done on a uniform methodology, but it was interrupted by the start of the Great Patriotic War and not carried through to the finish. Nonetheless, the Central Inventory Bureau, using the results of work by the brigades of engineer-specialists and also data from the general inventory and re-evaluation of fixed capital based on conditions of 1 January 1940, drew up a "Draft of Norms of Depreciation Deductions for Railroad Transportation Fixed Capital." But these norms were not ratified or used in practice.

In the postwar years depreciation deductions were planned on the basis of a single norm, established by the Ministry of Railroads in 1952 at 6.5 percent, for all fixed capital. Of this amount six percent was used for capital repair and 0.5 percent for full replacement of fixed capital. This general norm of depreciation deductions was differentiated by groups of enterprises and organizations included in the Ministry of Railroads system. For the production fixed capital of the railroads it was set at 7.2 percent (6.6 percent of which was for capital repair), while for housing and municipal services it was 0.8 percent, for the structures of the Moscow Subway — 1.8 percent, for the administration of direct-route sleeping cars — 4.7 percent, and for industrial enterprises of the Ministry of Railroads — 5.8 percent.

In 1956 the government adopted a decree on re-evaluation of fixed capital and development of depreciation deduction norms differentiated by types of fixed capital. The re-evaluation was carried out based on conditions as of 1 January 1960 and depreciation norms were developed by the sectorial scientific research institutes.

Norms of depreciation deductions were developed for specific types of railroad fixed capital in 1959-1960 by the All-Union Scientific Research Institute of Railroad Transportation. The Economic Planning Administration, Finance Administration, and sectorial main administrations of the Ministry of Railroads took part in this work.

The depreciation deduction norms developed following uniform methodological instructions from USSR Gosplan and differentiated by types of fixed capital were put into effect on 1 January 1963. Introduction of these norms led to an increase of 21.8 percent in the total amount of depreciation deductions for primary railroad activities compared to 1962; this included an increase of 35.6 percent for full replacement and 17.6 percent for capital repair, primarily at the expense of medium repair which had formerly been financed directly from annual operating costs.

As time passed, however, these norms became outdated and failed to keep up with the railroads' need for capital for replacement, capital repair, and modernization of fixed capital. The gap between operative norms and this need had a particularly strong effect on the technical condition of track structures. Betewen 1960 and 1972 the intensity of track use, characterized by freight intensity in millions of gross ton-kilometers per kilometer of total track length grew by more than 50 percent. The cost of capital repair of one kilometer of track increased by almost 65 percent in this period. The growth in the cost of capital repair of the track was not just a result of the rise in prices for materials and more complex working conditions; the need to perform technical reconstruction of the track was also a factor. This involved installing reinforced concrete ties, heavy rails, gravel ballast, jointless track, and other articles to bring the superstructure into line with the volume of freight and passenger traffic. All this work demanded significant capital.

The depreciation deduction norms established for the track superstructure did not fully take work to strengthen the track into account and did not reflect the growth in railroad traffic intensity. Deductions based on these norms were inadequate and, although it increased in money terms, the volume of capital repair of the superstructure in physical terms decreased steadily owing to the increased cost of repairing one kilometer of track.

The Ministry of Railroads was forced to use depreciation deductions from the cost of other types of fixed capital, above all rolling stock, to perform the minimum necessary volume of repair work on the track. Despite this, the shortage of capital for capital track repair remained significant and temporarily increased coefficients were established to the depreciation deduction norms for track structures. Use of these coefficients made it possible to increase the capital allocated for capital repair of track structures by 115 million rubles in 1972, 200 million rubles in 1973, and 280 million rubles in 1974 [70].

The depreciation deduction norms introduced in 1963 also became outdated because the service lives of fixed capital, above all rolling stock, machinery, and equipment, from which the norms were calculated were too long and did not take sufficient account of the high rates of scientific-technical progress and obsolescence of fixed capital today. Moreover, the classification of repair work and periodicity of capital repair were changed in many cases as a result of the increased intensity of use of fixed capital and employment of progressive methods of operation. Depreciation norms did not take this into account and the capital deducted using them was less than was actually needed.

These norms also failed to consider the rise in prices for materials, fuel, and electricity, increase in wage rates, and change in norms for planning and building railroad structures which took place in 1963. All these factors caused an increase in expenditures for capital repair and replacement of fixed capital. At the same time, factors such as the growth in labor productivity, improvement in the organization of repair work, and broad application of mechanization of construction and repair work, tended to reduce these costs.

The establishment of depreciation deduction norms without taking account of the increased intensity of use of fixed capital, the rise in prices for materials, fuel, and electricity, the increase in wage rates, the change in scheduled time between repairs, and other factors that determine expenditures for replacement and capital repair of fixed capital made it necessary to revise the depreciation deduction norms in effect since 1963. In 1969 a resolution was adopted to reevaluate fixed capital and more precisely differentiate depreciation deduction norms. Methodological instructions ratified by USSR Gosplan were followed in this work, just as they had been during the development of depreciation deduction norms for specific types of railroad transportation fixed capital in 1959-1960.

2. Basic Principles and Methodology of Calculating Depreciation Deduction Norms

Depreciation deduction norms are established for all types of fixed capital in railroad transportation: buildings (production, residential, municipal, and cultural-domestic), structures, transmission devices, machines, equipment, rolling stock, tools, inventory, and long-term planted areas. The norms are based on even wear by years. The objects of depreciation are the fixed capital of the production subdivisions of the railroads used in natural form for long periods of time in the process of freight and passenger conveyance.

Norms of depreciation deductions are determined for both simple and complex inventory objects. Furthermore, they are calculated not for each object which differs by individual characteristics, but for groups of objects that have the same production designation and roughly equivalent average service lives. Such norms of depreciation deductions are averages for the objects making up a particular group.

The capital allocated based on depreciation norms forms the depreciation fund, which is used for simple reproduction of fixed capital, that is, compensation for normal natural wear in the shipping process. One part of the depreciation fund, which is used for partial compensation for wear by capital repair and concurrent modernization, is expected to guarantee the functioning of the object with its assigned technical-operating indicators for the full established service life. The other part is used for full replacement of objects of fixed capital that have been withdrawn when these objects were no longer usable or their use was economically unwise. Therefore, the norms of depreciation deductions are also determined separately for full replacement of fixed capital and for capital repair taking into account concurrent modernization.

Determining the norms of depreciation deductions separately for full replacement and capital repair of fixed capital does not, however, mean that these are two different norms. On the contrary, the norms are closely interrelated parts of a single general depreciation norm. Where the average service life, which is the primary indicator for determination of depreciation norms, is shorter the norm of deductions for full replacement will be higher and the norm of deductions for capital repair will be lower because, when other conditions are equal, the amount of capital repair will be less.

Establishing a correct ratio between depreciation norms for full replacement and for capital repair is very important. As a rule, expenditures for capital repair should be significantly less than the cost of a new object. In the absence of factors that make it necessary to continue using the particular object, the maximum expenditure for capital repair should not be more than half of the original cost of the object [28]. The criterion of maximum cost for capital repair often varies for different types of fixed capital depending on scarcity and the existing possibility of replacing those types of rolling stock, machinery, equipment, and other objects of fixed capital whose continued use is economically unsound.

Norms of fixed capital depreciation deductions are usually established for average operating conditions. Deviations from these conditions are taken into account by correction factors applied to the depreciation norms. These factors take account of: (1) degree of loading of machines and equipment, which depends on the number of shifts and number of hours they work in a day, in other words the intensity of use; (2) degree of aggressiveness of the environment in which the fixed capital is used; (3) special climatic and geological conditions of the region.

Correct determination of depreciation deductions for full replacement and capital repair of fixed capital is growing in importance with rapid scientific-technical progress. Norms for full replacement should stimulate accelerated replacement of machinery, equipment, and rolling stock above all. Accelerating the turnover of money embodied in fixed capital plays an important part. This can be accomplished either by establishing shorter service lives for means of labor or by changing the method of calculating depreciation deduction norms.

In view of the need to stimulate scientific-technical progress and replace equipment and machinery quickly the question arises of the wisdom of using the methods of accelerated depreciation of fixed capital in a socialist economy [27, 45, 95]. These techniques are based on the use of decreasing rates, where depreciation deductions gradually decrease as the age of the fixed capital grows.

In addition to advocates of use of accelerated depreciation techniques, there are also opponents. For example, Yu. I. Lyubintsev, reviewing the issue of using accelerated depreciation in a socialist system, observes that "the methods of accelerated depreciation employed under capitalism not only lose their advantages when transferred to socialist production, but in our opinion become a brake on technical progress, an additional financial burden at a time of vigorous changes in the technical re-equipping of production, particularly manufacturing industry" [75, p 164]. A. V. Vikhlyayev has also noted the retardant effect of accelerated depreciation on the introduction of new machinery [34].

The starting point for deciding the question of the wisdom of using accelerated depreciation methods under socialist conditions is the question: which of the methods most fully reflects the wear of fixed capital in the particular period of its service life. The wear of fixed capital is not even over time, of course. Generally, in the first years of the service life when the fixed capital is still new, wear is not greater, as some economists who propose accelerated depreciation methods believe [95], but less, and it grows as the fixed capital ages. This point was emphasized very vividly by K. Marx, who compared expenditures for the repair of means of labor in different periods of their life with a person's needs for medical care. Noting the increase in expenditures to eliminate wear as means of labor grow old, K. Marx wrote the following: "It is exactly like an old person who must, to avoid a premature death, spend more for medical care than a person filled with the strength of youth" [1, Vol 24, p 196].

The problem of determining the intensity of increase in wear for specific types of fixed capital in different periods of the service life has not been thoroughly studied yet. But regardless of when the wear of fixed capital is greater and when it is less, expenditures to eliminate the wear should always be applied in equal shares to the value of the output created with the participation of this fixed capital. This is precisely the purpose of depreciation. Otherwise it is impossible to substantiate the need to finance capital repair through a specially formed depreciation fund. From this point of view, the method of increasing depreciation proposed by Yu. I. Lyubimtsev [75, p 167] can hardly be applied in practice, even though it does correctly reflect the growth in physical wear and obsolescence of fixed capital with the passage of time.

Thus, under socialist conditions accelerated depreciation of fixed capital is economically unwise.

Proposals to determine depreciation deduction norms for replacement with due regard for the time factor have received some distribution [18, p 53]. There are differing views on this issue. Advocates of establishing depreciation deductions norm with due regard for the time factor usually point out that the depreciation fund for full replacement of fixed capital is not spent in the period when it is computed, but rather later when the fixed capital is being withdrawn from use. To establish norms they propose using the relationship derived by A. L. Lur'ye in 1948 for change in depreciation deductions when variations with different service lives are compared [74, p 85]. Taking the effect of postponing expenditures into account, depreciation deductions for full replacement of equipment can be determined from the equation

$$K_0 = \sum_{i=0}^{i=t-1} A(1+E_H)^i, \tag{30}$$

where K_0 is the cost of equipment with a service life of t years; A is depreciation deductions; E_H is the normative coefficient of efficiency of capital investments; i is the values of the service life of the equipment in series from 0 to t-1 years.

To determine depreciation deductions we calculate them for the last year of the service life of the equipment

$$\sum_{i=0}^{i=t-1} A(1+E_H)^i = \frac{A(1+E_H)^t-1}{E_H} = K_0. \tag{31}$$

From this the depreciation deductions

$$A = \frac{E_H K_0}{(1+E_H)^t-1}. \tag{32}$$

The norm of depreciation deductions for full replacement H_B will be (in percentage)

$$H_B = \frac{A}{K_0}100 = \frac{E_H}{(1+E_H)^t-1}100. \tag{33}$$

Depreciation deductions determined by formula (32) taking the time factor into account are significantly smaller than deductions calculated by the conventional methods. The difference is even more significant when the normative coefficient of efficiency of capital investment is higher and the service life of the objects of fixed capital is longer. For example, a structure which has a cost of 1 million rubles and a service life of 50 years will have depreciation deductions of 20,000 rubles a year calculated by the conventional formula; using the formula taking the time factor into account where $E_H = 0.12$ they will be 420 rubles, a much smaller amount. Therefore, when depreciation deductions are calculated using a norm determined taking the time factor into account, the initial cost is not fully transferred to the output created with this object.

Some other students of this issue support the proposal to determine depreciation deduction norms taking the time factor into account. For example, S. Zakharov [46] believes that existing norms of depreciation deductions for full replacement are too high because they are applied to the original cost of the fixed capital at a time when full replacement is done at the replacement cost, which is lower than the original cost. The significant amounts of unused depreciation deductions formed in this way, the author believes, should produce a profit corresponding to the average normative coefficient of efficiency of capital investment for industry, which is 0.15, if used elsewhere. Going on from this, he proposes that norms for depreciation deductions for full replacement be established by a formula using complex percentages. In the case of long service lives, however, depreciation deductions determined by such norms become negligible and for practical purposes the share participation of fixed capital in the production of output disappears almost completely.

Another important circumstance that cannot be ignored is that the advocates of determining norms of depreciation deductions taking the time factor into account assume that wornout fixed capital will be restored to its earlier form, that is, without taking scientific-technical progress into account. K. Marx wrote: "Means of labor customarily undergo constant change owing to industrial progress. Therefore, they are replaced not in their original form, but in the changed form" [1, Vol 24, p 191]. Therefore, the depreciation deductions must be calculated so that they will cover the cost of purchasing fixed capital which is more productive, reliable, and economical than the former design, and usually also more expensive.

Depreciation deductions for full replacement of fixed capital should stimulate the introduction of new equipment. This was expressly envisioned by the Directives of the 24th CPSU Congress on the Five-Year Plan of Development of the USSR National Economy for 1971-1975: "Develop and gradually introduce new, shorter periods of depreciation for production equipment, limiting the volume of inefficient capital repair and increasing the share of depreciation deductions alloted for replacement of wornout and obsolete equipment" [4, p 242].

Thus, it hardly seems wise to determine depreciation deduction norms taking the time factor into account.

Another debatable proposal is made by V. S. Ligonenko, who believes that the "norm of depreciation for capital repair of fixed capital must be determined with due regard for the time factor and length of cycles between repairs" [73, p 79].

At the present time norms of depreciation deductions for full replacement H_B are usually determined as a percentage of the original (restoration after re-evaluation) cost of the fixed capital using the formula

$$H_B = 100/t, \quad (34)$$

where t is the service life of the object (depreciation) in years.

The depreciation norm calculated in this way shows as a percentage that part of the cost of the object which must be deducted each year to accumulate sufficient money during its service life to fully replace the wornout object with a new one.

In a case where an object that has been withdrawn because of wear can be used as scrap metal, wood, and the like, the norm of depreciation for full replacement is determined taking the so-called liquidation value into account, according to the following formula

$$H_B = \frac{100}{t} \frac{П - Л}{П}, \quad (35)$$

where П is the original cost of the object of fixed capital and Л is the liquidation value, defined as the difference between earnings from sale of the withdrawn object and the cost of work to dismantle it and turn it into scrap.

This norm of depreciation deductions is determined only when the liquidation value of objects of fixed capital is quite large.

Norms of depreciation deductions for capital repair and modernization of structures, rolling stock, machinery, equipment, and other forms of railroad transportation fixed capital H_K are determined as percentages of their original cost using the formula

$$H_K = \frac{Kn + Cm + M}{Пt} 100, \quad (36)$$

where K and C are expenditures for one capital repair and medium repair respectively, in rubles; n and m are the number of capital repairs and medium repairs respectively during the service life of the object of fixed capital; M is expenditures for modernization of a unit of equipment, means of transportation, or other forms of fixed capital during

In some cases the liquidation value that forms during capital repair must be taken into account just as it was in determining the depreciation norm for full replacement. For example, when capital repair is done on wooden snow fences, a significant liquidation value is formed through use of the unsuitable fencing material as firewood. The total cost of capital and medium repairs recorded during the calculation of the norm of depreciation deductions for capital repair should be reduced by this value.

The number of capital repairs is determined as the quotient from dividing the service life of the object by the length of the period between capital repairs. In this case it is considered that the final capital repair is not performed

$$n = \frac{t}{N} - 1, \qquad (37)$$

where N is the period between capital repairs in years.

The number of medium repairs performed at periods of more than one year during the service life of the object is computed according to the formula

$$m = \frac{t}{N_1} - \frac{t}{N}, \qquad (38)$$

where N_1 is the period between medium or medium and capital repairs in years.

The periodicity of capital and medium repairs is established by approved rules for the performance of repair work on particular types of fixed capital.

Expenditures for modernization carried concurrently with capital repair are usually taken out of capital repair expenditures. If this cannot be done, expenditures for capital repair and modernization are taken as a total amount. In this case the formula for calculating the depreciation norm for capital repairs is simplified and takes the form

$$H_{\kappa} = \frac{Kn + Cm}{\Pi t} 100. \qquad (39)$$

For complex objects of capital consisting of several simple objects, the norm of depreciation deductions for full replacement H'_B is determined taking the service lives of the simple objects into account

$$H'_{в} = \frac{100}{t} \frac{\Pi + \Sigma bk - Л}{\Pi}, \qquad (40)$$

where t is the service life of the complex object as a whole taken on the basis of the service life of the longest lasting simple object, in years; Π is the original cost of the entire complex object, in rubles; b is the cost of particular simple objects replaced k times during the service life of the complex object; Л is the liquidation value of the complex object taking withdrawal of simple objects into account, in rubles.

The norm of depreciation deductions for capital repair of complex objects H'_K is determined with due regard for annual deductions for capital repair of simple objects based on the established periodicity of repair work for them

$$H'_{\text{к}} = \frac{(\Sigma K + \Sigma C + M)}{\Pi t} 100, \qquad (41)$$

where ΣK is expenditures for capital repair of simple objects during the service life of the complex object, in rubles; ΣC is expenditures for medium repair of simple objects during the service life of the complex object, in rubles; M is total expenditures for modernization during the full service life of the complex object, in rubles.

The norms of depreciation deductions for each type of fixed capital in railroad transportation are calculated according to the formulas given above. For objects with indefinitely long service lives that are renewed in the process of capital repair, however, norms of depreciation deductions for full replacement do not have to be established. For them it is advisable to determine only norms for capital repair and modernization [55].

This point of view is shared by V. Yu. Budavey, who believes that "to insure continuity of production society must provide that the cost of appropriate output and services include only expenditures for repair of long-lasting structures. Depreciation deductions for replacement need not be made in this case" [27, p 104].

Another point of view, however, is also expressed in print. L. M. Kantor, for example, believes that depreciation deductions for both replacement and capital repair must be computed for long-lasting structures (among which he includes the track superstructure). Referring to the accelerated pace of scientific-technical progress, he argues that a 100-year service life is very long and cannot be adopted for any of these structures. The 500-year service life adopted for the track superstructure and other long-lasting structures is much too high, while the norms of depreciation deductions for full replacement are too low [16, pp 226-227].

D. A. Baranov, reviewing the question of the depreciation of fixed capital whose replacement occurs by parts and classifying the track superstructure in this group, writes: "The incredible exaggeration of the average period of turnover for this type of fixed capital (from 18.2 to 500 years) came about because it was supposed that full renovation of this type of fixed capital can only be done all at once, by laying the entire railroad roadbed over and, furthermore, that the replacement of wornout simple basic elements is capital repair of initially invested fixed capital, not true renovation by parts" [20, p 47].

Such a position is understandable. Indeed, if we base our thinking on the service lives of the particular elements of the track superstructure, the average weighted service life is right around 18 years. But it must be kept in mind that with this approach there can be no norm of deductions for capital repair and modernization and all deductions for replacement will have to be used for capital repair, which is accomplished by replacing different elements of the track superstructure. This distorts the very meaning of the inventory object "track superstructure," and generally accepted concepts of capital repair of track disappear. Therefore, for the track superstructure as for other objects of fixed capital which have indefinitely long service lives, only a norm of depreciation deductions for capital repair and modernization should be established. But because these structures may become obsolete in the future, a service life of 500 years is adopted for them and a norm of depreciation deductions for full replacement of 0.2 percent is established.

It is advisable to determine the norm of depreciation deductions for capital repair of the track superstructure per 1 million gross ton-kilometers taking the intensity of track use into account. Before the norm is determined a calculation should be made of annual expenditures for capital, medium, and track-lifting repair based on operative repair schedules and the unit costs of particular types of repair. For example, the depreciation norm per 1 million gross ton-kilometers for mainlines H_r may be determined by the formula

$$H_{\text{г}} = \frac{K_{\text{в}} + C + \Pi_{\text{р}}}{H_{\text{т}} \Pi_{\text{в}}} 100, \qquad (42)$$

where K_B is the cost of one capital repair of one kilometer of track superstructure, in rubles; C is the cost of all medium repairs of one kilometer of track superstructure in the period between capital repairs, in rubles; Π_p is the cost of all track-lifting repairs of one kilometer of track superstructure in the period between capital repairs, in rubles; H_T is the norm of tonnage between capital repairs, in millions of gross ton-kilometers; Π_B is the initial cost of one kilometer of track superstructure, in rubles.

The norms of depreciation deduction for medium and track-lifting repair of station tracks, switches, and sidings belonging to the railroads can be determined in a similar fashion.

The full norm of depreciation for all types of track repair (capital, medium, and track-lifting) as a percentage of total replacement cost of the track superstructure in this case could be determined per 1 million gross ton-kilometers by dividing the total annual sum of expenditures for capital, medium, and track-lifting repair of the superstructure of all railroads (mainline, station, siding, including switches) by their total replacement cost and the calculated amount of average freight intensity in millions of gross ton-kilometers per kilometer of total length of mainlines and multiplying the resulting ratio by 100.

It is also more correct to determine the norm of depreciation for the catenary system of electrified railroads with consideration of the intensity of its use, which is expressed by the number of passages of current collectors, and only for capital repair. This is advisable because the catenary system is renewed continuously by replacement of individual design elements during capital repair.

It is also advisable to establish norms of depreciation deductions for capital repair considering intensity of use for rolling stock. For example, they may be determined depending on annual distance traveled by locomotives and cars [55].

3. Development of Depreciation Norms in 1972

The depreciation norms now in effect were worked out in 1972 and put into effect on 1 January 1975.

These norms were developed with due regard for the need for accelerated replacement and modernization of obsolete fixed capital. Shorter depreciation periods were adopted for calculating the norms in order to limit the volume of inefficient capital repair and increase the share of depreciation deductions for replacement of wornout and obsolete types of machinery and equipment.

In the process of developing the norms the average service lives and periods between repair for fixed capital were determined more precisely. Economically sound service lives were determined on the basis of calculation and analysis of economic and technical factors, including: physical wear and obsolescence of fixed capital, efficiency of expenditures for capital repair and related modernization, actual age of fixed capital in operation, actual possibility of replacing particular types of equipment and rolling stock with new, improved models, and so on.

The average service lives of rolling stock, machinery, and equipment were established with due regard for the obsolescence of existing units and the economic benefits of newly built units. It was taken into account in this that the more economical the new units were, the more obsolete they made existing machines, equipment, and rolling stock, thus reducing their service lives.

The average service lives of locomotives, cars, machines, equipment, and tools established by sectorial divisions of the Central Scientific Research Institute of the Ministry of Railroads were tested at railroad enterprises, reconciled with the main sectorial administrations of the Ministry of Railroads, and adopted for calculating new norms of depreciation deductions.

For the large, expensive railroad structures such as the roadbed, reinforced concrete and metal bridges, tunnels, and other long-lasting objects, the service lives were the maximum allowable based on wear and ranged from 80 to 500 years.

During the development of new norms of depreciation deductions substantial attention was devoted to precise determination of the periodicity of fixed capital repairs. In most cases the repair schedules ratified by the Ministry of Railroads were adopted for calculating the norms. In this case the periods between repairs established by the ministry in 1969-1971 were generally taken without alteration. But if the repair schedules were established earlier than 1969, they were analyzed and compared with actual times reported on the railroads and enterprises of railroad transportation; the volume of capital repair had to be considered. In the case of insignificant deviations the ratified capital repair periods were also adopted without modification for calculating depreciation norms. Where there were significant deviations in the volumes and times of capital repair from those ratified by the ministry these indicators were determined more precisely taking into account actual performance and the recommendations of the railroads and main administrations of the Ministry of Railroads.

Data on the replacement cost of fixed capital and information from railroads, plants, and other railroad transportation enterprises concerning actual service lives and expenditures for capital repair and modernization were used to work out the new norms of depreciation deductions.

In all cases the replacement cost of fixed capital was taken on the basis of the ratified price lists and schedules specially developed for the re-evaluation of fixed capital based on condition as of 1 January 1972. This established a connection between the depreciation deduction norms being developed and the replacement cost of the fixed capital obtained after re-evaluation.

Expenditures for capital repair of track structures, the catenary system, and other complex objects were determined by design elements based on the cost of repair and service lives.

The prices for repair contained in the ratified price lists were used in determining the costs of capital repair of rolling stock, machinery, and equipment. An analysis was made of the correspondence between price list prices and actual expenditures for repair over several years. Expenditures for capital repair were adopted with consideration of such factors as change in prices, lower cost of repair owing to better organization and reduction of labor inputs to do repair jobs, use of more wear-resistant materials, decrease in the cost of spare parts in connection with their production at specialized plants, and others. In the absence of factual data on expenditures for capital repair, these expenditures were taken from the ratified price lists or calculated by comparing special cost computations and estimates.

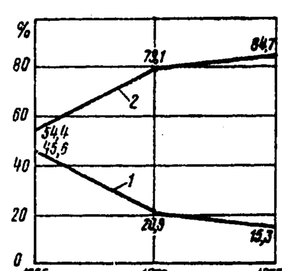
In addition to expenditures for capital repair of fixed capital the norms of depreciation deductions considered capital used for small-scale modernization involving technical improvements through design modification, replacement of particular parts and assemblies with better ones, and installing new attachments and gages for particular machines and aggregates. Modernization was considered in those cases where it was economically efficient, that is, made it possible to raise labor productivity, reduce the prime cost of shipping, increase train weight, and improve the speed and safety of train travel, improve working conditions for employees, and so on.

Analysis shows that under current conditions a great deal of work is underway to modernized the fixed capital of railroad transportation; it is being finance through depreciation deductions for capital repair and through the plan of capital investment.

During the development of norms of depreciation deductions in 1959-1960 it was assumed that roughly 30 percent of all modernization work would be done during capital repair and the remaining 70 percent would be done on the basis of the capital investment plan. Analysis of expenditures for modernization of the fixed capital of railroad transportation indicated that this ratio had changed. Whereas all expenditures for modernization roughly doubled between 1965 and 1975, significantly less modernization work than expected was done on the basis of the capital repair plan. At the same time, the proportion of modernization done under the capital investment plan grew.

As Figure 17 shows, the volume of modernization work financed from the capital investment plan rose from 54.4 percent to 84.7 percent in the years studied, while similar work on the capital repair plan dropped correspondingly from 45.6 to 15.3 percent.

Figure 17. Volume of Work To Modernize Fixed Capital of Railroad Transportation Performed Under the Capital Repair Plan (1) and the Capital Investment Plan (2)



A great deal of work is being done in railroad transportation to reconstruct and strengthen the track superstructure and improve signal and communications devices. Analysis of the technological processes involved in this work shows that it is most efficient to do them concurrently with capital repair. Therefore, if modernization or reconstruction of fixed capital is done concurrently with capital repair, it is considered in the norms of depreciation deductions for capital repair.

Expenditures for modernization of rolling stock, machines, and equipment done separately from capital repair (rebuilding depots, shops, locomotives, and the like and renovating obsolete equipment) are not considered in depreciation norms for capital repair because these expenditures are financed from the capital investment plan and, in addition, from capital in the fund for production development and bank loans.

In order to include it in the calculation of norms of depreciation deductions the cost of modernization work was determined on the basis of: (1) analysis of actual expenditures for modernization in past years with due regard for possible change in the volume of modernization work in the coming 10 years; (2) standard plans for modernization of rolling stock and equipment; (3) direct calculations and expert evaluation; (4) plans for modernization of the rolling stock, machinery, and equipment of railroad transportation.

A number of significant changes were made in the depreciation norms that were developed when the norms were reviewed at USSR Gosplan. One of them was that the depreciation norm for capital repair of the track superstructure was made constant, as was also done in 1960. This means that it did not depend on freight intensity, even though this approach created certain difficulties with financing capital repair of the superstructure.

The norms of depreciation deductions for all types of fixed capital were determined as percentages of their replacement cost.

The new norms of depreciation deductions for the most important types of railroad transportation fixed capital, taking into account changes that have been made during revision, are given in the appendix to this book.

These norms are progressive. They take fuller account than the former norms of the accelerating pace of scientific-technical progress and are directed to faster renewal of the fixed capital of railroad transportation. The norms are established on the basis of shortened service lives for rolling stock, machinery, and equipment and more fully reflect obsolescence and the intensity of use of fixed capital.

Before 1975 there were 93 norms of depreciation deductions for specific types of fixed capital in railroad transportation; there are now 160. The reason for this is fuller consideration of new types of fixed capital that have appeared on the railroads as the result of scientific-technical progress. Among the types of fixed capital for which depreciation deduction norms have been developed for the first time we could note: rolling stock and power supply installations of AC electric roads, automatic classification hump equipment, equipment to automate ticket and terminal transactions, flow-type conveyor lines for locomotive and car repair, gantry cranes to reload large containers, flotation devices to decontaminate waste water, and others.

As calculations show, the re-evaluation of fixed capital and employment of new depreciation norms under 1975 conditions led to an increase in depreciation deductions and a rise in their share of the operating costs of railroads. The increase in depreciation deductions compared to deductions at the previous norms (taking into account temporary increase factors) was 6.7 percent. Within this deductions for full replacement rose 30.3 percent while deductions for capital repair and concurrent modernization decreased 2.5 percent.

The average norm of depreciation deductions calculated for differentiated fixed capital norms was 4.8 percent in 1976, which included 1.7 percent for full replacement and 3.1 percent for capital repair and modernization. Thus, the average service life of railroad transportation fixed capital decreased from 80 to 60 years.

When calculating the average norm of depreciation deductions for railroad track superstructure deductions were considered separately for mainlines, station tracks, switches, and sidings. Table 34 gives the approximate depreciation norms for these types of superstructure.

Table 34. Norms of Depreciation Deductions for Track Superstructure, percentage.

Superstructure	Total	Included in That: Full Replacement	Included in That: Capital Repair
Mainlines	6.5	0.2	6.3
Station Tracks	2.8	0.2	2.6
Switches	4.9	0.2	4.7
Sidings	2.1	0.2	1.9
Average	5.5	0.2	5.3

The differentiation of the ratified average norm for the track superstructure by individual railroads is very important. The lack of such differentiation at the present time gives an incorrect picture of the prime cost of shipping, makes it more difficult to form material incentive funds, and causes unsubstantiated fluctuations in the amount of the payment per capita by railroads. The payment for capital is beginning to perform the function, uncharacteristic of it, of a regulator of the profit necessary to form incentive funds.

4. Planning Depreciation Deductions

Exact planning of depreciation deductions, which make up a significant part of railroad operating costs (more than 32 percent), is very important. The introduction of computer equipment is helping improve the quality of planning. Computers can be used for planning depreciation deductions only where ratified norms of depreciation deductions are employed. But this necessitates setting up records of the cost of fixed capital for those groups used to establish norms of depreciation deductions. Planning depreciation deductions using computers will make it possible to avoid a large amount of unwieldy, labor-consuming calculation work that is now done manually.

The railroads and Ministry of Railroads plan depreciation deductions on the basis of the average annual cost of the fixed capital being depreciated and average depreciation norms. They use data for the report year and the current year, which help establish the necessary indicators for the forthcoming planning year.

The amount of depreciation deductions for the planning year is calculated using a specially established form that is given in the "Methodological Instructions for Writing Drafts of Current and Future Plans for Development of Railroad Transportation" (Moscow, Transport, 1977, 272 pages). These instructions also present the methodology of planning depreciation deductions in railroad transportation. It would be wise, however, to make certain changes in the methodology now in use to calculate depreciation deductions more accurately. This refers primarily to determining the average annual cost of fixed capital being introduced and withdrawn.

According to the methodology the average annual cost of fixed capital being put into operation is determined by multiplying all fixed capital introduced by the coefficient K_π, which takes into account the evenness of introduction of fixed capital in the course of the planning year. The average annual value of fixed capital being withdrawn in the planning year is found analogously by multiplying withdrawal by the coefficient K_B, which takes into account evenness of withdrawal in the course of the year. The coefficients K_π and K_B are presently taken to be constant and equal to 0.35. But these coefficients can be determined more precisely.

On the railroads the coefficient of evenness of introduction of fixed capital can be determined as a weighted mean based on the value of rolling stock, machinery, and equipment, for which it is taken to be

0.5, and the value of various buildings, structures, and transmission devices, for which it can be calculated with due regard for the planned period of introduction of specific objects of fixed capital on the particular road. In general form the coefficient K_{Π} is determined according to the formula

$$\kappa_{\Pi} = \left[\frac{\sum_{i=1}^{i=n} C_i (12 - e_i)}{12 C_{\Pi}} c_2 + \kappa'_{\Pi} c_1 \right] 0{,}01, \qquad (43)$$

where C_i is the cost of object i (structure, building, transmission vice) put into use in the planning year, in thousands or rubles; e_i is the ordinal number of the month of introduction of object i from the beginning of the year; n is the total number of structures, buildings, and transmission devices being launched in operation in the planning year; C_{Π} is the cost of all objects (structures, buildings, and transmission devices) being introduced in the planning year, in thousands of rubles; 12 is the number of months in a year; C_2 is the proportion of the cost of buildings, structures, and transmission devices in the total cost of the fixed capital being put into use on the road in the planning year, as a percentage; C_1 is the same figure for means of transportation, equipment, machinery, inventory, and tools delivered by industry in the planning year; k'_{Π} is the coefficient of evenness of introduction of means of transportation, equipment, machinery, inventory, and tools; 0.01 is the coefficient for converting percentages to relative shares.

The value of fixed capital being withdrawn because of dilapidation and wear is determined on the basis of data on the withdrawal planned in the planning year or data on actual withdrawal of fixed capital in the report year with a correction for expected withdrawal in the planning year.

The average annual value of fixed capital being withdrawn is calculated multiplying its cost by the coefficient k_B. For means of transportation, machinery, equipment, tools, and inventory the coefficient k'_B, which considers evenness of withdrawal of this fixed capital, is taken as 0.5. For buildings, structures, and transmission devices the coefficient of evenness is determined considering the time of their withdrawal from use. The mean coefficient of evenness of withdrawal of fixed capital in the course of the year weighted by cost may be calculated using the formula

$$\kappa_{B} = \left[\frac{\sum_{j=1}^{j=m} C_j (12 - e_j)}{12 C_{B}} c'_2 + \kappa'_{B} c'_1 \right] 0{,}01, \qquad (44)$$

where C_j is the value of object j (a building, structure, transmission device) being withdrawn in the planning year, in thousands of rubles; e_j is the ordinal number of the month of withdrawal of object j from the start of the year; m is the total number of structures, buildings, 3/

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and transmission devices being withdrawn in the planning year; C_B is the value of all objects (structures, buildings, and transmission devices) being withdrawn in the planning year, in thousands of rubles; c_2' is the proportion of the cost of buildings, structures, and transmission devices in the total value of all fixed capital being withdrawn in the planning year on the road, in percentage; c_1' is the same thing for means of transportation, equipment, machinery, inventory, and tools.

Another refinement of the methodology for calculating depreciation deductions in the planning year involves the amount of the average depreciation norm used for calculations. At the present time it is taken on the basis of depreciation norms differentiated by types of fixed capital.

When planning depreciation deductions the average norm of depreciation is taken from the report for the year preceding the current year. Thus, if a plan is being drawn up for 1978, the depreciation norm for 1976 is used for calculations. As we can see, this does not take into account change in the structure of fixed capital in either the current or the planning year, which is reflected in the quality of planning. Therefore, it is advisable to use an average norm which takes into account changes in fixed capital that occur in the current year and are expected in the planning year.

When planning depreciation deductions related to shipping, the calculation includes all production fixed capital of railroad transportation with the exception of fixed capital that is leased out, dining cars, mail cars, cars that are located abroad, and the fixed capital of auxiliary enterprises. At the same time, some nonproduction fixed capital which is supported from expenditures for shipping is taken into account. This includes line buildings, the fixed capital of medical offices and clinics, clubs, red corners, stadiums, bath houses, laundries, and cultural-domestic facilities that are carried on the railroad balances.

Deductions for the entire fleet of freight cars and containers are considered in full when planning depreciation deductions for the railroads as a whole. But because cars and containers on the roads are used without individual road identification, when planning depreciation for a particular railroad the calculation should include a refinement that envisions determining depreciation deductions for freight cars and containers in the working fleet, not the registered fleet. Therefore, deductions for the registered fleet of freight cars and containers must be excluded from the general depreciaton deductions calculated for the road earlier and depreciation deductions for the working fleet in the planning year must be added. The Economic Planning Administration of the Ministry of Railroads notifies the railroads of the latter figure which it has determined system-wide for the planning year as a whole and then broken down by roads proportional to the working fleet of freight cars and containers on each road.

Planning depreciation deductions in road sections and sectorial line enterprises is very important for conserving and improving the use of fixed capital. After the re-evaluation of fixed capital based on condition as of 1 January 1960 and ratification of differentiated depreciation norms, conditions were created for planning depreciation deductions right in the road sections and their sectorial line enterprises. This gave a great boost to cost accounting.

When planning depreciation deductions for the planning year, each enterprise must: (1) group all its fixed capital in groups which have the same depreciation norms; (2) determine the average annual value of fixed capital according to these groups for the planning year; (3) by multiplying the average annual value by the depreciation norm, determine the amount of depreciation deductions for full replacement and capital repair separately for each group of fixed capital and for the entire enterprise as a whole.

The average annual value for each group of fixed capital is determined by taking the value expected at the beginning of the planning year, adding average annual growth through introduction of new fixed capital in the planning year and subtracting average annual withdrawal of fixed capital in the same year. The average annual value of fixed capital being introduced and withdrawn in the planning year is determined by dividing the value by 12 and multiplying the results obtained for fixed capital being introduced by the number of complete months that the fixed capital is in operation during the planning year, while for fixed capital being withdrawn it is multiplied by the number of complete months remaining after the month of withdrawal of this capital until the end of the planning year.

5. Computation and Use of the Depreciation Fund

After 1963 and the development and introduction of differentiaged norms for depreciation deductions, depreciation funds began to be formed directly at railroad transportation enterprises and organizations. These funds, which take account of the structure of fixed capital and their new value after re-evaluation, have grown steadily, as Table 35 below shows.

Thus, between 1963 and 1977 the total amount of depreciation deductions for the primary activity of railroads more than doubled, which included an increase of 216.8 percent for full replacement and 109.8 percent for capital repair.

Table 35. Growth of Depreciation Deductions for Primary Railroad Activities, percentage.

Purpose of Depreciation Deductions	1963	1965	1970	1975	1977
Full Replacement	100	117.4	161.3	286.8	316.8
Capital Repair	100	111.0	137.9	195.4	209.8
Average	100	112.7	144.1	219.3	237.7

The increase in the fixed capital of railroad transportation exercised a significant influence on growth of depreciation deductions. If all production fixed capital of the railroads in 1963 is taken as 100 percent, in 1965 it was 109.5 percent, in 1970 137.4 percent, in 1975 (considering the re-evaluation) it was 216.8 percent, and in 1977 it was 243.8 percent. The significant increase in fixed capital in 1975 reflects not only actual growth in physical volume but also the result of the re-evaluation based on condition as of 1 January 1972. In addition, the growth in depreciation deductions reflected change in the structure of fixed capital, the increase in depreciation norms for capital repair of track structures, and various other factors. Table 36 below shows change in the depreciation norm of fixed capital for primary railroad activity in the period under consideration.

Table 36. Average Depreciation Norm, percentage.

	1963	1977	Change
For Full Replacement	1.24	1.70	+0.46
For Capital Repair	3.52	3.19	-0.33
Total	4.76	4.89	+0.13

The objects on which depreciation is figured in railroad transportation are: depot, power supply, and locomotive supplying production buildings; the roadbed, artificial structures, and track superstructure; the equipment of traction substations and the catenary system; signal and communications devices; various forms of working and energy-producing machines, equipment, monitoring and regulating instruments and devices; train and switch locomotive, diesel trains, motorcars, electric trains, and passenger and baggage cars.

Depreciation for freight cars and containers is charged by the financial services of the roads based on the registered fleet of these types of fixed capital. The total depreciation charged to a railroad is reported each month to the Financial Administration of the Ministry of Railroads separately for capital repair and full replacement. There the total amount of the depreciation fund for freight cars and containers is redistributed among the roads proportional to the working fleet of freight cars and containers of each road. This procedure for distributing depreciation deductions on freight cars and containers was introduced on 1 January 1971 in place of distribution proportional to freight traffic performed. The railroads are notified of the redistributed sum of deductions and include it in their operating costs and the prime cost of shipping.

If the actual conditions of use of fixed capital deviate from average conditions, correction factors are applied to the depreciation norms when calculating depreciation deductions. For example, for equipment the correction factors for norms are established depending on the number of work shifts (see Table 37).

Table 37. Correction Factors for Norms of Depreciation Deductions for Capital Repair of Equipment.

Number of Shifts for Which Norms of Depreciation Deductions Were Developed	Correction Factor for Number of Shifts of Equipment Work		
	One	Two	Three
Three	0.6	0.8	1.0
Two	0.8	1.0	1.2

In addition, correction factors that take account of special natural conditions of the region, the effect of an aggressive environment and humidity, and the special features of use of fixed capital in various sectors of the national economy must be employed.

During the course of the year depreciation deductions are made each month. To simplify the calculations the amount for the preceding month is corrected in view of changes that have taken place in the composition of fixed capital in the current month. For fixed capital being put into operation for the first time, depreciation is charged from the first of the month following the month that it is received; for fixed capital that is being withdrawn the deduction stops on the first of the month following the month of withdrawal.

During repair and downtime of fixed capital depreciation continues to be charged. For fixed capital leased out, depreciation is taken by the lessee.

Depreciation deductions are reflected in bookkeeping records separately for full replacement and capital repair of fixed capital.

In addition to depreciation deductions, records are kept of wear on fixed capital. Since 1 January 1975 the wear of fixed capital has been recorded as the amount of depreciation deductions for full replacement.

The depreciation deductions charged on the railroad, in road sections, and at their sectorial line enterprises are included in annual operating costs and the prime cost of output.

There is a point of view which holds that annual operating costs should not include depreciation deductions for capital repair of fixed capital, but rather expenditures actually incurred for this purpose [27, p 91]. In this case, however, depreciation will not reflect the wear of fixed capital and the gradual transfer of its value to output; it will record only the actual value of capital repair of fixed capital, in other words, it will essentially be the same as annually planned operating costs.

This statement of the issue is unacceptable because the capital to pay for wear of new locomotives, cars, equipment, and other types of new machinery that railroad transportation receives in large quantities but does not yet require capital repair corresponding to its wear, should be accumulated and included in the operating costs of the railroads in order to distribute it evenly to the entire output produced in the period between repairs.

Analysis shows that the amount of annual deductions established by depreciation norms for full replacement usually does not coincide with the value of the fixed capital actually withdrawn in the particular year. This occurs because the norms of depreciation deductions for full replacement are determined on the basis of average service lives of fixed capital, and therefore they correspond to average withdrawal in a year. But actual withdrawal is a figure for each particular year and it varies for individual years. Therefore, despite the fact that there will be no withdrawal of new fixed capital in the first years of use, depreciation deductions for full replacement must be charged and considered in the prime cost of shipping. As they gradually accumulate, these deductions become a source for the purchase of new fixed capital just when the old fixed capital begins to be withdrawn.

Depreciation deductions for capital repair of fixed capital also do not correspond to actual costs for fixed capital in some years. The costs may be more or less than depreciation deductions, related to the actual need for capital repair.

The amount of actual expenditures for capital repair of fixed capital depends on many factors which cannot be fully taken into account in the norms of depreciation deductions. Specifically, these expenditures depend on the technical condition of fixed capital which results from the intensity of its use, the quality of manufacture, and other factors. If a particular object of railroad transportation fixed capital does not insure safe and economical work because of its technical condition, it is subject to replacement or capital repair and modernization regardless of whether the depreciation deductions envisioned for this purpose in the particular year are sufficient.

The amount of depreciation deductions for capital repair calculated by depreciation norms may differ substantially from actual annual expenditures for capital repair even for the entire railroad system. For particular roads and enterprises the deviation can be even greater.

Thus, the planning and report prime cost of shipping must take account of depreciation deductions not only for full replacement but also for capital repair determined from the value of fixed capital according to established norms.

The increase in depreciation funds formed at enterprises and organizations of railroad transportation demands careful analysis of expenditures incurred using these funds. The purpose of such analysis is to identify the actual use of depreciation deductions by designation and establish records of depreciation deductions for full replacement and capital repair of fixed capital that have been charged but not spent.

Both parts of the depreciation fund (the fund for capital repair and concurrent modernization and the fund for full replacement of fixed capital) have strictly designated purposes. The capital deducted for capital repair cannot be used for full replacement of fixed capital, with the exception of cases specially envisioned by government decree. For example, it is authorized to purchase new equipment with capital from the depreciation fund for capital repair if capital repair of the old equipment is economically unwise and inefficient; other permitted uses are paying for work to extend station tracks and lay out classification yards, equip service points to prepare cars for shipping grain and sugar, and to replace overhead communications lines with cables. It is very efficient and necessary to do these jobs with depreciation deductions for capital repair.

But in many cases not envisioned by special governmental decrees, the depreciation fund designated for capital repair is spent for renovation and replacement of fixed capital, which should be financed through capital investment. Examples of such jobs are installing bypasses and retaining walls, replacing small bridges with culverts, and straightening out river channels.

Use of the depreciation fund designated for capital repair to pay for restoration of certain structures can be explained by the fact that the Statute on Planned Preventive Repair of the Track Superstructure, Roadbed, and Artificial Structures of USSR Railroads provides that this work will be paid for from capital repair money. This financing procedure is certainly incorrect, because it leads to a shortage of capital for capital repair and, at the same time, failure to use the entire depreciation fund for full replacement. The latter is used as a source of financing for capital investment, usually directed to new construction. Therefore, it would appear advisable to amend the above-mentioned statute to provide for financing work on replacement of particular structures concurrently with capital repair using depreciation deductions for full replacement of fixed capital.

A distinctive characteristic of the development of the fixed capital of railroad transportation is that often reconstruction work cannot be done without capital repair. Among such jobs are replacing rails with new, heavier rails; placing the track on crushed rock ballast; replacing wooden ties with reinforced concrete ones; installing jointless track; reinforcing particular assemblies of artificial structures; resetting the lining and vault of tunnels; installing dehumidification and ventilation in tunnels; replacing wornout design elements with new ones in buildings and structures; partial replacement of wornout parts and assemblies in pieces of equipment with improved parts and assemblies. In most cases these jobs are all done through the depreciation fund for capital repair.

But the objective of capital repair is to maintain fixed capital in working condition for an established service life without fundamental reconstruction, which should be done according to a plan of capital construction paid for by the depreciation fund for full replacement and socialist savings.

It is very difficult to draw a clear line between capital repair and full replacement because capital repair often involves not just capital repair jobs but also replacement of wornout components, parts, and assemblies of structures with new ones and modernization of various machines, installed equipment, and rolling stock to mitigate the impact of obsolescence. The arbitrariness of the line between capital repair and full replacement is especially vivid in the case of railroad transportation. K. Marx wrote: "The line between repair proper and replacement, between the costs of conserving and the costs of renewing, is more or less arbitrary" [1, Vol 24, p 200]. He continues: "If we look at railroad rolling stock, it is absolutely impossible to distinguish repair and replacement" [1, Vol 24, p 201].

Under current conditions where repair technology has reached a high level, this is even more important. Indeed, all the parts of cars and locomotives may be replaced during capital repair. The established rules for factory repair of freight cars envision replacement, when necessary, of such crucial design elements as buffer, side, and top-center beams, part of the kingpin beams, and so on. Almost all major railroad structures are renewed by parts during capital repair, including the track superstructure, bridges, overhead communications lines, and the catenary system.

The norm of depreciation deductions for capital repair cannot be used alone for all objects of fixed capital which can be fully renewed in the process of capital repair, of course, because this would make it necessary to state that the fixed capital lasts forever. This is not the case. Even rolling stock, which can work as long as is required, will eventually be withdrawn from operation and, therefore, has a finite service life. This period is determined above all by obsolescence and the economic advisability of restoring fixed capital by capital repair.

The depreciation charged each month for capital repair is paid to the USSR State Bank and used to finance capital repair and concurrent modernization. In addition, the local income of station chiefs is a source for financing capital repair. If all capital used for capital repair in 1977 is taken as 100 percent, depreciation deductions account for the bulk of it (98.7 percent).

Part of depreciation for full replacement of fixed capital is deducted to the production development fund that is formed to finance the introduction of new machinery. The rest of the depreciation deductions for full replacement are paid by enterprises to Stroybank and designated for financing capital investment.

The value of the fixed capital of railroad transportation is growing as the result of a large volume of work to rebuild and modernize the track superstructure, signal and communications devices, rolling stock, and equipment. Fixed capital is also increased when objects that are worn out and withdrawn are replaced by more expensive, but economical and productive objects.

The extent to which the depreciation fund for capital repair charged to railroad transportation corresponds to the actual need can only be judged hypothetically. The actual expenditures do not reflect the real need for capital for capital repair and the degree to which it is met. Actual expenditures cannot exceed depreciation deductions for capital repair in any significant amount because at the present time it is accepted that all depreciation amounts charged in a particular year must be spent in the same year.

To determine the degree of use of depreciation deductions for capital repair it is necessary first of all to establish the purposes for which they are used. Analysis has shown that, in addition to direct capital repair of buildings, structures, equipment, and rolling stock, depreciation deductions for capital repair are used for work toward full restoration of railroad fixed capital. Up to three percent of the depreciation fund for capital repair is used for such purposes.

In addition, each year part of depreciation deductions for capital repair done in-house as a savings made possible by growth in labor productivity and decrease in the prime cost of work is used to finance capital investment.

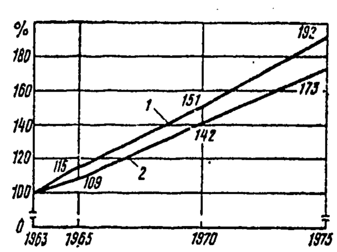
Using depreciation deductions for capital repair to perform a significant volume of work not directly related to capital repair creates difficulties with the financing of capital repair. Incomplete performance of capital repair of fixed capital cannot be identified here because actual expenditures generally cannot exceed depreciation deductions by a significant amount. Capital repair needs are often not fully met, and this has a negative effect on the technical condition of fixed capital.

For a long time the railroads suffered from a significant shortage of depreciation deductions for capital repair of freight cars and track structures. To bolster sources of financing for capital repair of these types of fixed capital the Ministry of Railroads was forced to redistribute depreciation deductions for capital repair, enlisting capital charged against newly introduced objects of fixed capital that did not yet require capital repair. This, however, will not help for long because after a certain time the new objects of fixed capital require capital repair and appropriate financing.

The shortage of depreciation deductions for capital repair of fixed capital led to a growth in so-called overlapping financing of expenditures for completed capital repair work. If the sum of these expenditures in 1963 is taken as 100 percent, in 1974 the figure was 150 percent.

It is important to compare costs for capital and ongoing repair of fixed capital. Until 1963 medium repair work was financed through operating costs. During development of differentiated depreciation deduction norms in 1959-1960, expenditures for medium repair done at periods of greater than one year were considered in depreciation norms for capital repair. But with the appearance of new types of fixed capital and the increase in intensity of use of existing fixed capital, expenditures for medium repair rose again, leading to an increase in expenditures for ongoing (current) repair (see Figure 18).

Figure 18. Change in Expenditures for Repair of Railroad Fixed Capital: (1) Ongoing; (2) Capital.



As the graph shows, expenditures for ongoing repair of fixed capital rose 2.1 times between 1963 and 1975, while expenditures for capital repair increased 1.7 times. The lower rate of increase for expenditures for capital repair is caused by the high rate of growth for replacement of fixed capital. With the reconstruction of traction on the railroads, reinforcement of the track superstructure, and construction of new roads and second tracks, the fixed capital of railroad transportation is increasing rapidly and expenditures for capital and ongoing repair are growing. The proportion of expenditures for ongoing repair relative to expenditures for capital repair rose from 41.5 to 52.8 percent in the period under consideration.

Depreciation deductions for capital repair are used for the following jobs and expenditures:

1. Actual capital repair of fixed capital and medium repair done at periods of more than one year, including work to dismantle and install equipment being repaired and expenditures to transport machines, equipment, and rolling stock to the repair point;

2. Planning-estimate and surveying work related to capital repair, regardless of the time of performance of the repair work (based on ratified price lists for planning-estimate work);

3. Changing wornout design components and parts in buildings and structures or replacing them with other ones manufactured from stronger materials, with the exception of basic construction components and assemblies that have maximum service lives and determine the service lives of the objects as a whole;

4. Full or partial replacement of wornout mechanisms and instruments that are inseparable parts of inventory objects or of individual assemblies of equipment with new, more economical units that improve the technical-operating indicators of the objects being repaired; expenditures for modernization of equipment done concurrently with capital repairs;

5. Replacement of wornout rails and switches with new, heavier ones, putting the track on crushed rock, replacing wooden ties with reinforced concrete ones; installing jointless track, reinforcing the roadbed against washsouts, slides, and cave-ins, replacing wornout bridge spans, reinforcing particular assemblies of artificial structures, resetting the lining and vaults of tunnels, work to dehumidify and ventilate tunnels, welding, fusing, and polishing rails and switch elements.

In addition, norm-controlled stocks of materials and spare parts needed for capital repair are formed from depreciation deductions for capital repair.

In view of the special features of the use of fixed capital in railroad transportation the Ministry of Railroads has been given the right to redistribute the depreciation fund for capital repair of the roadbed, artificial structures, track superstructure, locomotives, passenger and freight cars, and containers among the particular roads in conformity with a ratified plan. This creates conditions for normal operations work by the roads and insures maximally efficient use of depreciation deductions designated for capital repair.

Depreciation deductions for capital repair of other fixed capital, the buildings, equipment, transmission devices, inventory, and tools of railroad transportation enterprises, remain at the disposal of these enterprises and are used by them to finance capital repair of these types of fixed capital.

A reserve depreciation fund of 10 percent of depreciation deductions for capital repair of all fixed capital (except the capital centralized at the Ministry of Railroads) is created in the sections, at the roads, and in the ministry to finance possible early (ahead of schedule) capital repair.

6. Depreciation in Foreign Railroads.

The railroads in almost every country of the world use depreciation. Each country has particular characteristics in how it considers wear of rolling stock and railroad structures and ways of transferring its cost to the prime cost of shipping. All of the capitalist countries except the United States and many socialist states (Hungary and Czechoslovakia) figure depreciation deductions only for full replacement of equipment, locomotives, cars, and various railroad structures. Expenditures for capital repair are considered directly in operating costs of shipping.

The railroads of foreign countries use various methods of determining depreciation deductions, among them:

1. the method of figuring depreciation in identical shares (at a constant rate) based on the assumption that wear of fixed capital is even over the years;

2. methods that use decreasing (or increasing) rates where deductions decrease (or increase) as the fixed capital ages;

3. methods of charging depreciation according to actual expenditures for replacement of fixed capital.

The first method, known as the classical or straight-line method of depreciation, is common among the railroads of most socialist and also certain capitalist countries (Holland, Switzerland, the United States, Canada, and Australia). This method involves calculating depreciation by specially established norms of depreciation deductions that are based on average service life and are the same each year.

The most common method of determining depreciation deduction on the railroads of the capitalist countries is based on actual expenditures to replace fixed capital. This method is substantiated by the fact that the renewal of railroad fixed capital each year should occur in the amount of current wear, determined in current prices. However, this does not take sufficient account of the financing necessary to introduce new, improved technical equipment and produces correct results only where the fixed capital of the railroads is replaced in its old form and the average age of objects is roughly half of their service lives. Furthermore, determining the sum of expenditures to replace objects being withdrawn in the course of a year is very difficult. Because the withdrawl of railroad fixed capital occurs quite seldom in practice, it must be calculated by accepted average service lives for particular types of fixed capital.

The West German railroads determine the calculated, not actual value of annual wear in current prices by types of fixed capital on the basis of average service lives. The depreciation deductions necessary for this are determined from the value of the fixed capital established during re-evaluation according to indexes of price changes. Fixed capital being withdrawn because of wear is written off from the balance value. New types of equipment and rolling stock purchased in its place are usually technically improved and thus cost more. The difference in cost, which is considered as new capital investment, shows the increase in railroad fixed capital. It should be noted that strengthening the track superstructure by laying heavier rails, increasing the number of ties, installing jointless track, and performing other jobs is considered to be new capital investment.

On the French railroads actual annual expenditures for replacement, maintenance, and repair of technical means are considered to be equivalent to the wear of fixed capital. Norms for replacement of fixed capital are not established, however; only actual expenditures for these purposes are considered. All capital investment except new construction, which increases the amount of railroad fixed capital, is classified as expenditure for replacement.

In Italy the state railroads form a depreciation fund to replace rolling stock, rails, and fastenings. For other types of fixed capital actual expenditures incurred in the particular year are considered to be depreciation deductions. For rolling stock the minimum depreciation deduction is five percent, while for rails and fastenings it is 0.8 percent of shipping income. Capital investment to replace other types of structures and equipment is considered as growth in railroad fixed capital, while the value of structures and equipment being withdrawn is treated as a decrease in fixed capital.

Depreciation deductions on the railroads of the European capitalist countries are generally made from replacement, not original cost of fixed capital because of the extreme instability of the monetary system where, owing to inflation, the need for capital to replace railroad fixed capital is constantly growing.

At the 17th International Railroad Congress in Madrid it was emphasized during discussion of the question of financing and conserving railroad fixed capital that "as long as money maintains its value, the problem of depreciation is simply a matter of determining as accurately as possible the period of use of invested capital and distributing the total amount of depreciation over different years. But everything changes when the value of money drops, which has become a rule in virtually all countries. To conserve property despite the devaluation of money, the theory of depreciation based on replacement cost, that is, its cost at the moment of charging the depreciation, was advanced" [131, p 91].

In those countries where it is not permitted to charge depreciation against the replacement cost of the fixed capital of railroads, for example the United States, Japan, and Canada among others, it is determined from initial cost. To obtain an adequate amount of depreciation under inflation conditions, service lives in these countries are set very low and deductions are made at increased norms.

The methods used to calculate depreciation deductions are usually complemented by accelerated depreciation which allows most of the value of fixed capital to be written off in the first years.

Methods of accelerated depreciation have become widespread in such capitalist countries as France, the United States, and Japan among others. The most common methods are the diminishing balance method and the cumulative (sum of numbers) method. The essential feature of all methods of accelerated depreciation is that they express a significant part of profit in the form of depreciation deductions, which are not subject to taxation. As a result of the application of these methods, primarily to equipment, machinery, and means of transportation, their value is quickly transferred to output, but the profit, which is already in the form of depreciation deductions, is used to expand and rebuild enterprises. The share of depreciation deductions in total capital investment is growing. On the West German railroads, for example, the share of depreciation capital investment for reconstruction was 45 percent in 1974.

Where accelerated depreciation is applied to machinery and equipment, the norms of depreciation deductions reach 25-30 percent of their value in a year.

In West Germany the entire value of equipment is written off in 5.5 years through accelerated depreciation deductions; this is three times as fast as the accepted service life of the equipment. With accelerated depreciation in Italy, up to 40 percent of the value of railroad equipment and rolling stock can be written off in the very first year.

The norms of depreciation deductions in the United States are regulated in the most general way. The railroad companies are constantly campaigning to reduce the service lives of fixed capital and raise the depreciation norms. This is done in order to reduce the amount of tax paid. The depreciation deductions of companies reach large scale, exceeding actual wear of fixed capital several times.

As long ago as 1940 a law on accelerated depreciation of equipment used for military production was passed in the United States. In 1954 the right to accelerated depreciation was applied to all other enterprises, which were permitted to write off up to two-thirds of the value of fixed capital in the first half of its service life. The new depreciation rules introduced in 1962 reduced service lives and raised depreciation rates by an average of 30 percent compared to the level that had been adopted on the basis of the previously operative Bulletin F. Authorization was recently given to reduce write-off times for equipment put into use after 31 December 1970 by an additional 20 percent [67]. To increase the total amount of depreciation deductions, in 1972 norms for repair of equipment and means of transportation were established in the United States in addition to norms for renovation. The new norms for repair are almost twice as high as depreciation amounts.

It should be observed that U. S. railroads do not make deductions for fixed capital invested in the track superstructure. Thus, depreciation is charged for about 70 percent of fixed capital. Moreover, the average depreciation rates differ for particular railroads depending on the structure of their fixed capital.

Depreciation and tax policy in the United States aim to stimulate growth in the net profit of the monopolies for the purpose of bolstering private capital investment in accelerated renewal of fixed capital given an increased rate of obsolescence and the necessity of insuring that its value is written off at the proper time [17]. The policy of accelerated depreciation leads to a situation where the fixed capital of the railroads is depreciated very rapidly. A significant share of it is already expressed in the form of depreciation deductions. Table 38 gives figures that show how the balance amount of railroad fixed capital has changed in recent years. At the same time, the railroads are offering strong resistance to actually writing off structures, equipment, and rolling stock that have already been depreciated; they consider it necessary to use this capital for freight and passenger shipping.

Table 38. Share of Depreciated Value of Railroad Fixed Capital in 1975.

Country, unit of measure	All Railroad Fixed Capital Total	Percent	Of that, depreciated Total	Percent
Great Britain (All Railroads), millions of pounds sterling	1,258	100	698	55.5
West Germany (Federal Railroads), millions of marks	72,142	100	30,393	42.1
France (State Railroads), millions of francs	37,649	100	23,729	63.0
Italy (State Railways), billions of lira	3,547	100	n/a	-
United States (Class I Railroads), millions of dollars	37,100	100	10,163	27.5
Canada (All Railroads), millions of Canadian dollars	7,556	100	2,649	35.1
Japan (State Railroads), billions of yen	6,738	100	2,413	35.8

* Figures are for 1973.

Chapter VIII. Capital Construction and Capital Repair in Railroad Transportation.

1. Capital Investment in the Formation and Reconstruction of Fixed Capital.

The development, full replacement, and capital repair of the fixed capital of a socialist economy is carried forward on a planned basis.

Capital investment in railroad transportation is appropriated in conformity with the uniform state plan of development of the USSR national economy. The amounts of capital investment are established based on the prospects for growth of productive forces in the economic regions and the increase in freight and passenger traffic expected as a result. At this time the technical condition of railroad transportation fixed capital and the correspondence between its development and planned growth in shipping volume are considered. At the same time attention is directed to the fact that railroads must perform their assigned volumes of freight and passenger conveyance more economically. To achieve this capital investment is appropriated to take steps that will reduce the prime cost of shipping and increase the working efficiency of transportation enterprises.

At the 25th CPSU Congress Comrade L. I. Brezhnev observed that "capital investment should not be appropriated to ministries and departments in general or to cover new projects; it should be appropriated against planned growth in output" [5, p 46]. This approach to the appropriation of capital investment requires that capital be concentrated on priority projects for the purpose of stepping up their introduction; at the same time it restricts the simultaneous initiation of construction on many projects and the resulting immobilization of capital investment.

It is very important when planning capital investment to establish the economically optimal ratio between growth in shipping and capital investment. During the Eighth Five-Year Plan 16.1 kopecks of capital investment was spent for each 10 calculated ton-kilometers of growth in shipping, and in the Ninth Five-Year Plan it was 16.9 kopecks. In the first three years of the 10th Five-Year Plan this figure was about 40 kopecks.

The ratio between growth in shipping and capital investment depends on many factors and is linked in large part to the degree of utilization of the traffic and carrying capacity of the railroads and the level of use of production fixed capital. As a rule, where the level of utilization of carrying and traffic capacity is higher more capital investment will be required to incorporate growth in shipping. Improving the use of production fixed capital, by contrast, makes it possible to reduce the need for capital investment.

For this reason it is very important to make rational use of the country's transportation system and plan the volume of passenger and freight traffic correctly. The total volume of freight shipping can be determined on the basis of production plans and the distribution of output of all sectors of industry and agriculture by drawing up transportation-economic balances [112]. The total volume of shipping must be distributed among types of transportation with due regard for fullest use of the fixed capital of each type and increasing the participation of water, motor vehicle, and pipeline transportation in shipping.

Plans for shipping freight by railroads should take into account the location of enterprises and envision efficient supply of fuel and raw and processed materials to them.

The volume of passenger traffic is determined on the basis of the growing needs of the population for travel, which is linked to the steady rise in the material and cultural standard of living. When planning passenger traffic by rail it is necessary to consider the growing role played by other forms of transportation, above all air and motor vehicle transportation.

When we have figures on freight and passenger traffic for particular segments of the railroad system and compare existing traffic and carrying capacities with requirements, it is possible to establish the need to develop capacities by building new and reconstructing existing railroads, laying additional mainlines, electrification of lines, extending receiving and shipping sidings, installing automatic blocking, centralized dispatching, and so on.

New railroad construction is especially important. New railroads are being laid in regions of rich mineral and natural resources and they stimulate their industrial and economic development. It is also necessary to note the important role of new railroads being laid to improve the existing system and bring it into line with the principal directions of freight and passenger traffic in order to streamline transportation routes and reduce transportation output and shipping costs.

In recent years the volume of capital investment in new railroad construction has risen sharply and is now about 20 percent of all investment in railroad transportation. The largest part of this capital investment is used for reconstruction and improvement of existing fixed capital, primarily for the purchase of rolling stock, machinery, and equipment.

When selecting projects to build up fixed capital it is important to observe essential proportions in the development of particular sectors of the railroad system and to insure the required level of technical equipment in them so that conditions will be created for rational shipping and optimally efficient use of fixed capital. Thus, if a change from diesel to electric traction is planned to bolster the traffic and carrying capacity of a certain segment of the railroads, at the same time steps must be envisioned to re-equip the appropriate types of fixed capital on these roads to insure conditions for optimally productive use of electric locomotives: reconstruction and strengthening of track and artificial structures, extension of station tracks, reconstruction of locomotive depots and repair facilities, installation of new structures for inspection, repair, and supply of electric locomotives where necessary, and introduction of new and reconstruction of existing signal and communications equipment.

Comprehensiveness in development of fixed capital is an essential condition for efficient use of capital investment.

The distribution of capital investment by sectors of the railroad system should be reconciled with the potential and development of sectors of transportation construction and transportation machine building.

When planning the development of fixed capital, large amounts of capital are provided for work to establish normal working and living conditions for the employees of the newly built and reconstructed installations. Therefore, along with production facilities residential buildings, rest houses for locomotive crews, clubs, red corners, schools, hospitals, and the like must be built.

Capital investment should be carried out with maximum efficiency. The CPSU Program stipulates that "the party attaches paramount importance to increasing the efficiency of capital investment, selecting the most advantageous and economical areas for capital work, insuring maximum growth in output for each ruble of capital investment spent, and reducing the payback period of this investment" [3, p 86] .

2. Planning Capital Construction

When planning capital construction, expenditures for new construction, expansion, reconstruction, and technical re-equipping of railroad transportation fixed capital are determined separately. Work on reconstruction and technical re-equipping is financed largely through the production development fund and bank credit.

Expenditures for surveying and planning objectives, construction-installation work, and equipment purchase are also determined separately. Expenditures for the construction of production facilities (new railroads, second tracks, electrification of roads, strengthening of existing lines) and nonproduction facilities (residential and municipal-domestic buildings, clubs, hospitals, schools, and the like) are singled out. In the Ninth Five-Year Plan roughly 80 percent of all capital investment went for the development of production fixed capital and 20 percent for the construction of nonproduction facilities.

When objects of fixed capital are included in the capital construction plan, consideration is given to growth in shipping work and the rate of development of particular segments, large units, and stations so that the expenditures planned for the particular year will not be inefficient in the future because of a change in freight traffic, moving to sectors not covered by the plan.

Technical-economic substantiation is developed for each construction project included in the plan. This substantiation is a preplanning document. It substantiates the advisability of building the object of fixed capital, its location, projected capacity, and procedures for supplying it with fuel, electricity and the like; it also determines the economic efficiency of the capital investment. Moreover, the substantiation document presents technological and construction concepts, calculates the approximate volume of the principal jobs and a rough estimated cost, and determines priorities, times, and conditions for construction and the basic equipment to be installed at the object. It also reviews different variations of construction or reconstruction, which makes it possible to select the most efficient one.

The data from the ratified technical-economic substantiation are used to write the project specifications, a document that contains the basic information necessary to plan the forthcoming construction. The quality of the plan and the estimated cost of construction depend greatly on the care taken in writing the project specifications and the correctness of their substantiation.

The most important economic indicators of construction must not be made worse during the development of plan and estimate documents. The estimated cost of construction of each object may not exceed its cost as determined in the technical-economic substantiation.

The planning of facilities for railroad transportation is generally done in one stage involving development of the contract-detail design, which is to say the contract design combined with working drawings. Two-stage planning, where the contract design is developed in the first stage and the working drawings in the second, is permitted only in exceptional cases for large and complex objects.

Itemized (title) lists of construction projects are the basis for developing capital construction plans. These lists include both new construction projects and projects that have not been completed and are carried over to the planning year. Itemized lists of construction projects are developed on the basis of plans and estimates for the entire period of construction with a distribution of assignments for launching capacities and fixed capital by years. These lists are invariable documents for the entire period of construction.

Objects may be included in the itemized lists only if ratified plan and estimate documents for the year's volume of work are on hand on 1 September of the year preceding the planning year. In addition, by 1 April of the preceding year for projects included in the list questions of placing orders for equipment, instruments, cable, and other articles must be decided, the construction base must be insured, and adequate materials and work force must be allocated. The procedures for ratifying itemized lists of construction projects depend on the designations of the objects to be built and the amount of their estimated cost.

Each year internal itemized construction lists are written up on the basis of the ratified annual plan of capital investment and the itemized list of construction projects. These internal lists show the full estimated cost of construction of the object, the remainder at the start of the year, the volume of work to be done, and figures on the launching of capacities and fixed capital in the planning year. The internal itemized lists are the basic document for financing construction and planning construction work.

Regardless of the designation of the construction projects and their estimated cost the annual internal itemized lists are ratified by the purchasers with the consent of the general contractor. In railroad transportation where the estimated cost of projects is 3 million rubles or more the internal itemized lists are ratified by the Ministry of Railroads; for projects less than 3 million rubles they are ratified by the chiefs of the railroads and administrations of the ministry.

When drawing up internal itemized construction lists the first thing necessary is to fully insure that priority start-up projects have sufficient capital for launching at the schedule time. In addition, there must be a backlog to insure even work by construction organizations throughout the year, without dispersion of capital.

USSR Stroybank initiates financing for new projects and projects to reconstruct enterprises and transportation structures only when properly ratified plan and estimate documents are presented.

To insure high quality planning the plans and estimates for construction of railroad transportation facilities are subjected to state expert examination, and only after this are they ratified.

During development of the annual capital construction plan all construction projects contained in the internal itemized construction list are included. The volume of construction and installation work for the planning year is distributed among the working organizations. The work being done by railroad trusts and services, sectorial line enterprises of the railroads, organizations of the Ministry of Transportation Construction, and other organizations are singled out from the total volume of work. Organizations of the Ministry of Transportation Construction perform almost 80 percent of the total volume of contract construction in railroad transportation.

When planning capital construction special attention must be focused on concentrating capital investment and material and labor resources on the most important projects and start-up projects. They must not be scattered over numerous sites. New construction can be begun only when carryover construction projects are fully provided with financing, materials, equipment, and labor and are going forward on schedule.

The plan of capital construction and assignments for launching production capacities and facilities in operation should be coordinated with the material-technical supply plan and plans for the production and delivery of rolling stock.

The volume of capital investment and construction and installation work for all major sites should be planned for the entire period of construction with a breakdown by years.

It is very important to create an expandable reserve of construction and installation work to achieve evenness in construction and timely turnover of projects for use. This is just as important as completing work on start-up projects.

Providing construction projects with working drawings, materials, design components, and equipment completely and at the proper time, carrying out necessary engineering preparations, and solving all questions on which successful construction progress depends in advance will reduce the cost of projects and speed up completion. Supervision by the planning organizations of construction progress and the launching of start-up facilities and production capacities plays an important part, as does monitoring by USSR Stroybank of correct and efficient use of capital investment and reducing the estimated cost of construction.

Efficient use of capital construction and accelerating the launching of production capacities and facilities depends largely on the amount of incomplete construction which requires corresponding sources of financing. Incomplete construction diverts considerable capital from national economic circulation, so correct planning for it is exceptionally important. The volume of incomplete construction by construction sites, projects, and start-up complexes designated for production use is determined at the end of the year for itemized lists of construction projects based on plans and estimates in conformity with norms for length of construction and reserve work.

Shortening the time required to launch capacities and facilities is very important for reducing the scale of incomplete construction. These times are determined using the handbook of norms (SN 440-72) for length of construction of enterprises, buildings, and structures ratified by USSR Gosstroy and USSR Gosplan on 26 May 1972 [87].

The annual volume of capital investment in railroad transportation is more than 3 billion rubles. More than half of this goes for capital construction. Therefore, even a small decrease in the cost of construction produces a significant savings. Important ways to reduce the cost of construction are reducing construction time, raising the level of mechanization and electrification, broad use of standard plans and estimates in planning work, conserving labor, material, and monetary resources, and reducing overhead expenditures.

The use of improved machinery in construction not only reduces its cost; it also raises labor productivity and greatly improves and eases working conditions. Labor productivity in construction in 1977 was 37 percent higher than in 1970 [82, p 34]. Industrial methods of construction and full mechanization using progressive construction technology are becoming increasingly widespread in railroad transportation.

3. The Function of Repair Work and Performance Times

All jobs to eliminate wear and various malfunctions in fixed capital are classified as ongoing maintenance or repair, medium repair, or capital repair. Minor damage to certain parts and assemblies of rolling stock, machinery, and equipment and minor defects in buildings, structures, and transmission devices are taken care of during scheduled preventive and periodic repair and ongoing maintenance which is done regularly throughout the year.

Such repair work, including medium repair done more often than once a year, is classified as ongoing (current) repair.

Large parts and components of objects of fixed capital that go out of order after long periods of time, running into years, are repaired or completely replaced by larger repair jobs, medium repairs done at periods of greater than one year and capital (factory) repair. During medium and capital repair of locomotives, machinery, and equipment and factory repair of freight and passenger cars the equipment is dismantled where necessary, all wornout parts and assemblies are replaced or repaired, and the object is reassembled, adjusted, and tested. The repair work should be done with an eye to improving the technical parameters of the objects in repair, that is, modernizing them. Medium repair done with a period of greater than one year differs little in economic characteristics from capital repair.

During capital repair of buildings, structures, and transmission devices particular wornout design components and parts are repaired or replaced with new, stronger and more economical ones that improve the operating qualities of the objects. But capital repair cannot include full replacement of the basic design elements that determine the service life of objects: stone and concrete foundations of buildings and structures, walls of buildings, support members of bridges, the catenary system, communications lines, and so on.

Railroad transportation uses a system of planned preventive repair which is a set of organizational measures that aim to keep fixed capital in good condition and insure that it works reliably and without interruption. The planned preventive repair system establishes the volume of repair of fixed capital and the time when it is to be done. A carefully worked-out classification of repair jobs and correctly established repair times make it possible to use railroad fixed capital with maximum efficiency for a long time.

Capital repair, medium repair done with a period of greater than one year, and modernization done concurrently with capital repair are paid for from depreciation deductions, while ongoing repair is paid for with annual operating capital. Failure to determine the characteristics of capital, medium, and ongoing repair of fixed capital precisely may lead to a situation where ongoing repair work is paid for by depreciation deductions or, by contrast, work which should be considered capital repair is done with the operating capital of the current year. Therefore, it is very important to establish clear lines between the particular types of repair. The chief thing is to clear up the distribution of repair work by types of repair and establish precise repair periods on this basis.

All repair jobs are usually related to wear and withdrawal of certain parts and assemblies. If parts and assemblies that have gone out of order are grouped by repair or replacement times a system of repair work and performance times can be correctly established.

At the present time railroad transportation employs special statutes on planned preventive repair for: the track superstructure, roadbed, and artificial structures; general production structures; equipment and means of transportation. The purpose of these statutes is to insure conservation of the fixed capital by appropriate care and timely, high-quality repair.

The classifications of fixed capital repair established by these statutes serve as a guide for assigning capital repair and determining the sources of financing for repair work, reconstruction, and new construction. They show clearly what capital is used to finance repair jobs envisioned by the classification: current operating capital, depreciation deductions from capital repair, or capital investment.

Work to replace major design elements of structures and parts and assemblies of machinery, equipment, and rolling stock necessitated by normal wear in the process of shipping and done at periods of greater than one year is financed from depreciation deductions for capital repair.

The difficulties of maintaining the track superstructure in good condition have led to the establishment of several types of capital repair for it. The currently operative "Statute on Planned Preventive Repair of the Track Superstructure, Roadbed, and Artificial Structures of USSR Railroads" (Moscow, Stroyizdat, 1964) provides the following classification of repair jobs for the superstructure of railroad mainlines: ongoing maintenance, track-lifting repair, medium repair, capital repair, complete replacement of rails with new and reusable old ones, and capital repair of crossings.

Each of these types of repair work is usually associated with wear on particular elements of the superstructure. For example, capital repair is done on main tracks where wornout rails must be replaced with new ones and at the same time the ballast layer, ties, and roadbeds must be cleaned up or strengthened. Complete replacement of rails with new or reusable old ones on mainlines is done where it is necessary to replace worn-out rails in sectors where the ballast layer and ties are in good condition.

Medium repair is assigned for main and station tracks that need to have the ballast layer and ties cleaned up or strengthened. Track-lifting repair involves complete straightening of the track. At the same time the ties are completely packed under, and in necessary cases repaired or replaced, and the ballast is replaced in part, cleaned up, and filled in. The purpose of ongoing track maintenance is to insure that it is in proper condition and conforms to established norms and tolerances; this will guarantee long service lives for all elements of the track superstructure.

The volume and characteristics of the job done during the various types of repair and ongoing track maintenance are considered in detail in work [25].

In addition to the basic repair jobs, depreciation deductions for capital repair of the track superstructure are used for replacement of switches with new switches, replacement of transfer beams, placing switches on crushed rock, welding and fusing rails and the crosspieces of switches, grinding rails, repairing ties, installing and repairing barriers along the railroads, outfitting switches with snow removal devices, and so on.

Capital repair of the superstructure of mainlines should put the track in proper condition for the corresponding superstructure type. The superstructure type is assigned taking into account the freight intensity and speed of train travel in the year of the capital repair work. The following types of track superstructure have been established: (1) especially heavy — with freight intensity of more than 50 million gross ton-kilometers per kilometer of single track a year; (2) heavy — for freight intensity between 25 and 50 million gross ton-kilometers per kilometer of single track a year, and in sectors with high-speed passenger train travel (140 kilometers an hour or more) and sectors with especially intensive passenger and suburban train traffic (100 and more trains per track per day); (3) normal — for freight intensity of up to 25 million gross ton-kilometers per kilometer of single track a year.

Track superstructure repair work is assigned according to differentiated norms for the periodicity of track-lifting, medium, and capital repair depending on the number of millions of gross-tons in the particular track sector for all types of traffic, the type of superstructure, and the operating conditions of the sector.

The norms of periodicity of repair work for main and station tracks are set separately for lines with typed and nontyped superstructure.

Table 39 gives these norms for railroad lines with typed superstructures.

According to the norms, capital repair for R65 rails on crushed rock ballast is done after each kilometer has carried 500 million gross tons, that is, when the time for rail replacement has arrived. As tonnage builds towards this amount the ties become worn, the ballast is soiled, and medium (after 280 million gross tons) and track-lifting (after 150 and 400 million gross tons) track repair jobs are performed. Thus, for this type of track superstructure the repair cycle includes one capital repair, one medium repair, and two track-lifting repairs.

Periodicity norms for lines with nontyped superstructure cover only medium and track-lifting repair.

Periodicity norms for track repair are set depending on the service lives of the principal elements of the superstructure. For example, the service life of crushed rock ballast is determined by the degree of its contamination, which depends on shipping volume. The periodicity norms for medium and track-lifting repair work during which the ballast is cleaned up and replaced are given in millions of gross tons. They are a part of the planned preventive repair system and differ for different types of rails and ballast.

The principal reasons that wooden ties and transfer beams become unfit for use are rotting, mechanical wear, and cracking. Where roads have low freight intensity and mechanical wear is fairly slow, the ties and beams usually become unfit because of rotting; on heavily used road sectors where mechanical wear increases rapidly it depends on freight intensity. The average service life of wooden ties today is 16 years for treated wood and six years for untreated. Improving the quality of treating, bracing the ends, drilling holes in advance, and taking other steps to protect ties and beams against premature wear are very important for extending their service life.

The service life of reinforced concrete beams has not been definitely established, but it is in the range 35-50 years depending on the freight intensity of the line [13, p 32].

The service lives of rails that are now established were determined in millions of gross tons of freight carried. For rails laid on main lines the service lives are determined according to maximum permissible one-time use on these lines. The average service life of rails on main lines ranges from four to 25 years depending on traffic intensity. When this time is up the rails are moved from the main lines and relaid on little-used lines and station track where they will be used for an additional 20-30 years until fully worn out.

Тип верхнего строения пути (a)	Тип рельсов (b)	Конструкция пути (c)	Шпалы (d)	Балласт (e)	(f) Периодичность ремонтов, млн. т брутто прошедшего груза во всех видах движения нарастающим итогом			
					Подъемочный (g)	Средний (h)	Сплошная смена рельсов новыми (i)	Капитальный (j)
(k) Особо тяжелый	P75	—	—	—	(n) Производится по особым указаниям МПС			
(l) Тяжелый	P65	(p) Звеньевой и бесстыковой путь	(s) Деревянные и железобетонные	Щебень, сортированный гравий, асбестовый балласт (u)	150; 400	280	500	500
(m) Нормальный	P50	(q) То же	(q) То же	То же (q)	110; 280	200	350	350
		(r) Звеньевой путь	(t) Деревянные	Карьерный гравий и ракушка (v)	80; 150; 290	210	—	350
	P75 переложенные (o)	(q) То же	(s) Деревянные и железобетонные	Щебень, сортированный гравий, асбестовый балласт (u)	150	280	—	400
		»	(t) Деревянные	Карьерный гравий и ракушка (v)	100; 180; 350	260	—	400
	P65 переложенные (o)	»	(s) Деревянные и железобетонные	Щебень, сортированный гравий, асбестовый балласт (u)	100	200	—	280
		»	(t) Деревянные	Карьерный гравий и ракушка (v)	80; 150	210	—	290
	P50 переложенные (o)	»	(s) Деревянные и железобетонные	Щебень, сортированный гравий, асбестовый балласт, карьерный гравий, ракушка (w)	70	130	—	190

Table 39. Norms for Periodicity of Track Repair on Lines with Typed Superstructures.

[Table continued on next page]

Key:
(a) Type of Superstructure;
(b) Type of Rail [Russian "P" = English "R"];
(c) Rail Design;
(d) Ties;
(e) Ballast;
(f) Periodicity of Repair, Millions of Gross Tons of Load Carried for All Types of Traffic by Running Total;
(g) Track-Lifting;
(h) Medium;
(i) Complete Replacement of Rails with New Rails;
(j) Capital;
(k) Especially Heavy;
(l) Heavy;
(m) Normal;
(n) Done by Special Orders of the Ministry of Railroads;
(o) Relaid;
(p) Linked and Jointless Track;
(q) The Same;
(r) Linked Track;
(s) Wooden and Reinforced Concrete;
(t) Wooden;
(u) Crushed Rock, Sorted Gravel, Asbestos Ballast;
(v) Quarry Gravel and Shell Rock;
(w) Crushed Rock, Sorted Gravel, Asbestos Ballast, Quarry Gravel, Shell Rock.

The system of planned preventive repair envisions ongoing maintenance and capital repair for the railroad roadbed and artificial structures. Capital repair involves fixing up weak places in the roadbed, restoring and repairing water diversion, drainage, protective, and reinforcement structures, and widening the surface of roadbeds which are not of normal width.

Capital repair of the roadbed also involves work to restore or replace particular design elements of antideformation structures encompassing 30 percent or more of their volume but keeping the existing design and installing supplementary structures to insure stability and protect the roadbed under complex conditions.

The periodicity of capital repair of the roadbed and its structures is determined with due regard for the traffic intensity of the particular line and climatic and geological conditions of the region. The following periodicity of capital repair of roadbed protective structures has been adopted for average conditions (in years):

Walls:	
Wooden	5-7
Reinforced Concrete	10-12
Wooden Frameworks	8-10
Prisms:	
Earthen	15-17
Dry Rock	18-20
Rock with Mortar and Concrete	20-25

Traverses:
- Earthen 8-10
- Wooden 5-7
- Dry Rock 13-15
- Rock with Mortar and Concrete 18-20

Levees:
- Earthen 12-15
- Wooden 8-10
- Dry Rock 18-20
- Rock with Mortar and Concrete 20-25

Dams:
- Earthen 15
- Wooden 5-8
- Rock and Concrete 18-20

The periodicity of capital repair has also been established for water diversion, drainage, reinforcement, and other roadbed structures.

Under specific operating conditions the periods between capital repairs should be determined more exactly taking account of the actual condition of the roadbed and its structures as determined by detailed examination.

Ongoing maintenance of roadbed structures should involve work to prevent the appearance of trouble and eliminate problems that have come up as quickly as possible.

The times of capital repair of artificial structures are established by the planned preventive repair system by generalizing actual data on repair work done. Table 40 below shows these items.

Table 40. Times of Repair Jobs for Bridges and Viaducts on Metal and Massive Support Columns.

Structural Elements and Types of Work	Periodicity of Repair, years	Volume of Repair Work, %
1. Bridge Floor		
Complete Replacement of Bridge Timbers	15	100
Replacement of Counterrails	*	100
Replacement of Rail Anchor (Securing) Timbers	8	100
Replacement of Wooden Floor	5	100
Replacement of Floor of Reinforced Concrete Slab	10	15% of All Slabs

[Table continued on next page]

Structural Elements and Types of Work	Periodicity of Repair, years	Volume of Repair Work, %
2. Metal Span and Support Members		
Painting Under Normal Conditions	6	100
Painting in Unfavorable Climatic Conditions or when Air is Saturated with Harmful Gases	4	100
Replacement of Damaged Elements with Resetting of Weak Rivets or Replacement with High-Strength Rivets	25	5% of Weight of Metal
Complete Replacement of Worn-Out Metal Span Members (with Supporting Members)	60	100
3. Massive Support Members		
Partial Relaying of Stone and Brick Support Columns	40	15% of Support Members
Repair of Concrete and Rubble Concrete Support Members	40	10
Guniting Surfaces of Support Members	40	30% of Outer Surface
Cementing Stone and Brick Work	40	30% of Volume of Works
Applying Reinforced Concrete Outer Cover (Jacket)	40	10% of Outer Surface
Repair and Replacement of Damaged Foundation Stones	40	50% of Volume of Stones

* Counterrails are replaced when the track is replaced with heavier track or when a new type of bridge floor is installed.

For massive stone and concrete bridges, viaducts, and reinforced concrete span members and supporting columns various jobs are envisioned every 40 years; guniting the surfaces of massive elements, cementing up massive stone elements, partial replacement of support members, and repair and replacement of damaged foundation stones. For wooden bridges with wooden support columns worn-out elements are replaced and all elements are given antiseptic treatment every five years. The ends of culverts are repaired and reset every 20 years, while work to straighten sag in particular elements and guniting the surface of stone and reinforced concrete culverts is done every 50 years.

The periodicity of repair work has also been established for other artificial structures of railroads: tunnels, pedestrian bridges, retaining walls, regulating structures, and the like.

The following norms of periodicity of capital repair (in years) are established by the "Statute on Planned Preventive Repair of

General-Use Structures" (Moscow, Stroyizdat, 1965) for rail sidings and internal plant railroad track:

Roadbed	
Ditches:	
In Soft Earth	2-3
In Rocky Soil	8-10
Gutters and Chutes:	
Wooden	4-6
Stone and Concrete	6-10
Retaining Walls	18-25
Drainage Structures	8-12
Patchwork Turfing	3-5
Stone Pavement	5-6
Interwoven Patchwork with Fill or Paving	4-5
Fascines	2-4
Rock Fill	6-8
Levees and Dams:	
Earthen	12-15
Wooden	8-10
Stone and Concrete	18-20
Filtering Embankments	8
Track Superstructure	5
Artificial Structures:	
Major Bridges (Stone or Concrete Support Elements with Metal or Reinforced Concrete Spans):	
Support Members	40
Spans (Replacement)	50-60
Floor Beams (Complete Replacement)	15
Wooden Flooring (Replacement)	8
Elements of Metal Spans (Replacement of Damaged Elements)	25-30
Wooden Bridges (Replacement of Damaged Elements)	5
Tunnels:	
Drainage Structures	12-15
Other Structures	30-50
Culverts:	
Ends (Rims)	20
Stone, Concrete, Reinforced Concrete, and Metal Culverts	30-50
Wooden Culverts	5

For other types of structures found in railroad transportation such as water supply, sewage, and central heating structures, motor vehicle roads, electricity grids, and the like classifications of repair work and periodicity for their performance are envisioned by the "Statute on Planned Preventive Work for General Production Structures," ratified by USSR Gosstroy.

The periodicity of repairs for locomotives and electric and diesel trains is established by order 22Ts of the Ministry of Railroads, dated 31 July 1975. In addition to ongoing servicing and repair they are subject to medium and capital repair. In these types of repair the traction motors and auxiliary electric machines are removed from electric locomotives and trains and repaired to the extent and at the times established for them by the "Rules for Repair of Traction Motors and Auxiliary Machines of Electric Rolling Stock" (Moscow, Transport, 1972). As a rule, new or previously overhauled traction motors and auxiliary electric machines are installed in electric locomotives and trains during capital and medium repair.

The aggregate method is also used for capital repair of diesels and the traction electric motors and auxiliary machines of diesel locomotives and trains. The same times of medium and capital repair are used for traction electric motors and auxiliary machines as for locomotives.

The norms of periodicity for capital and medium repair of locomotives and factory repair of cars are given in Tables 41 and 42 below.

Table 41. Periodicity of Medium and Capital Repair of Locomotives.

Type of Locomotive	Periodicity of Repair, kilometers	
	Medium	Capital
Train Electric Locomotive:		
DC	680,000	2,000,000
AC	780,000	2,300,000
Passenger:		
ChS2, ChS3	700,000	2,100,000
ChS4,	800,000	2,400,000
Freight:		
VL22 , VL8, VL23	660,000	2,000,000
VL10 and VL60	760,000	2,300,000
VL80	800,000	2,400,000
Others	600,000	1,800,000
Switch, Transfer, and Outgoing Electric Locomotives	6 years	12 years
Electric Sections:		
ER	700,000	2,100,000
S^R, S^M	600,000	1,200,000
Train Diesel Locomotives:		
TE3, 2TE10	720,000	2,160,000
TEP60	900,000	1,800,000
TG102, TG16	460,000	920,000

[Table continued on next page]

Type of Locomotive	Periodicity of Repair, kilometers Medium	Capital
Switch, Outgoing, and Transmission Diesel Locomotives:		
TEM1, TEM2, ChME3, M62	7.5 years	15 years
ChME2, TE1, TE2, TGM3, VME1, and Others	5 years	10 years
Diesel Trains:		
D1 and DR1	600,000	1,800,000
D	480,000	1,440,000

Table 42. Periodicity of Factory Car Repair, years.

Type of Car	Level I	Level II
Boxcars, Flatcars, Tankers, Cement Cars, Dosing Hoppers, and Other Cars	10	
Flatcars with 63-66 Ton Capacities	12	
Gondola Cars	5-7*	
Acid Tankers, Bitumen Gondolas	4	
Refrigerator Trains, Sections, and Self-Contained Cars with Mechanical Cooling	8 Years After Manufacture or Level II Factory Repair	6 Years After Level I Factory Repair
Ice Cars	7	5 Years After Level I Factory Repair
All-Metal Passenger Cars	4	16
Dining Cars	4	12
Baggage and Mail Cars	5	20
Service Cars	6-9**	18

* Seven years for gondola cars that have been used less than 20 years; five years if they have been used more than 20 years.

** Six years for cars with air conditioning; nine years for cars without it.

For automatic blocking, automatic locomotive signaling and stopping, devices for dispatcher monitoring of train traffic, semiautomatic blocking, the electric staff system, independently operating signals, electrical and mechanical centralization of switches and signals, centralized dispatching, route monitoring devices, crossing signals, and equipment at mechanized and automated classification pumps the following types of planned preventive work are envisioned: ongoing maintenance (repair); capital repair; medium repair of high-voltage automatic blocking signal lines.

These units are repaired without interrupting train traffic while insuring complete traffic safety and observance of technical precautions. The volume of repair work and periodicity are determined with due regard for the need to observe the above-mentioned conditions and insure normal operation of signal, centralization, blocking, and communications equipment throughout the entire period between repair jobs.

Capital repair of these devices is done according to their technical condition. The "Statute on Planned Preventive Repair of Equipment and Means of Transportation" (Moscow, Transzheldorizdat, 1963) established the following times for capital repair of the basic elements of signal, centralization, blocking, and communications equipment in railroad transportation (in years):

Automatic Blocking

High Voltage and Signal Lines	12
Light Signals, Relay Boxes, Cable Lines, Station Post Installations	7
Battery Boxes, Power Supply Installations and Power Switch Boards, Rail Circuits	6
Floor-Mounted Station Units	3

Electrical Centralization of Switches and Signals

Control Devices and Consoles	8
Light Signals, Relay Stands and Boxes	7
Battery Boxes and Rail Circuits	6
Switch Drives with Fittings, Relay Booths, Local Control Columns	5

Automatic Locomotive Signaling

Locomotive Devices	5
Track Devices	7

Equipment of Mechanized and Automated Classification Humps

Car Retarders	3-8*
Electric Switch Drives of Main and First Beamed Switches, Scales	2
Same for Remaining Switches, Speed Measuring Devices	3
Equipment of Hump Automatic Centralization and Automation of Regulation of Speed of Uncoupled Cars	5

Radio Communication Within the Station

Station Radios.	5
Locomotive and Portable Radios	3

Train Radio Communication

Train Radio Communications Equipment Installed for the Train Dispatcher, Depot Duty Officer, and Station	5
The Same Installed on Locomotives	3

Radio Relay Line Devices, Mainline and Within-Road Shortwave Radio Communication

Train Radio Sets, Radio Receivers at Small Stations and Track Buildings	5

* Depending on the location of the car retarder and volume of car processing.

Medium repair of automatic blocking high voltage and signal lines is done once every four years.

In specific conditions the repair periods adopted may be reduced 20-30 percent depending on the impact of an aggressive environment and unfavorable climatic conditions in which the devices are used.

4. Planning Capital Repair

The plan of capital repair of fixed capital is worked out for one year, five years, and a future period of 10-15 years. The procedures for working out, reconciling, and ratifying a capital repair plan are presented in the literature [71] and in the "Methodological Instructions for Writing Drafts of Future and Current Plans for Development of Railroad Transportation" (Moscow, Transport, 1977).

The long-range plan of capital repair is drawn up for the volume of repair of the railroad track and rolling stock without an estimate in monetary terms.

The most important stage in the development of annual and five-year plans of capital repair is determining the volume of repair on the basis of information about the buildings, structures, equipment, and means of transportation on hand at the roads and sections and the repair schedules established for them. The actual condition of the fixed capital is taken into account.

The annual plan for capital repair of fixed capital is worked out according to a set list of indicators that comprise the most important forms of work on the track, locomotive, car, and other systems of the railroad, indicating physical volumes of work and their cost. It is a constituent part of the plan for railroad transportation and is developed with due regard for the other sections of this plan. Thus, the traffic intensity of the railroads determined by the shipping plan is taken into account in calculating the volume of repair on permanent structures, and the plan for use of rolling stock, determined by the planned volume of shipping, is the starting point for calculating the amount of locomotive and car repair work.

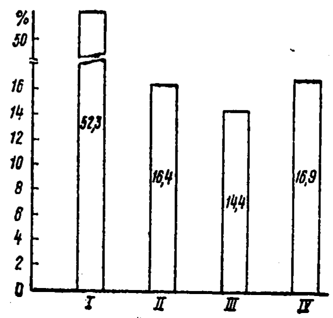
The introduction of new technology in railroad transportation is taken into account in development of the capital repair plan. For the locomotive system the plan envisions improvement in locomotives through modernization; for the track system it provides for fitting the track to one of the standard types of superstructure and strengthening it in accordance with the instructions of the Ministry of Railroads.

In addition, the plan for capital repair of fixed capital is closely linked to the plan of capital construction. Both plans begin from the need to insure the required traffic and carrying capacity on the railroads and aim at development and preparation of railroad transportation fixed capital to perform freight and passenger conveyance as fully and economically as possible. The capital repair plan, which also takes into account the task of insuring reliable and uninterrupted work by permanent structures, equipment, and means of transportation, should be written with due regard for the capital construction plan and reconstruction work being done.

The plan for capital repair of fixed capital is also closely linked to the railroad transportation plans for labor and material-technical supply, which provide capital repair work with the necessary labor and material resources.

During the planning of capital repair attention should be concentrated on substantiating the volumes of repair of track structures and rolling stock because they account for 80 percent of all expenditures for capital repair of fixed capital (see Figure 19 below). Repair of the track superstructure is the main form of work on the track system. Depreciation deductions are used to pay for both

Figure 19. Share of Most Important Railroad Systems in Total Expenditures for Capital Repair of Fixed Capital.



Key: (I) Track System;
(II) Locomotive System;
(III) Car System;
(IV) Other Systems.

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capital repair of the track and also medium and track-lifting repair work. The traffic intensity of the railroad and actual technical condition of elements of the superstructure of the track are taken into account in planning these types of work. In 1977 expenditures for work on capital repair of the track accounted for 37 percent of all expenditures for capital repair of railroad transportation fixed capital.

Capital repair of the fixed capital of railroad transportation is done by the in-house, internal contract, and standard contract method Under the in-house method sectorial line enterprises of the railroads repair the fixed capital with their own personnel; in this case the enterprise balance has the appropriate source of financing. With the internal contract method one line enterprise repairs the fixed capital of enterprises and organizations of its own road on a contract basis. It is somewhat arbitrary, but these two methods can be grouped together as one in-house method. In 1977 60 percent of the capital repair work was done by the in-house method.

Under the standard contract method work on capital repair of fixed capital is done by outside organizations or enterprises of railroad transportation not involved in operations activity on a contract basis. This work is planned by roads and systems, identifying the most important jobs and contractors. In 1977 40 percent of the work was done by the standard contract method.

Repair jobs included in the capital repair plan must have technical-economic substantiation. Thus, when the volume of repair work for the railroad track is being established, substantiation is given in the form of data on the traffic intensity in millions of gross ton-kilometers per kilometer of total length of main lines, types of rail laid, type of ballast and jobs planned in the planning year, their value and cost calculated at existing cost estimate rates. The capital repair plan for locomotives and cars must also be carefully substantiated, because they constitute a significant share of expenditures for capital repair.

Itemized lists of projects are compiled for all major work on capital repair of fixed capital. Among these jobs are capital repair of track, replacement of rails with new rails, reinforcement and replacement of bridge span members, large-scale bank-reinforcement and landslide-prevention work, capital repair of buildings, replacing the roofs of buildings at locomotive and car depots, and so on. The itemized lists of objects of capital repair give data on the location of the objects, physical volume and cost of work, completion time, who ratified the technical documents and when, and who will do the work.

In necessary cases plan and estimate documents must be drawn up for objects of capital repair of fixed capital. These documents include the contract design, estimates or estimated financial calculations, calculations of the unit cost of the work, and lists of defects. Contract designs are developed for those repair projects where changes in the design or principal design elements are intended and for: replacement of wooden roofs of buildings with reinforced concrete roofs; replacement of bridge span members; partial relaying of bridge supporting members; repair of the lining of tunnels; major roadbed repair, and others.

Estimates and financial estimate calculations are compiled on the basis of data on the volume of work to be done for each object of capital repair and operative norms. Individual estimates and financial estimate calculations are compiled for capital repair of large buildings and structures where a significant volume of different kinds of work is to be done. Financial estimate calculations are made for small objects of capital repair using consolidated norms.

Calculations of the unit cost of work are written for large-scale projects of a single type, for example capital, medium, and track-lifting repair of the track, capital repair of signal and communications equipment, and so on.

A detailed listing of all defects that are to be taken care of by capital repair is very important for working estimates and financial estimate calculations.

Estimates for capital repair are developed in operative prices based on norms, schedules, rates, price lists, and cost calculations established for capital repair work.

Procedures for working out planning and estimate documents for capital repair of objects of the track, buildings, and structures of railroad transportation were established by order P-25500 of the Ministry of Railroads, dated 17 September 1971.

Timely, high-quality performance of capital repair and associated modernization improves the reliability of fixed capital, promotes longer service lives, and creates necessary conditions for highly productive use of this capital.

Conclusion

Raising the efficiency of public production requires an improvement in the work of the country's entire transportation system, but above all railroad transportation, which is the leader in conveyance of freight and passengers. Improving the work of railroad transportation is closely linked to raising the intensity of use of production fixed capital, which has grown significantly in recent years.

During the first 60 years of Soviet power more than 58 billion rubles was invested in railroad transportation. The length of the railroad system on 1 January 1979 was more than 140,000 kilometers. The technical equipment of the railroads has also changed substantially. Powerful electric and diesel locomotives pull heavy trains along railroad tracks built of heavy R50, R65, and R75 rails on crushed rock and gravel foundations.

In 1976 the CPSU Central Committee and USSR Council of Ministers adopted the decree entitled "Measures to Develop Railroad Transportation in 1976-1980." This decree outlines the most important steps to strengthen the material-technical base of the railroads and increase their traffic and carrying capacity in many regions. In the first three years of the 10th Five-Year Plan, 1,700 kilometers of new roads were built, chiefly in the eastern parts of the country. In addition, 1,860 kilometers of second tracks were put into use, 2,000 kilometers were electrified, and 9,200 kilometers were outfitted with automatic blocking and centralized dispatching equipment. The traffic capacity of 18,000 kilometers of track was increased [91].

The excellent technical equipment of the railroads enables them to handle an enormous volume of freight and passenger traffic. But the needs of the national economy and population for transportation are growing more rapidly than the material-technical base of the railroads, and the railroad system is experiencing difficulty meeting these needs. General Secretary of the CPSU Central Committee and Chairman of the Presidium of the USSR Supreme Soviet Comrade L. I. Brezhnev, speaking at a meeting of the first secretaries of kray and oblast committees of the CPSU of the Far East, discussed ways to overcome these difficulties: "The difficulties in transportation are not just a matter of a shortage of means of transportation. It is necessary to improve transportation planning, reduce empty runs, deliver cars for loading at the proper time, cut time losses during loading and unloading, and put storage facilities in order."*

The most complete ways to evaluate the increase in efficiency of the shipping process in railroad transportation are by growth in labor productivity, decrease in material-intensiveness, and increase in the output-capital ratio. All these indicators depend significantly on the level of use of railroad rolling stock, equipment, and permanent structures.

The problem of increasing the efficiency of use of fixed capital occupies a central place in this book. Supplying railroads with new equipment and raising the level of qualifications of railroad workers created the essential conditions for an increase in the output-capital ratio. This ratio is growing slowly in railroad transportation, however, and in the 10th Five-Year Plan it has even decreased slightly.

A thorough analysis is needed to identify the causes of the drop in the output-capital ratio and disclose reserves for increasing it. This analysis must consider the influence of various factors on the ratio. These factors can be divided into two groups.

The first group includes factors that reflect conditions that are objective results of the course of national economic development. These are the change in the structure of shipping and its location by

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* "Poyezdka Leonida Il'icha Brezhneva po Sibiri i Dal'nemu Vostoku" [The Trip of Leonid Il'ich Brezhnev to Siberia and the Far East], Moscow, Politizdat, 1978, p 33.

regions of the country; the change in the operating conditions of the railroads, determined by the degree of utilization of the traffic and carrying capacities of the lines, stations, and junctions; the rise in the cost of new railroad construction associated with its move, for the most part, into the regions of the European North of the USSR, Siberia, and the Far East, where climatic and geological conditions are most difficult; the rise in prices for the cars, locomotives, and equipment delivered to the railroads.

The second group includes subjective factors related to the activities of the employees of railroad transportation of the enterprises of other sectors of the economy. Among these factors are the quality of organization of work at stations, junctions, and sidings and development of plans for forming trains, train traffic schedules, and the like; the introduction of progressive methods of using and repairing the fixed capital of railroad transportation and loading and unloading cars; improving administration of transportation, organizing cost accounting, and carrying its results to every crew and employee; giving the employees of the railroads and industrial enterprises a material interest in efficient use of locomotives, cars, and other railroad fixed capital.

Such an analysis of the output-capital ratio will make it possible to determine exactly which factors are influencing it and how much they depend on the employees of enterprises of various sectors of railroad transportation and the employees of industrial enterprises. Then appropriate steps can be taken in time to improve the use of fixed capital.

Rational location and comprehensive development of railroad transportation fixed capital is very important to create conditions for optimal use of this capital. This is an important factor in creating an optimal structure of fixed capital.

Given steady growth in shipping volume and the necessity of constantly developing and bolstering production fixed capital, a major reserve for raising the output-capital ratio in railroad transportation is accelerating introduction of scientific-technical advances. The quality of fixed capital and its capacity, reliability, and productivity are rising thanks to scientific-technical progress.

Realization of the high efficiency of newly built fixed capital and raising the output-capital ratio require more rapid introduction of fixed capital into use and full loading and a reduction in the cost of building transportation structures and buying rolling stock, machinery, and equipment. The rise in prices and costs that has been observed recently is in large part a result of the improved quality of construction, use of new designs, expenditure of significant sums for environmental protection, and the increased cost of materials, equipment, and the like. In addition, there are still cases where capital construction is scattered around, deadlines are extended, and capital investment is not adequately concentrated at start-up projects. There are even some cases of wasteful use of materials and considerable downtime for construction machinery.

The output-capital ratio in railroad transportation depends largely on raising the efficiency of use of rolling stock, increasing the length of time that locomotives and cars are in use, and bolstering the intensity of their use per unit of time.

For this reason, the work practices of the collectives of enterprises of the Moscow Railroad, which were approved by the CPSU Central Committee in March 1979, deserve broad dissemination. These collectives are speeding up shipping by increasing the weight and length of trains. To permit such trains to run on the roads steps were taken to improve the organization of train traffic, bolster rolling stock technical servicing points, fix up the track, improve power supply devices, train workers, and improve the system of material incentive for highly efficient use of rolling stock. Dissemination of these practices will make it possible for the railroads to meet national economic needs for freight shipping more fully and to speed up the delivery of freight to customers.

Appendix. Service Lives and Norms of Depreciation Deductions for the Fixed Capital of Railroad Transportation.

Groups and Types of Fixed Capital	Service Life, Years	Norm of Depreciation Deductions from Value of Fixed Capital, %		
		Total	For Full Replacement	For Capital Repair
Roadbed Structures				
Railroad Roadbed	500	1.4	0.2	1.2
Drainage, Water Diversion, and Reinforcement Structures of Railroad Roadbed:				
Wooden and Earthen	22	7.1	4.5	2.6
Stone, Concrete, and Reinforced Concrete	35	4.2	2.8	1.4
Artificial Structures				
Reinforced Concrete, Concrete, and Stone Bridges of All Types and Designs	100	1.3	1.0	0.3

[Continued on next page]

Metal Bridges with Span Lengths:				
To 25 Meters	100	2.1	1.0	1.1
More than 25 Meters	100	2.4	1.0	1.4
Wooden and Metal Bridges on Wooden Support Members	20	5.8	5.0	0.8
Reinforced Concrete, Concrete, Stone, and Cast Iron Culverts and Chutes	100	1.4	1.0	0.4
Wooden Culverts and Chutes	10	13.2	10.0	3.2
Corrugated Steel Culverts	60	1.8	1.7	0.1
Concrete and Reinforced Concrete Supporting and Protective Structures (Against Landslides, Avalanches, and Cave-Ins, Foundation, Enclosing, and Catching Walls, Tunnels, Mudflow Chutes, Shelves, Trenches, and the Like)	60	2.0	1.7	0.3
Regulating and Reinforcement Structures of Bridges	40	2.7	2.5	0.2
Railroad Tunnels of All Designs	500	0.7	0.2	0.5
Subway Tunnels	500	0.24	0.2	0.04
Subway Stations	500	0.266	0.2	0.066
Ground-Level Entryways of Subways	14	1.2	0.7	0.5
Pedestrian Bridges and Tunnels	80	1.9	1.2	0.7
Superstructure and Other Track Structures				
Track Superstructure of Railroads (Ballast, Ties, Rails and Fastenings, Switches, and Other Elements)	500	5.5	0.2	5.3
Sidings and Other Railroad Tracks at Enterprises	60	3.1	1.5	1.6
Subway Railroad Tracks	500	1.87	0.2	1.67
Narrow-Gage Railroad Tracks	15	8.5	6.7	1.8
Crossings	20	7.6	4.2	3.4

[Continued on next page]

Permanent Snow Fences:				
Reinforced Concrete	30	4.1	3.3	0.8
Wooden	15	7.4	6.3	1.1
Portable Snow Shields and Posts	10	9.5	9.5	-
Passenger and Freight Structures				
Reinforced Concrete and Stone Covered Railroad Platforms	80	2.4	1.3	1.1
Open-Air Railroad Platforms and Loading Areas, Open Construction Areas at Stations Where Intersection Points of AC and DC Current, Distribution Devices of Power Plants, and Traction and Transformer Substations Are Grouped, Asphalt-Concrete, Reinforced Concrete, and Stone	50	3.3	2.0	1.3
Wooden Railroad Platforms	20	10.0	5.0	5.0
Crane Tracks	20	7.9	4.2	3.7
Wooden Ice-Loading Platforms	15	12.0	6.6	5.4
Locomotive Supply Structures				
Turning Circles	50	3.0	2.0	1.0
Storage Tanks for Diesel Fuel and Lubricants:				
Metal	35	4.7	2.8	1.9
Reinforced Concrete	50	3.3	2.0	1.3
Metal Storage Tanks for Petroleum Products	20	7.5	5.0	2.5
Sand Loading Installations for Locomotives	20	5.6	4.5	1.1
Mechanized Slag Removal Installations	18	7.0	5.5	k.5
Inspection Pits	60	3.1	1.7	1.4
Stone, Concrete, and Reinforced Concrete Racks	40	3.2	2.5	0.7

[Continued on next page]

Water Supply Structures				
Water Towers:				
Metal	20	5.9	5.0	0.9
Brick with Metal Tanks	40	3.4	2.5	0.9
Brick and Reinforced Concrete with Reinforced Concrete Tanks	50	2.8	2.0	0.8
Wooden	10	11.7	10.0	1.7
Water Posts	20	5.6	4.4	1.2
Flotation Devices with Metal Floats	15	7.8	6.6	1.2
Electricity Transmission and Communications Equipment				
Catenary System of Railroads on Metal and Reinforced Concrete Towers	50	4.0	2.0	2.0
Overhead Power Transmission Lines with Voltages of 0.4-20 kv:				
On Metal or Reinforced Concrete Towers	30	3.6	3.0	0.6
On Towers of Treated Standard Timber and Untreated Larch	24	5.7	4.0	1.7
On Towers of Untreated Timber	16	8.0	6.0	2.0
Overhead Communications Lines*	24	9.0	4.0	5.0
Composite Units				
Mobile Power Plants with Diesel Engines	25	6.7	3.7	3.0
Small Mobile Railroad Power Plants with Outputs of up To 9 Kwt	9	25.6	10.8	14.8

* A coefficient of 1.3 is applied to the general norm of depreciation deductions for overhead communications lines that run along the seacoast and rail sectors on steam and diesel traction.

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Power Plant Cars	18	10.0	5.5	4.7
Railroad Power Plants with Outputs of 30-100 Kwt	12	16.1	8.0	8.1
Power Plant Motorcars, Railroad Power Plants and Aggregates with Outputs of More than 100 Kwt	16	14.4	6.1	8.3
Other Mobile Power Plants	8	23.5	12.5	11.0
Stationary Locomobiles	16	14.0	6.0	8.0
Energy-Supply Trains with Steam Turbines	20	10.3	5.0	5.3
Power and Electrical Engineering Equipment of Traction Substations and Power Plants				
Power and Electrical Engineering Equipment and Distribution Devices (Electrical Equipment of Open and Enclosed Distribution Devices, Switches, Buses, Measuring and Power Transformers, Insulators, Convertors, and Other Equipment)	28	6.4	3.5	2.9
Electrical Engineering Equipment of Railroad Traction Substations:				
DC	25	5.4	3.8	1.6
AC	23	6.1	4.1	2.0
Electrical Engineering Equipment of Collection Points of Switches of the Catenary System at Stations Where AC and DC Currents Intersect	22	7.1	4.4	2.7
Other Power Equipment				
Auxiliary Diesel-Mechanical Power Equipment (Fuel Supply Equipment, Pump, Boilers with Pumps, and the Like)	28	10.5	3.5	7.0
Selenium and Silicon Rectifiers	20	8.6	5.0	3.6

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Batteries:*				
Permanent Acid	17	9.1	5.9	3.2
Permanent Alkaline	8	12.5	12.5	-
Portable Acid	3	33.3	33.3	-
Metal-Cutting Lathes				
Wheel Lathes and Spindle Rolling Lathes	25	6.9	3.9	3.0
Rail-Cutting and Drilling, Cutting-Off, and Rail-Planing Lathes	15	14.1	6.5	7.6
Hoisting-Transporting and Loading-Unloading Machines and Equipment				
Gantry Cranes with Load Capacities of:				
Up to 15 Tons	12	12.4	8.2	4.2
From 15 to 50 Tons	14	11.0	6.9	4.1
More than 50 Tons	15	10.3	6.4	3.9
Cranes Mounted on Railroad Cars with Load Capacities of:				
Up to 16 Tons	20	10.9	5.0	5.9
More than 16 Tons	30	7.4	3.0	4.4
Truck-Mounted Cranes	11	15.5	9.0	6.5
Tower Cranes	18	8.4	5.5	2.9
Gantry Crane-Loaders	25	6.0	3.6	2.4
Screw and Rack-and-Pinion Jacks	6	21.7	16.0	5.7
Hydraulic Jacks	12	12.1	8.1	4.0
Gas-Powered Lift Trucks	6	25.6	16.0	9.6
Electric Lift Trucks	6	22.7	16.0	6.7
Ice-Supplying Machines	6	24.4	16.1	8.3
Mechanical Lift Trucks	10	22.0	10.0	12.0
Escalators	50	7.17	2.0	5.17

* When batteries are working under large peak loads (at power plants and substations) and in the "charge-discharge" mode, a coefficient of 1.7 is applied to the general norm of depreciation deductions.

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Machines and Equipment for Maintaining and Repairing the Railroad Track				
Electric Ballasters, ShchOMD Gravel Cleaning Machines, and Track Straightening Machines and Devices	18	10.5	5.3	5.2
Rail Polishing Cars	24	15.4	4.1	11.3
VPO-3000 Straightening-Packing-Finishing Machines	18	16.2	5.5	10.7
Set of Removable and Standardized Equipment of a Track-Laying Train	10	11.9	9.4	2.5
Flatcars with Affixed Equipment	30	4.3	3.0	1.3
Track Plows and Snow Plows	30	6.6	3.1	3.5
Track-Laying Cranes, Motorized Flatcars	20	8.5	4.9	3.6
Snow Removal Machines, Narrow-Gage Track Layers	12	11.5	8.0	3.5
Railroad Snow Removal Machines:				
Plows	25	9.7	3.6	6.1
Rotary	30	8.7	3.1	5.6
Railroad Snow and Earth Removal Machines	20	8.0	4.7	3.3
Brush-Type Snow Removal Machines	25	6.7	3.9	2.8
Trains for Hauling Sections of Rail	25	7.6	4.0	3.6
Cyclical-Action Tie-Packing Machines, BMU Gravel Cleaning Machines and Planers Mounted on Tractors, Packing Machines	15	13.6	6.5	7.1
Flow Lines and Machines for Assembling and Dismantling Rail Links, and for Tie Repair	12	13.9	8.2	5.7
Mobile Rail Welding Units	10	12.7	9.9	2.8
Devices for Thermal Treatment of Welded Rail Junctions	10	15.5	9.8	5.7

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Machine Tools for Cutting Off Burrs	10	12.1	10.0	2.1
Rail-Welding Machines:				
Permanent	12	17.7	8.1	9.6
Mobile	6	21.5	16.6	4.9
Presses for Straightening Switch Tongues	15	10.9	6.6	4.3
Hydraulic Presses for Testing Welded Rail Junctions, Rail-Straightening Presses	20	11.9	4.8	7.1
Removable Portal Cranes for Replacing Rails	8	18.3	12.3	6.0
Track Repair Units Mounted on GAZ-51A Trucks	12	14.5	8.1	6.4
Devices for Clearing Snow and Sand from Switches	10	11.3	9.3	2.0
Machines and Special Equipment for Maintaining and Repairing Railroad Rolling Stock				
Stands, Installations, and Special Equipment for Repairing Rolling Stock	12	12.8	8.2	4.6
Loading-Liquid Rheostats	10	13.2	9.6	3.6
Induction Heaters	5	29.8	19.2	10.6
Tilters	15	11.5	6.5	5.0
Mechanisms for Lifting Cars and Replacing Their Assemblies	12	13.0	8.0	5.0
Equipment of Automatic Brake Check Points	12	15.2	8.1	7.1
Mechanisms Used for Repairing Cars	15	10.4	6.5	3.9
Machines for Painting and Drying Cars	10	15.4	10.0	5.4
Mechanisms Used for Repairing Car Electrical Equipment	10	20.1	9.5	10.6
Flow-Conveyor Lines for Repairing Locomotives and Cars	12	14.3	8.0	6.3

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Washing Machines for Washing Rolling Stock and Their Parts	14	10.3	6.7	3.6
Installations for Washing Rolling Stock	15	9.4	6.5	2.9
Machines To Prepare Cars for Shipping	15	9.7	6.5	3.2
Equipment of Technical Inspection Points	10	14.9	9.9	5.0
Equipment for Centralized Testing of Automatic Brakes	15	10.1	6.5	3.6
Small Electric Cranes	20	8.9	4.9	4.0
Other Specialized Railroad Transportation Equipment				
Car Retarders with Control Devices and Piping	16	17.7	6.2	11.5
Workshop Cars for Repairing Scales, Loading-Unloading Equipment, and Other Railroad Transportation Devices and Equipment	30	3.6	3.2	0.4
Signal, Centralization, Blocking, and Communications Equipment of Railroad Transportation				
Selective Communication Command Stations	20	7.0	5.0	2.0
Equipment of Intermediate Selective Communication Points	12	11.2	8.3	2.9
Automatic Blocking Equipment (Including Track Devices for Automatic Locomotive Signaling), Point-Type Automatic Locking, Dispatcher Monitoring of Train Traffic, Crossing Signals, Crossing Barriers, and Portable Automatic Blocking	25	6.3	4.0	2.3
Semiautomatic Blocking	30	4.6	3.3	1.3
Automatic Locomotive Signaling	25	7.1	4.0	3.1
Electric Staff Signaling	40	8.1	2.5	5.6
Independent Signaling	40	3.9	2.5	1.4

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Electrical Centralization of Switches and Signals	25	6.2	4.0	2.2
Centralized Dispatching Equipment	25	5.6	4.0	1.6
Mechanized Centralization of Switches and Signals	40	4.7	2.5	2.2
Route Monitoring Devices	30	7.0	3.3	3.7
Control and Measuring and Testing Equipment for Communications, Signaling, Centralization, and Blocking:				
Permanent	14	8.5	6.7	1.8
Portable	8	14.2	12.5	1.7
Measurement and Adjustment Instruments and Devices				
Automatic Devices of Classification Humps	20	7.0	5.0	2.0
Ticket-Selling Machines for Sorting Coins and Giving Change, Automatic Ticket and Coin-Changing Machines	10	13.0	10.0	3.0
Track-Measuring Trucks	12	21.1	8.2	12.9
Mobile Rail Defectoscopes, Removable	8	19.8	12.5	7.3
Defectoscopes for Monitoring Parts and Assemblies of Rolling Stock	8	12.5	12.5	-
Car Defectoscopes, Magnetic and Ultrasonic	15	21.0	6.5	14.5
Track-Measuring and Bridge-Testing Cars	22	10.9	4.1	6.8
Weighing Equipment				
Platform Scales	17	10.5	5.9	4.6
Car Scales	25	5.2	3.9	1.3
Weighting Platforms and Weight-Testing Cars	35	5.3	2.6	2.7

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Computer Equipment				
Electronic Digital Computers with Program Control, General-Purpose Specialized, and Controlling	10	12.0	10.0	2.0
Analog and Keyboard Electronic Computers	10	11.0	10.0	1.0
Keypunch and Keyboard Electromechanical Computers	14	11.0	7.0	4.0
Other Equipment				
Automatic Baggage Storage Compartments, Information Devices, Seat Distributors for Trains, Indicators of Train Destinations, Electric Ticket-Stamping Machines	10	12.4	9.1	3.3
Locomotives				
Electric Locomotives:				
DC	30	9.2	3.0	6.2
AC	30	9.7	3.0	6.7
Mainline Diesel Locomotives	25	9.6	3.8	5.8
Diesel Switch Engines:				
With Electric Drive	30	6.5	3.1	3.4
With High-Speed Diesel Motors	25	9.3	5.7	3.6
Diesel Trains	25	10.0	3.8	6.2
Diesel Cars	25	10.3	3.9	6.4
Steam Engines and Tenders	30	8.2	3.2	5.0
Electric Trains:				
DC	35	8.2	2.6	5.6
AC	35	10.6	2.6	8.0
Subway Rolling Stock	35	8.28	2.8	5.48

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Cars				
All-Metal Passenger Cars:*				
First-Class	40	8.4	2.4	6.0
Second-Class Compartment	40	6.4	2.4	4.0
Second-Class Open	40	6.9	2.4	4.5
Baggage	40	5.8	2.4	3.4
Dining	30	8.1	3.3	4.8
Mail	40	5.7	2.4	3.3
Passenger Cars with Wooden Bodies	30	3.2	3.2	-
Enclosed Freight Cars (Box Cars)	40	5.7	2.4	3.3
4-, 6-, and 8-Axle Gondolas	25	7.9	3.5	4.4
Flatcars	35	5.0	2.5	2.5
Dosing Hoppers	30	7.1	3.0	4.1
Transporters	35	4.4	2.4	2.0
Tankers:				
Petroleum and Gas	35	4.5	2.5	2.0
Acid	10	11.4	9.2	2.2
Refrigerator Trains and Cars with Machine Cooling	25	6.8	3.5	3.3
Isothermic Cars with Ice-Salt Cooling	20	13.7	4.7	9.0
Industrial Transportation				
Narrow-Gage Freight Cars and Flatcars	5	23.1	18.1	5.0
Narrow-Gage Freight and Passenger Diesel Engines and Passenger Cars	12	16.2	8.2	8.0
Narrow-Gage Steam Engines	10	21.0	10.0	11.1
Small Diesel Switch Engines, Motor Trolleys, and Loading-Unloading Trucks	20	15.0	4.8	10.2

* A coefficient of 0.75 is applied to the norm of depreciation deductions for capital repair for all-metal passenger cars (first and second class, compartment, and open second class) equipped with air conditioning.

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Removable and Transporting Trolleys	9	24.0	11.0	13.0
Electric Trucks, Cars, and Carts, Baggage Carts, Track Carts, and the Like	8	16.6	12.5	4.1
Tools for Servicing and Repairing Railroad Track				
Hydraulic Distillation Instruments, Straighteners, Wood Screwdrivers, Spike Hammers	4	28.9	24.7	4.2
Portable Rail-Cutting, Rail-Drilling, and Rail-Polishing Lathes	9	19.9	10.9	9.0
Other Track Tools	9	15.0	11.1	3.9
Containers				
All-Purpose Containers:				
Metal	20	8.2	4.8	3.4
Wooden	12	18.0	8.3	9.7
Railroad Wooded Windbreaks				
Windbreaks and Other Planted Wooded Areas of the Steppe (Chernozem) Zone:*				
Oak and Conifer Species	50	3.0	2.0	1.0
Other Species	40	4.2	2.5	1.7

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* The following coefficients are applied to the general norm of depreciation deductions for wooded windbreaks: 0.8 for the forest and forest-steppe zones; 1.2 for the arid steppe zone; 1.5 for the desert and semidesert zones.

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