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16 April 1982

# USSR Report

## TRANSPORTATION

(FOUO 2/82)

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JPRS L/10465

16 April 1982

# USSR REPORT

## TRANSPORTATION

(FOUO 2/82)

CONTENTS



 [III - USSR - 38d FOUO]

AIR

UDC 629.733.3

USE OF DIRIGIBLES FOR CONSTRUCTION, TRANSPORT WORK

Moscow PROMYSHLENNY TRANSPORT in Russian No 12, 81 pp 19-20

[Article by B. G. Broude, candidate of technical sciences: "Installation and Transport Balloons"]

[Text] The journal PROMYSHLENNY TRANSPORT in issue No 7 for 1978 and No 3 for 1979 carried selections of materials on dirigibles and balloons and the general process for using them. The author of the article below considers the possibilities of using these aircraft for installation and transportation work in industrial construction.

Attempts have been made in recent years in our country and abroad to build aeronautical craft for special construction-installation and hoisting-transportation jobs. For example, the Moscow Tsentrotekhmontazh [Central Technical Installation] Trust has built and tested two types of aerostat-cranes with low load capacities: the spherical EPAK-1 and the Lentil-shaped EMA-10 (see the journal IZOBRETATEL' I RATSIONALIZATOR, Nos 3 and 12 for 1977). Unfortunately, this project was just an attempt by amateurs, with practically no sound scientific and production-technical base, to prove the wisdom of building and employing a new, promising means of installation.

When the wind comes up captive (tethered) balloons, which the EPAK-1 was, return to the ground and are pressed against it. Therefore, efforts have been made for a long time to give the ship a streamlined form and provide it with tail stabilizers which are inflated by the winds. These aerostats are always set up downwind and receive additional aerodynamic lift (the so-called "kite effect").

The lentil-shaped EMA-10 flying crane copied the shape of an aerostat on which the English and French have worked in the past and are working today. But during horizontal movement and in strong winds these "flying saucers" proved unstable. To keep the EMA-10 crane in a stable horizontal position, therefore, it had to be equipped with two engine-propeller units and complex automatic controls. The results of full-scale testing of models of these cranes showed that they are inferior to helicopters with respect to maneuverability and precision of setting down cargoes.

The Leningrad Orgtekhstroy [Organization of Technical Construction] Trust developed a captive aerostat-crane that we believe is more successful. They designed a kite-type craft. The loaded aerostat was moved by means of three winches installed at angles of 120 degrees relative to the center of the area. The aerostat was to be raised and lowered by operating the winches simultaneously. To move the load on the horizontal it was necessary for the winches to operate at different, in speed, but coordinated rpm's.

Orgtekhstroy retained the author of this article, from the Leningrad Academy of Civil Aviation, to conduct aerodynamic experiments with models of these aerostat-cranes. We investigated the airflow of the aerostat crane in the proximity of construction projects. The experiments enabled us to determine the aerodynamic characteristics of the aerostat, select its optimal shape, and design the tethering line system. We established that the aerostat is most stable when it is in front of a small object and behind a long object that shields it from the wind. Unfortunately, this project was not completed either.

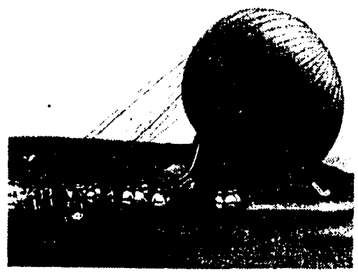
A captive aerostat can also be used successfully to transport cargo, for example to lift mineral products at an open-cut mine and load them into railroad cars, as was shown in Yu. S. Boyko's article "Freight Aerostats for Open-Cut Mines" (PROMYSHLENNY TRANSPORT, No 10, 1980).

It is wise to use electrical winches, light, moderate, strong cables, and automatic devices to control the aerostat-crane. The automatic devices greatly simplify operation of the crane and enable it to put the load down more precisely.

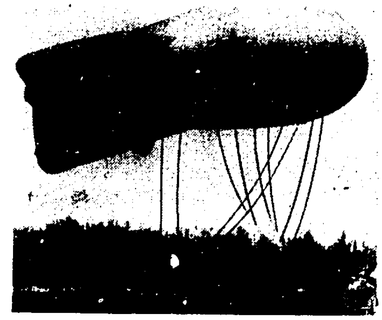
The aerostat-crane only moves freight around within a construction site. The freight is delivered to the site by motor vehicle, air, or rail transportation. With a fairly small volume of freight of normal dimensions its delivery causes no special problems. The problem arises with transporting heavy and large-dimensioned articles such as hydroturbine rotors, turbogenerators, nuclear reactors, and the like. The problem is especially critical in the Far North, Siberia, and the Far East. Airplanes are unsuitable there because of their inadequate load capacity and the necessity of building runways. Helicopters do not need runways, but their load capacities are not more than 20 tons, while their flight range without refueling is 200-250 kilometers.

Under these conditions, the use of dirigibles to transport large-dimension and heavy articles is very promising. Their load capacity can reach 300 tons and more, and they can also be designed and adapted as aeronautical cranes. In our opinion, the dirigible-crane could be a transportation-installation craft which would enable us not only to transport equipment "from door to door," that is without any transshipping, but also to install it right at the point of operations.

This should be a dirigible with large load capacity for carrying freight in the cabin and on external suspension. To use the dirigible as a crane it must have good maneuverability when flying at low speed and "hovering" in one place. These qualities can be created by automatic control systems that change the vector of thrust of the propeller-engine group.



The wind forces a spherical captive aerostat to the ground.



Moored kite aerostat

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When unloading unitary freight the dirigible-crane must be balanced without releasing lifting gas. There are several possibilities to achieve this: securing it to the ground; suspending a new weight or taking on ballast; and, various ways of controlling aerostatic lift.

The principal difficulty in building a large-capacity dirigible-crane is its enormous dimensions. To carry a load weighing, for example, 500 tons will require a dirigible with a volume of more than 1 million cubic meters, which may be 300-400 meters long. Sea-going vessels of this length are built, so there is reason to hope that with contemporary scientific and technical advances industry will also be able to build giant aeronautical vessels.

Many designs of combined aircraft which use aerostatic and aerodynamic lift have been devised to reduce the dimensions of these ships and increase their flying speed. Among them are "helistats" (dirigible-helicopters), airplane-dirigibles, flying wing-dirigibles, and so on.

Only "helistats," which are capable of hovering like a helicopter, can be used as transportation-installation equipment. But operating them will be much more expensive than a dirigible-crane because of their very large power plants, high fuel consumption, and complexity of design.

Most of the combined aircraft are unsuitable for use as cranes because they cannot "hover" in the air and require runways.

In conclusion, we should state that transportation-installation aerostats with large load capacities can only be built on a contemporary scientific-technical level at a specialized science-production enterprise. The statement by doctor of technical sciences O. A. Chembrovskiy in the interview published in issue No 10 of PROMYSHLENNY TRANSPORT for 1981 is very instructive. He said that the most valuable feature of aerostats is their ability to perform both transportation and loading-unloading jobs. This feature makes it possible to organize the transportation of, for example, heavy and large-dimension freight directly from the assembly site at the manufacturing plant to its destination at the planned point in the installation section of the enterprise under construction. It is noteworthy that the Energoaerotrans [Energy Aerial Transportation] Trust headed by O. A. Chembrovskiy has begun building prototypes of such ships.



11,176
CSO: 1829/122

MOTOR VEHICLE

UDC 621.433

STATISTICS ON BOTTLE-GAS DRIVEN VEHICLES GIVEN

Moscow KHIMIYA I TEKHNOLOGIYA TOPLIV I MASEL in Russian No 11, Nov 81 pp 6-10

[Article by V. N. Ivanov and V. I. Yerokhov: "Gas Fuel for Automobile Engines"]

[Text] Given the present scope of increasing automobile use, providing motor transport with efficient, stable energy carriers is one of the most important national economic problems. As majority of the specialists consider the nearest feasible alternative to reducing the consumption of liquid petroleum-origin fuel to be the changeover of a certain portion of the motor vehicle fleet to using gaseous fuel such as compressed petroleum gas (SNG) or natural gas (PG). At present, preference is being given to SNG, on which about 15,000 automobiles are running in our country.

With a view towards broadening the products list of fuel-energy resources for automotive transport and saving liquid petroleum products, the extensive use of compressed PG as a fuel has been examined and the basic directions and stages of experimental design work and organizational-technical measures to develop designs for and efficiently operate bottle-gas vehicles have been determined. An experimental-industrial lot of ZIL and GAZ (two different compression modifications) vehicles was manufactured in 1981 and extensive operational tests were begun in L'vov and Berdichev. In subsequent years, we plan the following production of bottle-gas vehicles: 1982 -- 5,000, 1983 -- 10,000, 1984 -- 35,000, 1985 -- 50,000 and beginning in 1986 -- 100,000 annually. Twenty-five gas filling stations for compressed PG are to be put into operation, including one in Moscow, two in Leningrad, three in Donetsk, two in Tashkent, one in Noril'sk, and so forth.

As compared with the traditional liquid petroleum-origin fuels, gas fuels have a number of indisputable advantages. The NIIAT [Scientific Research Institute of Automotive Transport] has accumulated positive experience in operating vehicles on SNG and PG. The purpose of this work is to generalize available experience and determine prospects for using gas fuel in motor transport. In order to do this, we need to study the influence of the physical-chemical properties of gas fuels on the basic technical-operating qualities of automotive engines, to analyze the trends in using SNG and PG as a motor fuel, and to work out the technical-operating specifications for improving the motor properties of gas fuel.

The main SNG components are propane, which ensures optimum saturated vapor pressure in the gas mixture, and butane, the most easily-compressed component. The main properties of SNG as a motor fuel include pressure of the saturated vapors, density, specific heat of combustion and octane number (OCh). SNG saturated vapor pressure varies from 0.27 MPa (at -10°C) to 1.6 MPa (at 45°C). SNG has a high volumetric expansion coefficient, so the pressure in the gas cylinder increases by 0.6 to 0.7 MPa with every 1° rise in temperature. In order to prevent destruction of the gas cylinder, it will have a steam blanket of at least 10 percent of the usable capacity. At 0°C and 101.3 kPa pressure, the density of the liquid-phase SNG is 530-690 $kg/m^3$, of the steam phase -- 1.96 (propane) to 2.6 (butane) $kg/m^3$.

The octane number of the gas fuel is 90-110, permitting forcing automobile engines to compression ratios of 10:1 to 11:1. From the viewpoint of working fluid, gas fuel has a more favorable C : H ratio than gasoline. The carbon number -- ratio of carbon to hydrogen (C : H) -- of modern gasolines is about 6, and the numbers for SNG and PG are 4.9 and 2.96, respectively. The higher hydrogen content of the gas fuel also ensure more complete combustion of the fuel in the engine cylinders.

If the gas is used to power carburetor engines, the complex of carburetion processes no longer includes fuel vaporization in the intake pipe, with all the associated shortcomings, so the evenness of fuel distribution among the cylinders is improved. Maximum fuel distribution unevenness among the cylinders of a carburetor engine (35 percent or more) results in a higher carbon monoxide content (45-55 percent higher) in exhaust gases (OG), as well as a 35-45 percent higher hydrocarbon (CH) content, given a fuel mixture stoichiometric content of $\alpha$=1. Use of a gas fuel ensures a reduction of up to 20 percent in the maximum unevenness of fuel mixture distribution.

The combustion range of gas fuel is broader than for gasoline, permitting a more efficient depletion of the fuel mixture (up to $\alpha$=1.2 - 1.3) under basic operating conditions. The use of SNG and PG as motor fuels therefore ensures a substantial reduction in OG toxicity in terms of basic monitored parameters: CO content (two- to three-fold), $NO_x$ (1.2- to two-fold) and CH (1.1- to 1.4-fold), which meets the strict requirements of a majority of national standards. Comparison testing of ZIL-130 and ZIL-138 vehicles has shown that CO and OG content are 0.8-3.5 and 0.1-0.8 percent, respectively, throughout the range of steady speeds of movement (20-80 km/hr). This testifies to the real advantages of SNG and PG.

To accumulate the needed fuel reserve in the vehicle, PG is compressed to high pressure (20 MPa). A cryogenic PG storage technology in the vehicle is considered more promising and is viewed as an intermediate stage in the development of hydrogen engines, for which the reserves of working fluid in nature are practically unlimited.

The operation of a gas engine is the same as that of a gasoline engine. Gasoline, SNG and PG differ in components and densities, but are practically identical in energy content. Operating indicators of the ZIL-130 using different types of fuel are given in the table [following page]. As follows from the table, given the same compression ratio, maximum power is decreased by 5-7 percent when a gasoline engine is converted to SNG, which is associated with a slower speed of spread of the ignition front in the combustion chamber and leads to a reduction in the maximum pressure and temperature of the operating cycle. Moreover, for a number of reasons, the fill coefficient is 8-10 percent lower in a gas engine than in a gasoline engine. Thanks to the high OCh of gas fuels, the compression ratio in gas engines is 23-25 percent higher than in gasoline engines. The high anti-knock stability of gas fuels and their good miscibility with air permits forcing gas engines to higher compression ratios: for example, the ZIL-130 can be forced from 6.5 to 8 and the ZMZ-53 -- from 6.7 to 8.5.

| indicator | type of fuel | | |
|---|---|---|---|
| | gasoline | compressed petroleum gas | compressed natural gas |
| fuel system pressure, MPa | 0.03 | ≤1.6 | 20 |
| octane number | 76 | 110 | 110 |
| specific heat of combustion of the fuel mixture, α=1, kJ/kg | 111 | 110 | 108 |
| decrease in engine power at same compression ratio, in percent | -- | 5-7 | 15-16 |
| specific energy related to fuel weight, kJ/kg | 5,020 | 3,170 | 200 |
| vehicle range, km | 585 | 585 | 200 |
| weight of fueled vehicle, kg | 4,300 | 4,500 | 5,100 |
| usable load capacity, kH | 60 | 59 | 52 |

When operating on gas, a higher coefficent of excess air corresponds to the optimum fuel expenditure. As the fuel mixture is depleted, the speed of combustion drops. To compensate for this drop, an earlier spark advance angle is set: 4.5° and 6.5°, respectively, for vehicles in the ZIL and GAZ families operating on SNG and 5-7° for vehicles operating on PG.

When operating at economical vehicle speeds, a bottle-gas vehicle using SNG uses 12-14 percent less fuel than a ZIL-130 with a gasoline engine. Specific fuel expenditure by GAZ-53-07 bottle-gas vehicles is less than by base models with gasoline engines: 4.6 percent less on asphalt-concrete paved highways and 9.5 percent less under city driving conditions.

Switching to a carburetor engine using SNG, given an optimum compression ratio, generally leads to a 5-6 percent reduction in specific fuel expenditure (overall performance). Depending on the engine operating conditions, noise reduction using SNG reaches 7-8 dB. Motor capacity in gas engines operating on SNG and PG is 30-35 percent greater than in gasoline engines.

We have described the schematic diagram, design features and technical specifications of a bottle-gas installation for the ZIL and GAZ vehicles operating on compressed PG in work [1]. The level of standardization of bottle-gas vehicles operating on SNG and PG is quite high: 75 percent for the gas equipment and 95 percent for the engine.

When evaluating the possible scope of SNG use as a motor fuel, consideration must be given to the fact that propane-butane mixtures are being used successfully for municipal- and personal-services purposes, as a raw material for chemical industry, in industrial installations and in agriculture. Current strategy for developing a fleet of bottle-gas vehicles must be based on a precise forecast of SNG production and the production limit to meet motor transport needs. In this situation, we also need to take into account the constantly changing energy policies of the world market.

In countries with their own petroleum reserves and a developed petroleum extraction and oil refining industry, the commercial by-product gas output is entirely adequate to meet practically all their needs, including a fleet of bottle-gas vehicles. In spite of its adequate raw material resources, our country's SNG production is relatively limited. The USSR Ministry of Petrochemical Industry's proportion of SNG production is 62.9 percent, Ministry of Petroleum Industry -- 34.5 percent, and Ministry of Gas Industry -- 2.6 percent. The effectiveness of continued SNG production development is linked in considerable measures with the creation of new capacities.

At present, SNG is used 30 times more often to provide gas to population centers than is supply-line PG, including 1.3-fold more often in small cities, 5-fold in worker settlements and 40-fold in rural centers. In view of the fact that SNG is a valuable, high-quality motor fuel which is superior to traditional fuel of petroleum origin in some parameters and also with consideration of the strained situation which has developed concerning fuel for motor transport, we need to determine an efficient sphere of SNG use.

The development of bottle-gas vehicles is being delayed by the lack of stable SNG deliveries in the quantities and quality required to meet the needs of motor transport. Our country does not yet have a GOST [All-Union State Standard] for automotive-grade SNG. Automotive transport is using municipal-services gas, whose main parameters are regulated by GOST 20448-75. The SNG being used is not of stable composition in terms of components or amount of undesirable impurities, leading to failure to ensure normal engine operation, and the content of hazardous substances in OG is significantly higher than it might be. One very frequently encounters in the domestic and foreign literature conflicting information on the emissions and fuel economy of bottle-gas vehicles.

The gas fuel being supplied motor transport has a high oil content, which negatively affects the reliability of operation of the gas apparatus and the stability of gas reducer adjustments. This is associated with the use of compressors with bushings lubricated by motor oil to transport the SNG from the manufacturing plant to the consumer and with inefficient oil sump operation. Use of compressors with graphite bearing lubrication would be best.

In order to guarantee the operating features of bottle-gas vehicles, the USSR Ministry of Petrochemical Industry has worked out TU 38 001302-78 for the hydrocarbon compressed fuel gases for them. These gases are 80±5 percent propane, a scarce component of SNG. However, the TU does not anticipate seasonal variations in SNG, which has led to strain in the supply of SNG to motor transport and to violations of normative documents when operating the vehicles.

In the near future, is will be most appropriate to use PG, which does not require complicated technological processing. According to UNESCO data published in 1974, world PG reserves are 49.9 trillion cubic meters. According to expert estimates, about 40 percent of the world PG reserves are in the USSR. The basic consumers of PG in the 10th Five-Year Plan were industry (55 percent), electric power plants (25 percent) and municipal- and personal-services facilities (14 percent). In terms of energy parameters, one cubic meter of PG is equivalent to one liter of gasoline. Orienting motor transport towards using this energy carrier is a timely and substantiated, practical resolution to the most important national economic and social problems.

Prior to the start of the 1980's, bottle-gas vehicles were produced in small industrial lots. Additional production was ensured by re-equipping vehicles with gasoline engines to accept PG, which was associated with additional one-time expenditures. In our country, these expenditures have been 900 rubles per vehicle. In the United States, direct expenditures to convert a vehicle to use PG have been $600 and additional expenditures of $200 connected with the construction of gas filling stations. Here, the average cost of technical servicing (TO) of bottle-gas vehicles is only 3.8 percent higher than for carburetor vehicles, testifying to rather a high technical level of the gas apparatus and its adaptability to monitoring-adjustment operations [2].

The mileage coefficient for bottle-gas vehicles is generally somewhat higher than for carburetor vehicles, which is to be explained in part by the limited number of gas filling stations and by their considerable distance from motor transport enterprises (ATP). For a number of well-known reasons, bottle-gas vehicles stand idle more than vehicles with gasoline engines, so the fleet use coefficient for bottle-gas vehicles is somewhat lower.

As of now, a small number of bottle-gas vehicles is being operated in two ATP's of the UkSSR Ministry of Motor Transport. The inadequate scale of introduction of bottle-gas vehicles using PG is to be explained not by the system of motor transport organization, but by the lack of modern bottle-gas vehicle designs, production and a well-developed network of gas filling stations.

PG has a very important advantage over SNG which may predetermine its relatively rapid introduction into motor transport. The high density of SNG vapor (as compared with the density of air) and its diminished capacity, as compared with PG, for mixing with air determines the possibility that this vapor could accumulate in artificial and natural depressions such as inspection ditches, trenches, areaways, and so on, creating increased danger of fire or explosion. PG is lighter than air and volatized quickly, avoiding the above-mentioned negative phenomena. This creates objective prerequisites for lowering demands as to categorizing ATP production premises operating bottle-gas vehicles using PG.

The methods of evaluating the knock rating of liquid fuels based on octane number are ill-suited to gaseous fuels. This is associated in part with the fact that the combustion processes are not identical when detonating different types of fuel. The knock rating of gas fuels can be determined using a methane number (MCh), using as one component of the reference mixture methane, which possesses the highest resistance of all the common hydrocarbons to detonation, and hydrogen as an easily detonated component [3]. The MCh of the gas being tested corresponds to the volumetric content (in percent) of methane in a mixture with hydrogen at which operation of a special internal combustion engine under specific test conditions causes the same detonation as the gas fuel being tested.

Pressing problems include the development of a GOST or TU for motor-transport PG to regulate the range of components, moisture content and various impurities. When filling a vehicle, reducing pressure by 1 MPa leads to a reduction of 2.5° in gas temperature. The presence of moisture in PG causes the formation of ice plugs in the fuel line. PG methane content, the basic component, varies 15-17 percent as a function of source of extraction. Such phenomena are extremely undesirable in motor transport.

Thus, we need to work out appropriate GOST's and TU's and set up the production of special kinds of gas fuel in order to ensure guaranteed, stable technical-operating properties for bottle-gas vehicles.

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OCEAN AND RIVER

NEW TEXTBOOK PRESENTS PIPE WORKING, INSTALLATION PROCESSES ON SHIPS

Leningrad GIBKA TRUB SUDOVYKH SISTEM in Russian 1981 (signed to press 20 Jul 81) pp 3-4, 167-168

[Preface and table of contents from book "Bending Pipe for Ship Systems", by Boris Aleksandrovich Gorelik, "Sudostroyeniye", 4,600 copies, 168 pages]

[Text] As ships become more technically sophisticated the role and importance of ship systems and the pipelines included in them grow. This increases the labor-intensity of pipe work on ships. This work accounts for 10-14 percent of the total labor-intensiveness of constructing a ship; about 65 percent of this goes for working the pipe and 35 percent for installation and testing.

The technological process of working the pipe is being refined by introduction of progressive equipment, use of the scale modeling method for systems and lines, and setting up fully mechanized flow lines to work the pipe. The main line of improvement in industrial equipment is developing and building machines, for example pipe-bending machines, that can feed the pipe, grip it, and bend it according to program, without the use of manual labor. All these operations are done by specialized mechanized and automated devices controlled from a console. Highly qualified workers who are adequately familiar with contemporary equipment can operate these machines.

Scale modeling presupposes the production of design documents in the form of drawings which indicate not only the coordinates of the routes of pipelines, but also all essential dimensions for compiling a technological chart to serve as the basis for fabricating and working the pipe, especially bending it on pipe-bending machines.

The formation of fully mechanized pipe-working shops envisions a complete technological process of working pipe, beginning from semifinished parts and resulting in pipe of the necessary configuration.

The present textbook reviews the full technological process of working pipe in a fully mechanized shop with highly productive equipment. This distinguishes the present book from earlier ones, which gave information only on the basic operations of pipe working. The latest advances have been considered in writing the textbook. Primary attention was devoted to bending pipe.

The textbook has been written in conformity with the plan and program for training skilled workers at vocational-technical schools in the specialization "ship pipefitters." The content and form of presentation of the material meet the "Basic Requirements for Textbooks and Aids" worked out by the USSR State Committee for Vocational-Technical Education.

The material presented in the book can be used in secondary specialized schools and for brigade-individual training of ship pipefitters in production.

We request that comments and suggestions be sent to the following address: 191065, Leningrad, Ulitsa Gogol'ya 8, Izdatel'stvo "Sudostroyeniye".

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CSO: 1829/164

MISCELLANEOUS

## DATA ON ROLLING STOCK, OTHER COMPONENTS OF INDUSTRIAL TRANSPORTATION GIVEN

Moscow PROMYSHLENNY TRANSPORT in Russian No 12, Dec 81 pp 22-24

[Article by S. I. Kondys: "Industrial Transport in 1980"]

[Text] The publication of an annual statistical survey of the development of the transportation and warehouse facilities of industrial enterprises in issues Nos 11 and 12 of our journal has become a tradition. We attach great importance to preparation of this material because it contains summary information that illustrates trends in the development of industrial transportation. The 1980 survey is unique in that for a number of indicators it summarizes not only annual figures, but also figures for the 10th Five-Year Plan as a whole. It is entirely possible that readers of the journal will have specific comments and suggestions as to the form and content of these publications. Therefore, the editorial board earnestly requests that readers send letters and recommendations concerning the essential features of preparation of survey statistical materials on industrial transportation.

In 1980 the volume of freight shipping in industrial transportation was 16.4 percent higher than in 1975. The dominant forms of industrial transportation continued to be motor vehicles and railroads, accounting for 55.7 and 34.4 percent respectively.

Table 1. Structural Description of the Technical Resources of Standard-Gage Industrial Rail Transportation (in percentages)

| Indicators | 1975 | 1978 |
|---|---|---|
| Total Length of Standard-Gage Siding Track | 100 | 100 |
| Included in Above, by type of rail: | | |
| R 50 and Heavier . . . . . . . . . . . . . . . . . . . . . . | 28.2 | 30.7 |
| R 43 . . . . . . . . . . . . . . . . . . . . . . . . . . . | 51.1 | 36.1 |
| R 38 and Lighter . . . . . . . . . . . . . . . . . . . . . | 20.7 | 33.2 |

[Table continued, next page]

[Table continued]

| Indicators | 1975 | 1978 |
|---|---|---|
| Fleet of Locomotives Not Including Small Switch Engines | 100 | 100 |
| Included in Above: | | |
| Electric Locomotives | 8.6 | 7.6 |
| Diesel Locomotives | 73.4 | 86.6 |
| Steam Locomotives | 18 | 5.8 |
| Fleet of Standard-Gage Freight Cars | 100 | 100 |
| Included in Above: | | |
| Enclosed (Box Cars) | 3.4 | 3.0 |
| Gondolas | 17.6 | 16.5 |
| Flatcars | 26.8 | 19.9 |
| Tank Cars | 18.8 | 20.4 |
| Dumpcars | 23.0 | 24.9 |
| Other | 10.1 | 15.3 |

Industrial railroad transportation carried 10.92 billion tons of freight last year. Of this amount 3.68 billion tons (33.7 percent) was passed from sidings to the rail system, 3.3 billion tons (30.2 percent) was received from the rail system, and internal shipping reached 3.94 billion (36.1 percent). Roughly 51 percent (2.01 billion tons) of all internal rail shipping occurs at ferrous metallurgy enterprises and 20.8 percent (820 million tons) at enterprises of the coal industry. Thus, these two industrial sectors account for about three-fourths of the total volume of internal rail shipping.

Freight shipment at enterprises of intersectorial unified industrial rail transportation increased (450 million tons a year). The annual volume of freight shipping on narrow-gage industrial track has declined from 286.7 million tons in 1975 to 150.7 million tons in 1980.

Table 2. Share of Sectorial Ministries in Shipping Volume, Total Length of Siding Track, and Fleet of Industrial Transportation Locomotives and Cars as of 1 January 1976 and 1 January 1981 (in percentage)

| USSR Ministries and Departments | Volume of Shipping | | Total Length of Siding | | Locomotive Fleet (including switch engines) | | Fleet of Freight Cars | |
|---|---|---|---|---|---|---|---|---|
| | 1975 | 1980 | 1975 | 1980 | 1975 | 1980 | 1975 | 1980 |
| Ministry of Ferrous Metallurgy | 28.2 | 29.8 | 16 | 12.2 | 22 | 21.1 | 28 | 20.1 |
| Ministry of Coal Industry | 15.9 | 14.6 | 10 | 7.5 | 7.5 | 7.8 | 8.4 | 6.8 |

[Table continued, next page]

[Table 2 continued]

| USSR Ministries and Departments | Volume of Shipping | | Total Length of Siding | | Locomotives (with Switch Engines) | | Fleet of Freight Cars | |
|---|---|---|---|---|---|---|---|---|
| | 1975 | 1980 | 1975 | 1980 | 1975 | 1980 | 1975 | 1980 |
| Ministry of Construction Materials Industry | 6.6 | 6.6 | 4.4 | 3.4 | 6.4 | 6.2 | 2.7 | 2.3 |
| Ministry of Nonferrous Metallurgy | 4.9 | 4.0 | 4.5 | 3.6 | 4.6 | 4.5 | 4.9 | 4.3 |
| Ministry of Power and Electrification | 4.3 | 3.7 | 4.1 | 3.4 | 5.1 | 4.5 | 4.2 | 2.9 |
| Enterprises of Ministry of Railroads Intersectorial Rail Transport | 3.5 | 4.0 | 4.6 | 3.8 | 4.8 | 6.3 | 3.3 | 4.0 |
| Ministry of Chemical Industry | 2.6 | 1.6 | 3.6 | 2.1 | 3.7 | 2.3 | 9.2 | 4.2 |
| Ministry of Petroleum Refining and Petrochemical Industry | 2.2 | 1.0 | 1.1 | 2.2 | 1.1 | 1.1 | 2.1 | 1.7 |
| Ministry of Construction of Heavy Industry Enterprises | 1.4 | 1.1 | 1.7 | 1.2 | 2.2 | 1.2 | 3.3 | 2.2 |
| Ministry of Food Industry | 1.2 | 1.1 | 2.9 | 2.7 | 4.4 | 4.1 | 1.1 | 1.5 |
| Ministry of Heavy and Transport Machine Building | 0.5 | 0.5 | 1.1 | 0.8 | 1.5 | 1.5 | 2.3 | 1.8 |
| Ministry of Transport Construction | 0.6 | 0.5 | 1 | 0.8 | 2.2 | 1.6 | 3.2 | 1.8 |
| Ministry of Timber and Wood Processing Industry | 0.9 | -- | 3.6 | -- | 2.1 | -- | 0.8 | -- |
| Ministry of Pulp and Paper Industry | 0.6 | -- | 1.2 | -- | 1.5 | -- | 0.8 | -- |
| Ministry of Timber, Pulp and Paper, and Wood Processing Industry (since 1980) | -- | 1.5 | -- | 0.8 | -- | 2.9 | -- | 2.2 |
| Total | 73.4 | 70 | 59.8 | 44.5 | 69.1 | 65.1 | 74.3 | 55.8 |
| Ministry of Railroads | 15 | 18 | 18.6 | 17.3 | 30.9 | 34.9 | 25.7 | 44.2 |
| Other | 11.6 | 12 | 21.6 | 38.2 | | | | |
| Total | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

The freight turnover of standard-gage industrial rail transportation in 1980 reached 76.7 billion ton-kilometers (an increase of 8.2 percent during the five-year plan). The average length of shipment of one ton of freight by standard-gage railroad was 6.5 kilometers compared to 7.2 kilometers in 1975.

The total length of siding tracks of all gages increased 10,600 kilometers or 8.1 percent in 1976-1980, reaching a total length of 141,100 kilometers (broken down into 108,100 kilometers of standard gage and 33,000 kilometers of narrow gage).

Table 3. Structure of Lifting and Transportation Work by Freight Flows and Types of Transportation (in percentage).

| | Percentage of Loading-Unloading Volume | |
|---|---|---|
| | In Total Volume | Mechanized |
| All Freight Flows | 100 | 100 |
| Included in above figure: | | |
| a) External Freight Flows (Receiving and Shipping Freight) | 40.0 | 39.2 |
| Included in Above, by types of transportation: | | |
| Rail | 22.6 | 22.7 |
| Motor Vehicle | 14.1 | 13.0 |
| Water | 1.0 | 1.0 |
| Other Types of Transportation | 2.3 | 2.5 |
| b) Intershop (Internal) Freight Flows (Shipping) | 60.0 | 60.8 |
| Included in Above, by types of transportation: | | |
| Rail | 15.9 | 16.5 |
| Motor Vehicle | 20.8 | 21.0 |
| Floor-Operated | 3.4 | 2.9 |
| Conveyor | 10.6 | 11.2 |
| Other Types of Transportation | 8.8 | 9.2 |
| Manual Transporting | 0.5 | 0.0 |

The greatest increases in the length of standard-gage railroad tracks occurred in ferrous metallurgy, the coal industry, and the construction materials industry. On 1 January 1981 the length of track with type R-50 and heavier rails had risen significantly (to 30.0 percent), and a total of 7,800 kilometers of track had been laid on reinforced concrete ties (5.5 percent compared to 2.6 percent in 1975). During the five-year plan 7,556 kilometers of track were electrified, including 3,358.3 kilometers in ferrous metallurgy and 1,799.6 kilometers in the coal industry. On 1 January 1981 automatic blocking was set up on 1,362.6 kilometers, including 721.9 kilometers at enterprises of the USSR Ministry of Ferrous Metallurgy and 172.8 kilometers at enterprises of the USSR Ministry of Coal Industry; 27,993 switches had been put on centralized electric control, which raised the proportion of them to 11 percent compared to nine percent in 1975.

Table 4. Level of Mechanization of Loading-Unloading Work Rail Sidings (in Percentage).

| Ministries | Loading Cars | | Unloading Cars | |
|---|---|---|---|---|
| | 1979 | 1980 | 1979 | 1980 |
| All Siding Track | 96.1 | 95.5 | 93 | 92.9 |
| USSR Ministry of Ferrous Metallurgy | 99.3 | 99.6 | 96.8 | 97.6 |
| USSR Ministry of Power and Electrification | 99.9 | 97.9 | 98.1 | 96.9 |
| USSR Ministry of Nonferrous Metallurgy | 99.3 | 98.8 | 97.6 | 95.4 |
| USSR Ministry of Coal Industry | 98.3 | 97.1 | 98.5 | 98.9 |
| USSR Ministry of Construction Materials Industry | 95.0 | 97.2 | 94.7 | 95.9 |
| USSR Ministry of Timber, Pulp and Paper, and Wood Processing Industry | 93.5 | 92.1 | 88.1 | 89.1 |
| USSR Ministry of Meat and Dairy Industry | 42.5 | 37.8 | 43.5 | 42.1 |

To handle the increased volume of shipping and carry out technical re-equipping during the 10th Five-Year Plan deliveries of locomotives and cars to industrial rail transportation were increased by 28 and 27 percent respectively compared to the Ninth Five-Year Plan.

In 1976-1980 the proportion of diesel and electric locomotives in the locomotive fleet of industrial rail transportation rose from 85 to 94 percent, with the principal freight-shipping ministries having the following figures: 94 percent for the USSR Ministry of Ferrous Metallurgy, 92 percent for the USSR Ministry of Coal Industry Industry, 95.5 percent for the USSR Ministry of Nonferrous Metallurgy, 95 percent for the USSR Ministry of Construction Materials Industry, 95-100 percent for the machine building industries, and 87-100 percent for the construction ministries. The structure of the industrial transportation car fleet improved; trunk line cars comprise 47.2 percent, while industrial type cars are 28.6 percent (55.6 percent of them are dumpcars), and other types of cars are 24.2 percent.

In the last five-year plan the proportion of specialized railroad cars in the total fleet of cars of industrial transportation rose from 50 to 60 percent. The prime cost of shipping one ton of freight for industrial rail transportation as a whole in 1981 was 25.9 kopecks. Average car downtime on sidings was 7.8 hours compared to the norm of 6.6 hours.

In 1980, the 144 industrial railroad transportation enterprises of the Main Administration of Industrial Railroad Transportation carried 450 million tons of freight. The volume of loading-unloading work at these enterprises was 312.2 million tons, with a prime cost of freight shipping of 5.4 kopecks per ton-kilometer and a prime cost of freight handling of 21.2 kopecks per ton.

Table 5. Figures on Conveyor, Overhead Cable, and Monorail Transportation

| Ministries | Conveyor | | | Overhead Cable | | | Monorail | | |
|---|---|---|---|---|---|---|---|---|---|
| | Freight Delivered, millions of tons | Number of Systems | Total Length, meters | Freight Delivered, millions of tons | Number of Systems | Total Length, meters | Freight Delivered, millions of tons | Number of Systems | Total Length, meters |
| USSR Ministry of Ferrous Metallurgy | 679 | 3,427 | 491 | 8.9 | 30 | 55.4 | 82.5 | 3 | 446 |
| USSR Ministry of Non-Ferrous Metallurgy | 58.3 | 598 | 60.6 | 12.1 | 16 | 75.4<br>83.4 | 149.7 | 1 | 200 |
| USSR Ministry of Coal Industry | 344.4 | 2,428 | 686.2 | 8.29 | 37 | 16.1 | 3.9 | 11 | 5,865 |
| USSR Ministry of Power and Electrification | 411.8 | 1,109 | 248.6 | 1.1 | 4 | 54.7 | 0.12 | 1 | 60 |
| USSR Ministry of Construction Materials | 253.5 | 3,462 | 413.1 | 10.1 | 27 | 50.3 | 1,338.2 | 57 | 11,491 |
| Ministry of Chemical Industry | 45.1 | 993 | 173.5 | 5.8 | 10 | - | 127.2 | 25 | [illegible],644 |
| Ministry of Heavy and Transport Machine Building | 0.3 | 27 | 2.1 | - | - | - | 32.6 | 1 | 3,500 |
| Ministry of Transportation Construction | 18.2 | 332 | 23.5 | - | - | 15.1 | - | - | - |
| USSR Ministry of Timber, Pulp and Paper, and Wood Processing Industry | 18.9 | 1,683 | 147.3 | 0.27 | 36 | - | 140.6 | 58 | 3,064 |
| USSR Ministry of Agriculture | 0.6 | 356 | 48.5 | - | - | - | 1.2 | 1 | 1,500 |
| USSR Ministry of Land Reclamation and Water Resources | 23.7 | 443 | 30.1 | - | - | | 31.9 | 4 | 180 |
| USSR Ministry of Procurement | 224.5 | 16,067 | 1,498.1 | 0.001 | 1 | 0.08 | 1.3 | 2 | 50 |
| Ministry of Mineral Fertilizer Production | 37.7 | 133 | 66.9 | 0.8 | 4 | 18.4 | - | - | - |

Table 6. Figures on Number of Units and Balance Cost of Lifting and Transportation Equipment for the Principal Industrial Ministries as of 1 January 1981 (Surveyed Enterprises).

| | Electric Cranes (Overhead, Metallurgical, Gantry, Bridge, and Others) | | Light Duty Freight Hoisting Means (Electrical, Single, Beam, Support, and Suspended Cranes | | Continuous Tranportation Equipment (Belt, Chain, and Other Conveyors) | | Jib Cranes (Motor Vehicle, Railroad, Pneumatic Wheel, and Others) | | Floor Transportation Equipment (Gas and Electric Lift Trucks and the Like) | | Elevators, Winches, and Hoists | | Loading, Unloading and Warehouse Equipment (Car Tippers) and Cranes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Thou's of Units | Mill's of Rubles | Thou's of Units | Mill's of Rubles | Thou's of Units | Mill's of Rubles | Thou's of Units | Mill's of Rubles | Thou's of Units | Mill's of Rubles | Thou's of Units | Mill's of Rubles | Mill's of Rubles |
| Total for Industrial Ministries | 145.4 | 3,472 | 470.7 | 588.8 | 370.1 | 2,600 | 62.3 | 1,038 | 350.3 | 1,328 | 158 | 395 | 984.0 |
| Included in Above: | | | | | | | | | | | | | |
| Min. of Ferrous Metallurgy | 24.6 | 772 | 30.2 | 43 | 26.3 | 464 | 4.7 | 142 | 11.5 | 64 | 15.9 | 23.5 | 88.0 |
| Min. of Timber, Pulp & Paper, & Wood Processing Industry | 7.4 | 242 | 11.2 | 21 | 22 | 88 | 4.3 | 66 | 22.6 | 148 | 6.9 | 22.9 | 58.0 |
| Min. of Power & Electrification | 6.5 | 288 | 14.1 | 23 | 5.9 | 136 | 4.7 | 55 | 4.3 | 14 | 6.9 | 8.6 | 66.0 |

[Table 6 continued, next page]

[Table 6 continued]

| USSR Ministries | Electric Cranes (Overhead, Metallurgical, Gantry, Bridge, and Others) | | Light Duty Freight Hoisting Means (Electrical, Single, Beam, Support, and Suspended Cranes | | Continuous Transportation Equipment (Belt, Chain, and Other Conveyors) | | Jib Cranes (Motor Vehicle, Railroad, Pneumatic Wheel, and Others) | | Floor Transportation Equipment (Gas and Electric Lift Trucks and the Like | | Elevators, Winches, and Hoists | | Loading, Unloading and Warehouse Equipment (Car Tippers) and Cranes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Thou's of Units | Mill's of Rubles | Thou's of Units | Mill's of Rubles | Thou's of Units | Mill's of Rubles | Thou's of Units | Mill's of Rubles | Thou's of Units | Mill's of Rubles | Thou's of Units | Mill's of Rubles | Mill's of Rubles |
| Min. of Chemical Industry | 2 | 27 | 14 | 13 | 8 | 91 | 1.1 | 20 | 10.6 | 43 | 5.5 | 14.4 | 15.0 |
| Min. of Construction Materials Industry | 7 | 97 | 12 | 14 | 29.1 | 140 | 3.1 | 44 | 18.3 | 68 | 4.4 | 7.3 | 37.0 |
| Min. of Food Industry | 0.9 | 3 | 6.7 | 7 | 47.7 | 95 | 2.1 | 27 | 24 | 75 | 7.8 | 19.7 | 87.0 |
| Min. of Nonferrous Metallurgy | 5.2 | 172 | 15.3 | 22 | 31.7 | 72 | 2.5 | 53 | 6.7 | 40 | 3.9 | 11.9 | 54.0 |
| Min. of Coal Industry | 4.3 | 483 | 9.6 | 17 | 16.2 | 284 | 1.9 | 67 | 4 | 41 | 7.7 | 73.1 | 37.0 |
| Min. of Petroleum Refining and | 4.6 | 22 | 1 .7 | 10 | 46.7 | 63 | 1 | 17 | 9.6 | 42 | 4.6 | 7.6 | 11.0 |

Table 7. Figures on Hydraulic, Pneumatic, and Pipeline-Container Transportation

| Ministries | Hydraulic | | | Pneumatic | | | Pipeline-Container | | |
|---|---|---|---|---|---|---|---|---|---|
| | Freight Delivered, millions of tons | Number of Systems | Total Length, Kilometers | Freight Delivered, millions of tons | Number of Systems | Total Length, Kilometers | Freight Delivered, millions of tons | Number of Systems | Total Length, Kilometers |
| USSR Ministry of Ferrous Metallurgy | 172.2 | 147 | 449 | 375.3 | 49 | 46.5 | 100 | 3 | 6,350 |
| USSR Ministry of Non-Ferrous Metallurgy | 111.1 | 60 | 370.8 | 8,029 | 56 | 73.6 | 188.7 | 34 | 2,300 |
| USSR Ministry of Coal Industry | 49.7 | 61 | 349.7 | 1,388 | 26 | 3.6 | - | - | - |
| USSR Ministry of Power and Electrification | 538.7 | 160 | 248.6 | 4,737 | 128 | 584.3 | 1,148.9 | 7 | 5,230 |
| USSR Ministry of Construction Materials Industry | 72.5 | 128 | 162.9 | 73,695.3 | 539 | 191.2 | 2,500 | 11 | 18,510 |
| Ministry of Chemical Industry | 38.5 | 148 | 163.6 | 3,773.4 | 80 | 27.2 | 1,347.5 | 22 | 16,645 |
| Ministry of Heavy and Transport Machine Building | 0.4 | 1 | 0.8 | 83.6 | 7 | 0.9 | 0.4 | 1 | 100 |
| Ministry of Transport Construction | 0.5 | 3 | 0.3 | 406.4 | 17 | 2.6 | 11.0 | 2 | 160 |

Table 7. [Figures on Hydraulic, Pneumatic, and Pipeline-Container Transportation] continued

| Ministries | Hydraulic | | | Pneumatic | | | Pipeline-Container | | |
|---|---|---|---|---|---|---|---|---|---|
| | Freight Delivered, millions of tons | Number of Systems | Total Length, Kilometers | Freight Delivered, millions of tons | Number of Systems | Total Length, Kilometers | Freight Delivered, millions of tons | Number of Systems | Total Length, Kilometers |
| Ministry of Power Machine Building | 0.05 | 1 | 2.8 | - | - | - | - | - | - |
| USSR Ministry of Timber, Pulp and Paper, and Wood Processing Industry | 14.4 | 16 | 5.6 | 2,575.5 | 815 | 111.2 | 47.6 | 10 | 4,406 |
| USSR Ministry of Agriculture | - | - | - | 3.5 | 2 | 0.014 | 27.2 | 1 | 3,086 |
| USSR Ministry of Land Reclamation and Water Resources | - | - | - | 429.4 | 33 | 2.9 | - | - | - |
| USSR Ministry of Procurement | 0.4 | 53 | 5.6 | 5,202 | 439 | 37.6 | 12 | 1 | 2,200 |
| USSR Ministry of Mineral Fertilizer Production | 0.2 | 14 | 27.8 | 1,468.8 | 28 | 4.2 | - | - | - |





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Departmental motor vehicle transportation continued to develop. The annual volume of freight shipping by this form of transportation reached 17,644,000,000 tons, an increase of 13.4 percent in the five-year plan, with an average delivery distance of 17.9 kilometers. The fleet of motor vehicles was built up and its structure was improved by increasing the proportion of sepcialized vehicles.

Loading-unloading work. Significant technical re-equipping and development of the stock of hoisting and transportation equipment took place in 1976-1980 and the structure of this equipment was improved. Almost half of the electric cranes (by balance cost) are concentrated at enterprises of the USSR ministries of Ferrous Metallurgy, Timber, Paper and Pulp, and Wood Processing Industry, Power and Electrification, and Nonferrous Metallurgy. Continuous transportation equipment (by length of lines) is concentrated at enterprises of the USSR ministries of Construction Materials Industry, Coal Industry, and Ferrous Metallurgy. The level of mechanization of freight processing was raised. Mechanization of freight operations in processing railroad rolling stock in external shipping and motor vehicles in internal shipping rose especially fast. The level of mechanization of freight handling in 1980 was 95.5 percent for loading and 93 percent for unloading.

According to data from the USSR Central Statistical Administration, continuous and special types of industrial transportation are developing very rapidly, especially in mining industry (pipeline, hydraulic, and pneumatic transportation, including pneumatic container and overhead cable forms). The share of continuous types of transportation in the total volume of shipping by industrial transportation was 7.8 percent in 1975; in 1980 it had risen to 10-11 percent. The growth rate in volume of shipping by progressive continuous forms of transportation was 2.5 times the rate for other forms of industrial transportation.



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