

MOSCOW CIRCULAR RAILWAY HAS A LONG TRACK RECORD

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ABSTRACT

The Moscow railway junction, rapidly developing, by the end of 19th century no longer coped with cargo transportation. The reason for this was the dead-end organization of the stations, both in Russia and Europe, which played the role of terminal stations in large cities. After many but unsuccessful attempts to unload the railway terminal in Moscow, a decision was made to create a circular railway (Moscow Circular Railway (MCR)) in order to connect the dead-end radial branches and make the system more flexible and maneuverable. Well-known architects and engineers were invited to design and build the new railway, budgetary funds were allocated, emphasizing

the special importance of the facility for the state: the European countries and Russia stood on the verge of the First World War, and the predictable collapse of rolling stock threatened the railways with inevitable calamities. Under these conditions, MCR became a universal complex of engineering structures and civil buildings, not only serving transshipment of goods and transporting passengers, but also containing pedestrian overpass bridges and soldiers' barracks for mobile transfer of troops, as well as telegraph and telephone points of communication. This railway has been operating for 110 years and after reconstruction has received a new appointment as part of urban passenger transport.

Keywords: Moscow Circular Railway, history projects, architecture, stations, bridges, stations, topography, reconstruction, urban transport functions.

Background. With the opening of Moscow Central Circle in September 2016, interest in the history of the appearance of Circular Railway has increased enormously. Appearing in 1908 and serving pre-revolutionary and Soviet Moscow for quite a long time, it was hidden for new generations, and its history was forgotten. Only the peculiar architecture of the «circle» houses reminded of a long and unusual past.

Objective. The objective of the author is to consider history of construction of Moscow Circular Railway and the nearby buildings and structures.

Methods. The author uses general scientific methods, historical-retrospective method, comparative analysis, evaluation approach.

Results.

Now without delay

The first project of Circular Railway of merchant Sushkin appeared in 1869. Then in 1872, the engineers A. N. Gorchakov and A. A. Porohovshchikov offered their own version. According to their project, the railway went almost everywhere along the Kamer-Kollezhsky shaft, that is, along the border of the city. Its length was

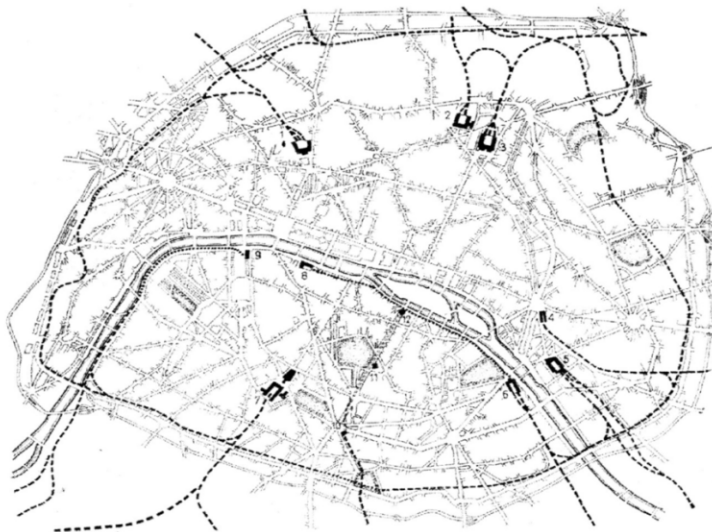
25 versts, excluding four branches leading to the center of Moscow. In the same period, projects were received from the Society of Moscow–Kursk Railway and Yaroslavl Railway. The Society of Ryazan–Ural Railway planned to lay a Circular Railway in the very center of the city from Trubnaya Square to Ilyinka.

The idea of «ringing» radial directions was not new for that time: already there were realized projects of ring roads around large cities in other countries: in Paris, for example, two ring railways were built (now one of them is abolished, and the other is included in the system of far subway).

Let us recall, however, what preceded the emergence of directly projects of Moscow Circular Railway.

In the second half of 19th century, the main lines that later became part of the Moscow railway junction were built.

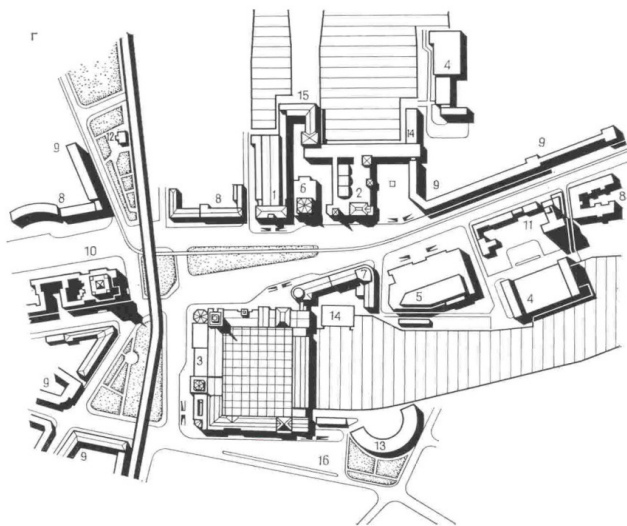
The first station in Moscow–Nikolaevsky (now Leningradsky) railway station appeared in 1851, and already in 1860 a decision was made to «draw» to this place two more railway lines. Thus, in a half-million city



Pic. 1. Railway junction of Paris.



Pic. 2. Komsomolskaya square with Kalanchevskaya binding branch.



in a short time there were railways to the north-west (Nikolaevskaya), northeast (Sergievo-Posadskaya) and the south-east of the country (Ryazanskaya).

Ryazansky (Kazansky) and Sergievo-Posadsky (Yaroslavsky) railway stations were built on the same Kalanchevsky wasteland (Komsomolskaya Square), as the first – Nikolaevsky, forming three terminal dead-end stations (terminals). However, realizing that the dead-end of the northern and southern directions leads to unsolvable transport tasks to transfer goods from one direction to another, in 1866 it was decided to connect Nizhny Novgorod Railway in diameter to Petersburg-Moscow Railway.

This binding Kalanchevskaya branch was a kind of prototype of the future Ring, temporarily solving the problem of cargo transportation at the Moscow railway junction.

In the 60s of 19th century there was a need to build a railway line to Smolensk, with the railway station (now Belorussky) at the Tverskaya Zastava. Construction began in the spring of 1869, and on September 20 next year passenger and goods movement was opened from Moscow to Smolensk. In 1870–1871 the line was extended to Brest.

One after another, three more roads were opened, also located near the city outposts: Moscow-

Paveletskaya (Saratovskaya) near Zatsëpa, Moscow-Bryanskaya (Kievskaya) in Dorogomilovo and Moscow-Vindavskaya (Rizhskaya) near the Krestovskaya outpost. All roads belonged to the Moscow railway junction, except for the Petersburg–Moscow (October).

Moscow at the end of 19th century and the beginning of 20th century was the largest center for both consumption and processing and delivery of goods in Russia. And at the same time – a huge storehouse. With the then existing arrangement of freight stations and their impossible crowding, clutter and slow overloads from one railway station to another, economic relations could not withstand any criticism and only increased the cost of goods. The total annual cargo turnover of Moscow reached 1 billion poods in transit, import and export. For the dispatch and receipt of goods from the stations, 20,000 draft drivers were employed. Such extensive transportation was carried out over long distances, which extremely restricted the movement along narrow streets of trams, coaches and people. In addition, the high costs of transporting goods were an excessive burden for both consumers and industry, as the situation on the sales markets worsened and the development of the city was hampered.

If we take into account the mobilization of troops (which in the current situation in Europe could not be



Pic. 3. Inauguration of MCR on July 20, 1908.

ignored), in which the number of trains increased by at least 15 %, it was clear to everyone that the Moscow junction should be brought to a proper state without the slightest delay. The extreme need for the construction of the Circular Road became imminent.

On November 7, 1897 at a government meeting in the presence of his Imperial Majesty Nikolay II it was recognized as desirable to proceed with the construction of Moscow Circular Railway.

On August 7, 1898 the highest assent to the production of surveys at the state expense was given, and immediately the engineer of communications P. I. Rashevsky began to research.

On December 31, 1899 the Conference was formed under the chairmanship of the Grand Duke Sergey Alexandrovich.

On February 9, 1900 the said Conference put forward the conditions that Circular Railway is called upon to meet, and also at what distance from Moscow it should be built. Based on this, P. I. Rashevsky made the final survey in 1902 and completed the construction, finished in 1907.

On July 20, 1908 the railway was transferred to the management of Nikolayevskaya Railway, and movement was opened.

The Circular Railway connected the radial branches and allowed the transfer of goods from one direction to another around Moscow, along its outskirts, and later to serve almost all the major industrial enterprises of the city.

The railway was also intended for the carriage of passengers, there were 14 stations, two stops and one telegraph settlement. Five stations Vladykino, Cherkizovo, Kozhukhovo, Kanatchikovo and Serebryany Bor provided goods operations with local cargo received from factories adjacent to these stations. The stations Rostokino, Lefortovo, Andronovka, Ugreshskaya, Kanatchikovo, Vorobyovy Gory, Presnya and the auxiliary station Kutuzovo, as well as Serebryany Bor and Likhobory were equipped as transfer stations for the exchange of cars of transit commodity traffic along the branches connecting them to the main railways. With the possible mass movement of troops through the Moscow junction, the exchange of military trains was planned to be carried out via the Bratsevo telegraph post.

Words of a contemporary

The count of versts along Moscow Circular Railway starts from the middle of the bridge, built for its passage through the main roads of Nikolayevskaya Railway, and goes clockwise. The contemporary



Pic. 4. Scheme of stations of MCR.

describes the surroundings of Moscow Circular Railway.

«From Nikolaevskaya to Moscow-Yaroslavskaya, the MCR goes through fields and forests, then crosses the Dmitrov highway, through which an iron bridge is built. On the right side there is a settlement (600 inhabitants) at the telegraph post Petrovskoe-Razumovskoye. Further – the village of Nizhny Likhobory (400 inhabitants). Further, Verkhny Likhobory (300 inhabitants) with five brick plants with a total capacity of up to 30 million bricks per year. Further, over the tracks of Moscow Circular Railway, an iron bridge was built along which Savelovskaya Railway runs.

After the 1st verst of MCR begins the countryside of the village of Vladykino (500 inhabitants), formerly owned by Theophanes Prokopovich, the famous preacher of the times of Peter I.

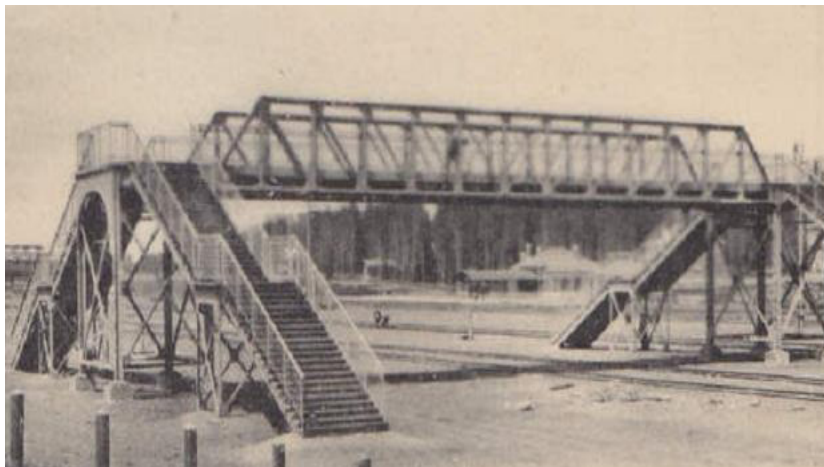
On the 2nd verst, overpasses for the allotted roads to two factories have been built.

Between the 3rd and 4th versts the railway passes through the birch forest belonging to Sheremetev, and crosses the Likhoborka river with a stone pipe.

4th verst. On the right side of the forest is the village of Ostankino – the estate of Count Sheremetev with a population of 3 thousand inhabitants, the palace (1796 architect Quarenghi) a la old Italian villas and a



Pic. 5. Barracks building at the station Lefortovo.



Pic. 6. Military overpass.

pond surrounded by a huge park with century-old lindens and cedars. According to the legend, in this park there are several oaks planted by the Emperor Peter the Great himself.

Further, MCR goes along a metal bridge, under which there is a road from Ostankino to the village of Sviblovo (250 inhabitants) on the Yauza River. On the left side of the railway there are 3 factories and further the countryside and the village of Medvedkovo (400 inhabitants) with a tent temple, once owned by knyaz D. Pozharsky. In the temple there is an ancient precious gospel with miniatures painted by the princess Sophia.

On the 5th verst on the right there is the countryside area – the village of Leonovo (200 inhabitants) and the dye factory of Ferman.

Throughout the 6th verst, the line passes among a mixed private forest and here Rostokino station is located by the name of the nearest village (2000 inhabitants). In the old days Rostokino belonged to the Trinity Lavra. Near the village «millionth» aqueduct was built – water pipe, built during the time of Catherine II, bringing water from the village of Mytishchi to Moscow. There are several silk-dyeing

factories in the village. From this station the branch separates into the station Losinoostrovskaya. The Circular Railway crosses the Yaroslavskoe highway through which the iron bridge is built...

The Belokamennaya station is located in the Losinoostrovsky forest, which was a place of royal hunting in ancient times, like Sokolniki, which, as it were, adjoins the forest. Now Sokolniki is a protected grove with beam clearings, on which there are summer cottages (42 000 inhabitants).

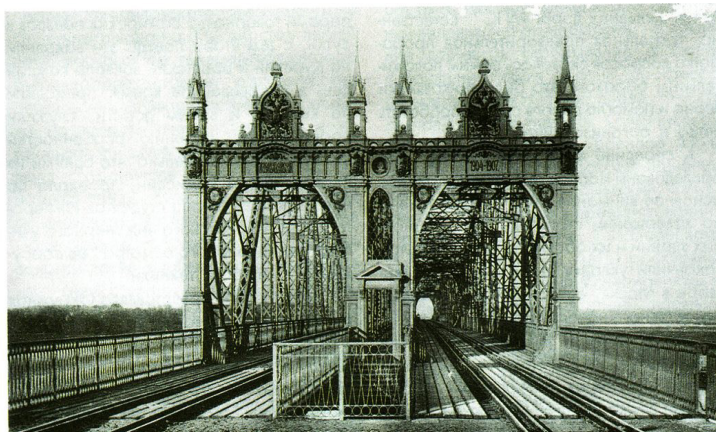
10th verst – on the right side on the bank of the Yauza the countryside is located – the village of Bogorodskoye (7 thousand inhabitants) with the factory of the Association of Rubber Manufactories. At the factory there is a school for the children of workers.

12th verst – Cherkizovo station, named after the village of Cherkizovo (26 thousand inhabitants), located on the right side of the pond, the former patrimony of the Moscow Metropolitan Alexei.

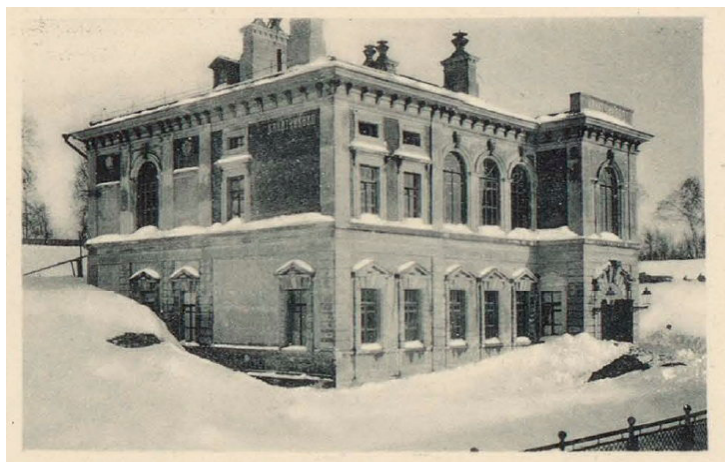
13th verst – over the tracks of MCR Stromynskoe (Preobrazhenskoe) highway passes. On the right there is Egorov's carpet-packing factory, on the left – the village of Kaloshino (700 inhabitants).



Pic. 7. Vlyadykino station.



Pic. 8. The portal of the Alekseevsky Bridge (now not preserved).



Pic. 9. Kanatchikovo station.

14th verst of MCR crosses the three-span iron bridge across the Serebryanka River. Almost a verst to the left is the Izmaylovskaya Manufactory and next to it there is a charity institution (1849) for the elderly military ranks, the Preobrazhenskoe Old Believers' Cemetery (1771) and the Nikolaevsky Congregational Monastery (1866). On the right there is the silk factory of Zhuchkov. Further, MCR crosses Nikolaevskaya Street with the bridge.

From 14th to 18th versts, the railway passes through the part of the city where the largest number of factories and plants are located (in Lefortovo alone there are 100 plants).

15th verst of Circular Railway crosses the Izmaylovskoe Highway, passing over it over the overpass. This highway leads to the summer cottage district «Izmailovsky Menagerie» with a population of 1000 inhabitants. Recently, at «Izmailovsky Menagerie», the Imperial Acclimatization Society engaged in the feeding of silkworms and discovered an experimental apiary for beekeeping.

17th verst: Lefortovo station. To the right there is the Moscow-sorting station of Kazansky Railway and Post Perovo (branch 10). Further, MCR crosses the Nizhny Novgorod (Vladimir) highway with an iron bridge. To the right of this point there are 2 oil refineries.

19th verst: the point of intersection with Moscow-Kazan railway, passing an iron bridge over Circular

Railway. On the right is a group of factories, among which are the kerosene stations of the Nobel brothers. Station Andronovka – from it there are connections of branches 11, 13, 15, is located near the summer residence Perovo and Kuskovo (1900 inhabitants) – the old patrimony of boyars Sheremetyevs. In the palace – a rich collection of ancient paintings and family portraits. In the magnificent park there is an extensive greenhouse with three hundred year old laurel trees, as well as busts, marble statues, columns presented by Empress Catherine II. In the park, there are three oak trees, planted in 1883 with the sovereign's own Emperor Alexander III.

Near the palace there is a gazebo with a decoration inside made of the sea shells. In it, among other things, there is a golden coach of Catherine II. To the right of the palace there is a drawbridge and six guns taken from the Swedes near Poltava.

Branch 13 goes to the station Moscow-Tovarnaya of Nizhny Novgorod Railway, and branch 15 – to Lublino of Moscow-Kursk Railway. On the right side of the road there is the Rogozhskoe cemetery (1771). Near it, there are two churches, a house of worship and a women's school.

21st verst: behind the machine-building plant of Gutman there is a car park of the International Society of Sleeping Cars. Further the road crosses from above the Moscow-Nizhny Novgorod railway and the Ryazan highway. To the left of this point there is the village of





Pic. 10. Sergievsky (Andreevsky) bridge.

Koracharovo (2 thousand inhabitants) and then the village of Gravornovo (225 inhabitants). On the right is the village of Khokhlovka (500 hectares), oil depots and a tannery.

22nd verst. On the right, five oil depots were located one after another. On this verst Circular railway crosses Moscow-Kursk Railway and further the Simonovsky water pipeline, enclosed in a stone pipe. On the right of the railway is the station Ugreshskaya. On the branch No. 15, near Chesme platform has a dye factory of Libish and a nearby village of Lublino with a shady park of Goloftiev estate. Above the tracks of the MCR, an overpass was built, under which runs the Nikolo-Ugreshkoe (Perervian) highway to the Nikolo-Ugreshsky Monastery (1381), founded by Dmitry Donskoy. At the end of the 22nd verst Sukino bog is located – the place of new urban dumps.

23rd verst – near the railway there are irrigation fields.

24–25 versts. To cross roads to the village of Kozhukhovo (1500 m) an iron bridge was built above the tracks of the Circular Railway. On the right side there is the Simonov Monastery (1370), founded by Fedor of Rostov, nephew of Sergey of Radonezh. The bell tower of the temple is the highest in Moscow (more than 100 m). Immediately there are oil depots of the Eastern Society. These warehouses are connected by railway Lizinskaya branch with Moscow-Kazan railway.

26th verst. To the right of the railway on the left bank of the Moscow River there are several factories. Here is the station Kozhukhovo (1500 inhabitants). Its inhabitants, except for agriculture, are still engaged in supplying sand to the city, extracted from the Moscow River.

27th verst. To the left of the line there is the village of Kolomenskoye with two churches (1500 inhabitants) ... The village was founded by fugitives from the city of Kolomna during the invasion of Batu in 1237. Not far from the village there is a lonely building surrounded by a large garden. Here, the famous artist Vereshchagin, who died on March 31, 1904 in Port Arthur during the explosion of the battleship Petropavlovsk, often spent the summer months.

28th verst. The Circular Railway passes through the Moscow River on the Alekseevsky Iron Bridge (now Danilovsky). Behind the bridge there is the new factory of the Danilov worsted spinning mill. On the right there is a wallpaper factory of Alpatova, a cotton print and a wool-spinning factory. Further Circular Railway

crosses the Warsaw highway, over which the iron bridge is built. To the left there is the village Nizhnie kotly (350 inhabitants).

29th verst. A bridge has been built over the tracks of the MCR, along which the Paveletskaya railway tracks pass. To the left there is Zaletkin's tannery and the silk factory of L. I. Katuar.

30th verst. On the Yakunchikovskoe highway there are a countryside Cheryomushki, Yakunchikov estate and two brick plants. The Yakunchikov plant produces 12 million bricks a year. Over the tracks of Circular Railway an overpass to Semenovskoye village was built. To the right there is Kanatchikov's dacha, which houses a hospital for the mentally ill for more than 500 people.

31st verst. Among the birch grove there is Kanatchikovo station, from which two branches (20 and 21) go, connecting the Circular railway with Paveletskaya.

32nd verst. A verst to the right there is the Danilovsky Monastery (1591) in honor of the victory at the village of Kolomenskoye over the Tatar khan Kazy-Girey. At the monastery there is the richest cemetery in Moscow. Above the tracks of Circular Railway, an overpass was built along which Kaluzhskoe highway passes. Here there is Zhivodernaya Sloboda (3000 hectares). On the right begins Neskuchny garden. It is located on the hilly bank of the river. Opposite the palace on the slope there is a beautiful flower garden. From the palace into the depths of the garden there are many paths passing through picturesque ravines, through some of them bridges and grottoes are piled. Particularly beautiful are the places near Elizavetinsky Pond and Elizabethan Grotto. Most of the avenues are planted with maples that have grown and formed arches above the alleys...

Near the Moscow River, as if rivaling beauty and grandeur with the surrounding scenic terrain, an iron arch bridge stands, named in memory of the murdered Grand Duke Sergei Alexandrovich «Sergeevsky» (now Andreevsky). The bridge represents a grandiose crescent-shaped arch with a span of 135 meters, thrown from one bank of the Moscow River to the other. Massive coastal foundations with towers are faced with granite. In both the foundations are arranged along the archway, under which the roads for the crew ride pass. From these roads there are iron stairs to the sidewalks for pedestrians located on both sides of the bridge arches.



Pic. 11. Passenger building of Presnya station.

On the 33rd verst the Circular Railway runs along the floodplain of the river, and on the left there are Vorobyevy Gory. In the area of Vorobyovy Gory station there are 17 different factories and plants, including Khamovnichesky brewery, which produces about 400 000 buckets of beer per year. There is also the village of Vorobyovy Gory, where there is a grove, planted, according to legend, by Emperor Peter 1. At the same village the restaurant of Krynkin is located near the precipice.

On the left near the road line, on the bank of the river there is the factory of aniline and alizarin paints of the Trade House F. Baer and K. Next – aperture (from ed.: impregnation of fabrics) factory of Kuznetsov.

On 34th verst there is the Babylonian well, which is considered a saint. According to legend, it was dug by order of Tsar Alexei Mikhailovich on the site of the former Babylonian garden. To the left there is the temple of Tikhvin's Mother of God, where the miraculous icon is located. Two hundred meters away there is the regulating tank of the Moscow City Water Pipeline, with a capacity of 2 million buckets, the average level in it is 80 meters above the Moscow River. On the right is the Novodevichy Convent (1524), 500 meters from the University Clinic. In a kilometer from there – the Maiden's Field – a place of folk festivals...

On 35th verst, the arch bridge of Emperor Nikolai II rises (Krasnoluzhsky, now Luzhsky). On the left side, 500 meters away, there is the cloth-finishing factory of Dosuzhev. Then comes the stoppings of the Potylikha, from which the branch № 22, connecting the Circular Railway with Moscow-Bryansk branch, branches off. On the left side of the Setun River there is a village Troitskoe-Golenischevo (750 inhabitants) and a summer residence of the Nikolaevsky Institute.

On 36th verst there is also an iron bridge across Moscow-Bryansk Railway. Further Kutuzovo station, from which two connecting lines No. 23 and No. 24 go to Bryansk Railway, and No. 25 connects the Circular railway with the Moscow-Brest railway. Further, Circular railway crosses the Smolenskoe (Mozhayskoe) highway. To the left of this point Mozhayskoye Highway rises to the so-called «Poklonnaya Gora», from where a charming view to the capital opens. And here, as the legend says,

Napoleon in 1812 vainly expected Muscovites to bow. Further to the right is Dorogomilovskoe cemetery.

37th verst – The Circular Railway fourth and last time crosses the Moscow River on Dorogomilovsky Bridge. Next is the intersection point of Moscow Railway with the Moscow-Brest Railway, under which the iron bridge was built.

38th verst – on the left side there is the village Shelepikha (500 inhabitants). Danilovsky sugar plant is also nearby, from which own railway branch goes. Opposite the village of Shelepikha is the village of Pokrovskoe (800 inhabitants) and the village of Fili (500 inhabitants), which are united by a huge Shelaputinsky park. On the high hill stands the Church of the Intercession, which Peter often visited in his youth. In the middle of the temple there is still a royal place.

39th verst: station Presnya, from which there are branches No. 27 and No. 28, connecting it with the Moscow-Brest Railway and telegraph post. From the station Presnya to 42–43 versts Khodynka field is located, closer to the city there are racing and running racetracks.

42nd verst: stopping point Voennoe pole. In one verst from the right side of the railway is the Small All-Saint Grove and Petrovsky Park with the Petrovsky Palace. Russian princes before the coronation stop in this palace to start from there their solemn entrance to the ancient capital. The road to the camps of the Moscow Junker and Tver Cavalry Schools passes over the Circular railway over the overpass. On the right is the Moscow Alekseevskoye shelter for the military invalids and the village of Vsesyvatkoye (1 000 inhabitants), where the princess Sophia and Miloslavsky organized the Strelets revolt. In the village there is a factory of pottery pipes and a carpentry. Here the knyazes Skopin-Shuisky, Romanov and others founded their main apartment «the knyaz's court», which still exists. They say that all the looted treasures of the False Dmitri are buried in the «knyaz's court».

43rd verst: station Serebryany Bor, from which there are branches No. 28 and No. 29 from the station Podmoskovnaya near the Moscow-Vindava Railway and Glebovo-Streshnevo post. On the right side is the embroidery factory of Timashev.

44th verst – for about a verst MCR passes a century-old pine forest. On the right side of the





Pic. 12. Stopping point Voennoe pole.



Pic. 13. Latrine facilities at Presnya station.



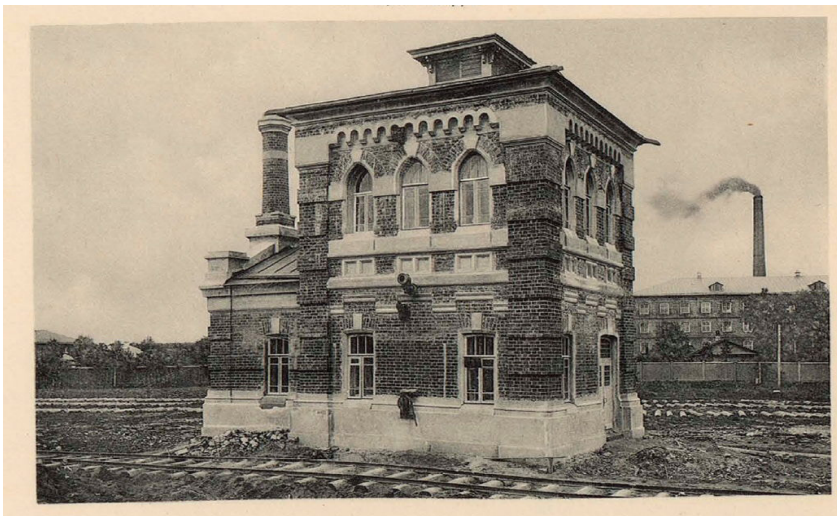
Pic. 14. Warehouse at the station Serebryany Bor.

Ilinskoe highway is the village of Koptevskie vyselki (800 inhabitants), whose inhabitants are engaged in the export business and the delivery of their cottages for summer time as the dachas.

45th verst. The Circular Railway crosses Moscow-Vindava Railway, passing over it with an iron bridge. Near the station Podmoskovnaya of this road on the left side of the Circular line is the village of Pokrovsko-

Glebovo-Streshnevo with the estate and palace of Princess Shakhovskaya-Glebova-Streshneva (9600 inhabitants). On the left side – a holiday village near the village of Tushino (500 inhabitants). Here, too, there is a factory for the production of soldier's cloth, founded by Peter I.

46th verst. The line of the MCR passes under the Petersburg highway an iron bridge. On the right is the



Pic. 15. The house of the chief of the track service in Likhobory.

cast-iron foundry and machine-building plant, and near it there is a plant of lithographic types. Next is the Telegraph Post Bratsevo with branch No. 30, connected with the post Glebovo-Streshnevo. To the right of this point is the village of Koptevo (500 inhabitants). On the left side there is a brick factory, Kazan and Golovinsky women's monasteries.

Along 48 and 49 versts from both sides of the line there is a whole series of lakes on which the cloth factory of Iokish is located. Nearby is the village of Mikhalkovo (400 inhabitants), the village of Petrovskie vyselki (500 inhabitants). Mikhalkovskoe highway passes here over the Circular Railway. On this highway is the Deguninsky Chemical Plant.

At 49th verst there is the Likhobory station, on the right is a large summer place Petrovsko-Razumovskoe with an agricultural institute. The park of the Institute is organized in the image of Versailles.

Further, MCR approaches Nikolayevskaya Railway – to the initial point of the MCR».

Conclusion.

This was the real position of the MCR, which served as a huge service for the transportation of goods, cargo and the transfer of troops during not only the First, but also the Second World (Great Patriotic) wars. It was, in fact, a small state, leading an autonomous life, having all the means necessary for life support: houses for its employees, bakeries, warehouses, public latrines at stations, telegraph posts, water-lifting towers.

MCR was a prestigious place of work: it attracted a large number of people from the suburbs, gave them primary vocational education, decent earnings, housing.

Movement on the ring was conceived as cargo and passenger. However, the passenger movement gradually faded, on the one hand, due to the busy schedule of freight trains, on the other – in connection with the appearance of other types of urban transport: trams, trolley buses, buses. For a long time, there was no passenger traffic on the road at all. In the Soviet

years, attempts were made to restore it – on the Moscow Ring Railway (so it began to be called when the city's border was far from it), but without success.

In recent decades, with the increase in passenger traffic in Moscow and the fact that the capital has grown territorially more and the Ring Railway has appeared in densely built districts, a decision was made to include MCR in the urban passenger transport system.

The organization of passenger traffic on the Small Ring of the Railway named the Moscow Central Circle (MCC) is a difficult technological task: up to 100 pairs of electric trains a day leave the line, and therefore the number of stop points at the MCC in comparison with the old MCR rose twice: from 16 to 32, including 19 large TIHs, 12 – with an interchange to subway, 6 – to radial directions, and one provides both types of interchanges simultaneously.

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