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ELECTRIFICATION OF USSR RAILROAD NETWORK

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INTRODUCTION

This study, based on Soviet open sources, attempts to present the development in use of electric traction on the USSR rail systems covering the entire period since its initiation in 1926 to September 1956. The available information has been arranged according to the geographical location of rail lines, their administrative subordination and in chronological order. Some data on the operations of the electrified lines and the electric locomotive enginehouses were also included. However, no special research was attempted for detailed description of enginehouse facilities, electric power supply systems and complete operational data. The latter could be subjects for a separate study at a later time.

The production of electric locomotives as a closely related subject was briefly discussed in a separate chapter.

The study was divided into nine chapters: the first is concerned with the general problems of railroad electrification and length of lines, Chapters 2 thru 8 discuss electrification of lines by systems, and the last chapter - rolling stock production.

The task of electrification is the concern of five USSR Ministries and depends on their efficiency and cooperation (1). In spite of the fact that the advantages of electric traction were widely acknowledged in the USSR for quite some time (2) many leading Soviet specialists and administrators are blamed for giving preference to steam traction (3). This fact may be the cause for the extremely slow rate of electrification work, which has been characteristic for the last few years (4). One should compare, for example, the speeches of M. Kaganovich in 1954 and 1956. In 1954, M. Kaganovich, First Deputy Chairman of the Council of Ministers of the USSR, urged stepping up electrification of rail systems (5). Two years later, he and B. P. Beshchev, Minister of Transport, openly acknowledged failure in this task and even accepted the sharp criticism expressed by Khachaturov (6).

Some drawbacks in the development of electric traction have been found in the leading Soviet scientific organizations, such as the Institute of Complex Transport Problems which failed to give adequate attention to work on the development of both electric and diesel traction (7).

It was openly acknowledged that the organizational system of the electrification work was not expedient and suggestions were made to make changes (8). In response to this, a few steps were made, including the assignment of Robel' for the newly created position of Deputy Minister for New Techniques (9) and also the order to accelerate the rate of electrification was issued jointly by Ministers Beshchev and Kozhevnikov in April 1956 (10). But nothing brought favorable results (11). As late as September 1956 Soviet publications reported a lag in rail electrification (12).

Contrary to the usual Soviet statements about their superiority in all technical fields, a new trend has been noted. Soviet officials and leaders in technical science began more and more to draw attention to the technical progress in railroading of foreign countries and tentative comparisons have been cautiously made (13). Several examples have been given in this study.

In fact many Soviet authorities have acknowledged that primitive and out-dated methods in railroading are used and that there is a lack of mechanization (14). Simultaneously, though, the use of atomic energy in the transportation field was

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Near Kiyev, only 37 km Kiyev - Boyarka - Vasil'kov line was electrified by November 1953 (35), although some progress was reported in the electrification of the Kiyev - Darnitsa line (36).

Near Riga, the only electrified line is the 45 km stretch from Riga to Kemeri where the last section was completed by the end of 1951(37).

The only electrified line near Tallin is the 11.2 km stretch from Tallin to Peskyule, completed in 1924 (38).

The Zaporozh'ye - Dolgintsevo line (Stalin system) electrified prior to 1941, remained the only electrified line of the Krivoy - Rog - Donbass route in 1956 (39) (chapter IV).

The plans for the electrification of the Yasinovataya to Pyatikhatki stretch made in 1932-1933 (40) were never accomplished, and the same goal was set again for the 1956-1960 period (41).

In 1954, plans were made for the electrification of the 25 km Khar'kov - Merefa line of the Southern system (42) to be completed in 1957 (43), and work was actually in progress on the entire Khar'kov - Merefa - Lozovaya line in 1956(44).

The electrification of the 278 km Muromsk - Apatity - Kandalaksha line (plus 22 km Apatity - Kirovsk branch) of the Kirov system was started in 1934 (45) and completed by 1941 (46). Electrification for Kandalaksha - Loukhi section was suggested in 1956 (47).

The electrified rail network of Transcaucasian system (Chapter VI) comprised 26 per cent of the total length of the system in 1950 (48) and 50 per cent in July 1956(49). By the beginning of 1956 there were about 1,000 km of electrified lines, as stated by Golovanov (50). It is expected that the ratio of electrified lines will increase to 60 - 65 per cent by the end of the Sixth Five Year Plan period(51).

There were over 1,000 km of electrified lines on the Sverdlovsk system in the early part of 1956 (52). Most of these lines are in the northern Urals. Of significance is the planning to build and electrify a new 320 km line from Sinarskaya to Krasnoyfimsk and thus relieve heavy traffic of the existing east-west connections of this area (53).

The most ambitious program of the Sixth Five-Year Plan is the electrification of the route from Moskva to Irkutsk (54),(Chapter VIII). Since the total route is made up of a number of rail systems, the data was classified in sequence of rail systems in the eastward direction, and titled by the name of the system. Some information on the diezelization of the Makushino - Isil'Kul' section has been added without going into details of diesel traction, which will be the subject for a separate study.

By the beginning of 1956, 1,443 km of sections on the route were already electrified and construction and erection work was started on an additional 672 km (55).

The first line of the Moskva - Irkutsk route is the Kuybyshev system where 11 km (from Kuybyshev to aircraft center in Bezymyanka)* were electrified in 1944 and an additional 11 km to Smyshyayevka by 1952 (56). The current Five-Year Plan calls for a total of 680 km of rails to be electrified by 1960, as told by A. Okhremchik, chief of the system (57).

* See the report on "Principal Freight Handling Stations of the Railroad Network of the USSR" AF 1068515 dated 31 December 1956, pp 12 and 31.

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The main line of the Ufa system is electrified by sections from east to west. The Sixth Five-Year Plan envisages the changeover to electric traction of the total main line (58). The 170 km Dema - Kropachevo section was electrified by Jan 1955 (in 4 years) (59); 105 km Dema - Rayevka section, electrified and opened for traffic on 3 October 1956, (60) and 250 km Rayevka - Pokhvistnevo section due to be put in operation in 1957 (61).

The total 746 km of the South-Urals system is subject to electrification as told in a 1954 source (62). Since World War II electric locomotives have been in operation on the Chelyabinsk-Zlatoust section (63), on Kropachevo - Chelyabinsk section in 1953 (64) and on the entire Chelyabinsk - Dema section (65) by 1955.

The 52 km Berdyaush - Bakal section was under electrification since 1954 (66), as well as the entire Chelyabinsk - Kurgan - Makushino (this station is of the Omsk system) line (67).

According to the Sixth Five-Year Plan the 512 km Magnitogorsk - Abdulino trunk line will be constructed and electrified (68). The work on this line was commenced in 1956 and is progressing expediently (69).

The electrification of the Omsk main line (582 km of main line and 423 km of the "Vagay route" toward Sverdlovsk) was started in 1954, (70) in an east to west direction (71) and in April 1956 the last steam locomotives were taken off the main trunk line (72) with diesel locomotives in operation on Makushino - Isil'Kul' section (73). This dieselized section is slated for electrification by 1959 (74). The electrification of the "Vagay route" on the 149 km section between Omsk and Nazyvayevskaya was completed in November 1956 (75).

The plans were also made to construct and electrify a new trunk line from Omsk to Barnaul (76) in order to ease double-track Omsk - Novosibirsk line which is overburdened by heavy traffic. Here, the earth work has been started (77).

On Tomsk system a 141 km double-track Belovo - Novokuznetsk section was electrified during the Second Five-Year Plan. This line carried Kuznetsk coal and Urals ore (78). And only in 1955 the line from Chulymskaya to Novosibirsk and Novosibirsk to Inskaya were electrified (79).

The Sixth Five-Year Plan called for electrification of the Promyshlennaya - Belovo line (80).

The East Siberian system so far used basically steam traction, the only exception being the newly electrified 134 km Irkutsk - Slyudyanka section, where operations started in the second half of 1956 (81). Plans were made to electrify the 123 km Cheremkhovo - Irkutsk line (82), and in October 1956 preparations were being made for electric motor car service on the 63 km Irkutsk-Podkamennaya rail section (83).

The problems and tasks of electric locomotive industry, the development of electric locomotives and motor-car production have been presented in the last chapter of the study. Comparisons have been made between the planned and actual production figures and an attempt was made to present this data in chart form. The details on the production and performance of the Novocherkassk Electric Locomotive Building Plant were not included, since this will be the subject for a separate study. The difference between planned figures and actual achievements is considerable. It seems to be doubtful whether the ambitious plan for the Sixth Five-Year Plan period to produce 2,000 electric locomotives can be fulfilled.

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The poor production results of the first half of 1956 with only 105 electric locomotives produced (84) would not warrant too much certainty that this will happen.

This report will be supplemented with periodical additional studies concerned with the current developments, changes, and progress of projects under way.

CHAPTER I.

A. General Problems of Rail Electrification in the USSR.
B. Length of Electrified Rail Lines in the USSR.

A. General Problems of Rail Electrification in the USSR.

The change over from steam to electric traction on the USSR rail transport is a rather complicated task and depends greatly on the performance of five Ministries: Ministry of Transport, Ministry of Transport Construction, Ministry of Electrical Industry, Ministry of Electrical Power Stations, and Ministry of Electrical Power Station Construction (1).

At the present time the Ministry of Transport Construction carries the heaviest volume of work on rail electrification (2), after taking over the responsibility from the Ministry of Transport (3).

The advantages of electric traction were widely acknowledged in the USSR (4) and moreover, it was admitted that the future of the Soviet rail transport depends on its change over to electric traction (5). As stated by I. S. Sal'nikov, during the World War II, the electrified rail lines played a very important part in the operations of railroads which coped with extremely heavy traffic hardly possible to be carried out by any other country (6).

In 1954, M. Kaganovich, First Deputy Chairman of the Council of Ministers of the USSR, in the speech delivered during the railroad workers convention, declared that the introduction of electric traction should be the first and the most important step in the rehabilitation program of the USSR railroad transportation (7).

N. Lomagin, chief Main Administration for Electrification and Power Industry stated that the rate of electrification on the rail transport is higher in the USSR than in any other country (8). But, he added, it is not high enough for the USSR. In 1954 the initiation of operations on the newly electrified sections was not complied with the plans (9). Lomagin urged to step up the rate of electrification work and to reduce the cost (10).

Two years later, in 1956, L. M. Kaganovich in his speech at the XX-th Congress of the Communist Party declared that Khrushchev has quite justly criticised the railroaders and their administrators for lagging in the work on the electrification of railroads and the introduction of the new technique (11). He said that it was quite evident that simultaneously with the switching to the new type of traction, the newest technique in all branches of the railroad transport should be introduced; otherwise, the electrification can not be fully effective (12).

Similar admission was made by B. P. Beshchev, Minister of Transport, who stated in his speech delivered on 24 February 1956 before the XX-th Congress of the Communist Party that in his report of the Central Committee Khrushchev indicated that rail transport is not up-to-date in its technical equipment, operates on in-

efficient traction, i.e. steam traction, and duely criticized those in charge of the Ministry of Transport for conservatism in matters of technical re-equipment of transport (13). In spite of the importance and necessity of the electrification of railroads, those, who were in charge of railroad transport, not only failed to struggle for the introduction of electric traction, but did not fully use appropriations set aside for this purpose (14). Out of this criticism the Ministry of Transport must draw its own conclusions and concentrate its attention on the problems of technical re-equipment of railroad transport and, above all, on the wide introduction of electric and diesel locomotives (15).

B. P. Beshchev said that the tremendous task of rail electrification will dominate the whole practical effort of the Ministry of Transportation, transport specialists, engineers, technicians and all railroad workers. In connection with this there is a difficult task of educating and re-educating new technical personnel (16).

In connection with the educational and training program, three-month courses for the study of diesel and electric locomotives were organized at the Moskva Institute of Railroad Engineering. Long-time specialists in transportation were sent from all parts of the country for this training. However, the entire organization of the courses was faulty and inadequate. Neither the program nor any adequate system in lecturing was established, and moreover some of the given information was false; for example on the construction and the operation of locomotive joints and spare parts (17). Furthermore, the Institute was not capable of providing a lecturer for the repair of electric locomotives, in spite of the fact that its department for the electrification of railroads existed for many years. In general the lecturers on the staff of the Institute were not qualified for teaching. (18).

In connection with the studies on electric and diesel traction, I. Ivanov, Director of the All-Union Scientific-Research Institute of Rail Transport declared that attention and consideration should be given to the latest technical achievements and developments in foreign countries (19). It is of interest to stress (mentioned in this study on several occasions) that the Soviet administrators and leaders in the technical sciences more and more draw attention to the technical progress in foreign countries and even make tentative comparisons.

Some of the leading Soviet specialists still seem to prefer to maintain steam traction on railroads (20). Complaints were made that the Institute of the Complex Transport Problems, headed by Khachaturov, the well known specialist in transportation, gave little attention to the problems of developing progressive types of traction in transportation, i.e. electric and diesel (21). The Main Administration of Locomotive Service was accused of being superficial in its attitude toward the development of new technique in rail transportation (22).

The administrators of the Main Administration of the Electrification and Electric Power Industry, and the Main Administration of the Capital Construction (of the Ministry of Transport) were accused of being tolerant toward the systematic failures of the construction organizations under the Ministry of Transport Construction in carrying out plans (23). Gotsiridze, deputy Minister of the Transport Construction was blamed for neglect to boost the rate of electrification work (24). It was reported that the Ministry of Transport Construction delayed the reconstruction of shops in the enginehouses where electric and diesel locomotives were already in operation (25).

Garnyk, Deputy Minister of Transport was blamed for giving preference to steam traction. The Krasnoyarsk system was given as a vivid example: the expenditure of 160,000,000 rubles was involved in the project of the development of steam

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locomotive facilities at Mariinsk, Chernorechenskaya, Krasnoyarsk, Klyukevennaya and Tayshet stations. However, the existing facilities were quite adequate to serve until the line would be changed over to electric traction (26).

When the Ministry of Transport Construction took over the responsibility of rail electrification from the Ministry of Transport the expectation was that the tempo of work will be stepped up. But, on the contrary, the fulfillment of the 1956 January quota was worse than during the same period in 1955 (27). The Ministry of Electric Power Station Construction delayed the construction of electric power lines.

Because of the lack in electric power 250 km of rail lines (completely ready for the change over to electric traction) continued to operate on steam traction (28). The Ministry of Electric Power Station Construction was urged to step up the construction of high-voltage electric power transmission lines* (29).

As reported in Gudok in March 1956, a new position, that of Deputy Minister for New Technique was created (30). Robel' was appointed for the newly established job, the main task of which was to supervise the development in science and new technique in rail transportation. It was expected that since priority will be given to the problems of electrification, improvement was expected to follow shortly but such was not the case. (31).

An article in Gudok of 1 March 1956, expressed concern over the possibility of successfully carrying out the electrification work under existing conditions. For example: the Main Administration of Electrification and Electric Power Service faces many difficult problems in connection with the use of alternate current of industrial frequency, development of the newest systems in remote control of traction substations, and so on. This problem of how the technical department could handle the magnitude of work, was raised as there were only two engineers on the staff to work on the development of electric traction (32).

During March 1956, it was admitted in Gudok that the basic inefficiencies in the electrification of the USSR rail transport consisted in the lack of proper organizational system. The existing organizational structure was acknowledged to be inadequate to carry out the ambitious and wide scale program of rail electrification. It was suggested that steps be taken for the creation of a new and strong organization which would be entrusted with the task of rail electrification (33).

The Decree of the Council of Ministers (29 April 1956) emphasized the fact that rail electrification is the most vital and significant task of the Ministry of Transport Construction and all subordinated organizations (34). As a result of the Decree, the Minister of Transport (Beshchev) and the Minister of Transport Construction (Kozhevnikov) issued a joint order to accelerate the rate of rail electrification (35).

Still, in spite of the decree and the order, the tempo of electrification work (as reported in June 1956) was not stepped up. (36).

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* The Sixth Five Year Plan slated the construction of 6,500 km of high-voltage electric transmission lines for the rail transport. (Rail Transport, No. 7, 1956, p. 22).

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In August 1956, Yu. Polyakov, engineer and chief inspector of the Ministry of State Control accused the ministries of Transport and Transport Construction in lack of cooperation and in applying primitive methods in work. He stated that instead of organizing specialized industrial bases and promotion of automation in all construction-assembly work in electrification both Ministries distributed assignments to various organizations and enterprises giving full authority to solve problems in any desired way. Thus, assignments for the construction of the contact network and other objects were given to many organizations (37). Most of them did not give priority to electrification projects. Furthermore, they had specialization in some other production field. For example, some plants which were assigned to manufacture reinforced concrete supports for electrified lines were actually engaged 2/3 of their time in other kinds of production (38).

In connection with the production of reinforced concrete supports, Tishchenko, chief of the Main Administration of Electrification (of the Ministry of Transport), expressed his doubt as to the expediency of this type of supports. Tishchenko pointed out that during his trip abroad he learned that in France, for example, steel towers have replaced entirely the reinforced concrete ones. The latter were found obsolete and unfit due to the cracks which appear with time (39).

The other reason for the slow rate of rail electrification is the fact that many processes are still carried out manually, like unloading sand, gravel and other construction material; mechanization is used only in 15 per cent of the total volume of work (40). Even the supply of labor and machinery to the construction sites of the electrification projects is considerably poorer than in other similar projects (41). Such an efficient and successful trust as "Mosdonbasstransstroy" secures labor force for electrification work only 10 - 30 per cent of the plan (42).

As late as September 1956, a complaint was made that the Ministry of Transport Construction had not accelerated the rate of electrification work, but to the contrary, had slowed it down, as compared to the past. The same reasons were mentioned again, i.e. inadequate organization of construction work, primitive and out-dated methods, lack of mechanization. For example; up to the present time ditches for the foundation of contact network supports are excavated manually (43).

The Main Administration of Electrification and Electric Power Industry was blamed for lagging in rail electrification in September 1956 (44). The subject of utilization of atomic energy in transportation is touched upon by I. I. Golovanov, in his book on electric traction and its effectiveness (45). He speaks about the first atomic power plant (5,000 kilowatt capacity), which is already in its second year of operation (46). Another source admits that development of atomic power plants during the Sixth-Five Year Plan period will be on an experimental basis (47). It is planned nevertheless, to work on the development of atomic-powered application in the transportation field (48).

B. Length of Electrified Rail Lines in the USSR.

Prior to the Revolution there were no electric railroads in the USSR (49). In 1920, on the initiative of Lenin the "GOELRO" (State Commission for the Electrification of Russia) (50) planned for 10 years (51) set the goal to electrify 3,700 kilometers of rail lines (52). In compliance with the State plan for electrification the first official listing of lines to be electrified was established in 1926; according to the listing during 1925 - 1930 period the total length of lines to be electrified was 372 kilometers (53).

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Actual electrification of rail lines was begun only in 1926 when the Baku - Sabunchi suburban line was put in operation (54). There were 20.5 kilometers of electrified rail lines in 1926 (55). By the end of 1930 the goal set by "GOELRO" to electrify 3,700 km was completed only 2.5 per cent (56).

As stated in the "The USSR in Figures" published by the Central Administration of Economic and Social Statistics of the State Planning Commission of the USSR, 1935, the operating length of electrified railways in January 1930 was 18 kilometers, in 1931 - 55 km and in 1932 - 64 km (57). The last figure (64 km) does not correspond with the figure given in 1934 for the Second Five-Year Plan, which stated there were 50 km of electrified lines in 1932 (58). According to Obraztsov's 1948 book, by the end of the First Five-Year Plan period (1932) the length of electrified lines comprised 153 kilometers (59).

A statement in the Electrification of Railway Transport, 1932, revealed that the June plenum of the TsK VKP (b) decided to electrify during 1932 - 1933 a total of 3,690 km of rail lines, including 3,215 km for freight traffic and 475 km for densest passenger traffic (60). On the basis of volume of electrification work assigned for 1932, as stated in another issue of "Electrification of Railway Transport", it was planned to put in operation 1,161 km of freight carrying electrified lines and 217 km of suburban lines during 1932 - 1933 (61).

Obviously the plans were not fulfilled because, as reported in the "Plan for 1935", there were 350 km of electrified lines in 1933 (62). As stated in the Great Soviet Encyclopedia the entire Second Five-Year Plan (1933 - 1937) envisaged the electrification of 18,000 - 20,000 km of rail lines, which would include the Siberian Trunk line connecting the Kuzbass with Donbass, with exits to the central industrial districts (63); the following objectives for electrification were set by the plan:

268 km of suburban lines of the Moskva Rail Junction,
99 km of suburban lines of the Leningrad Junction,
104 km of rail lines of Mineral'nyye Vody and Borzhomi branch lines,
423 km of Donbass - Krivoy-Rog lines for shipments of coal and ore (64); the lines of the Urals - Kuznetsk basin for shipment of coal and ore including:

360 km of lines of the Urals rail network and
162 km of lines of the Kuzbass network;
261 km of Transcaucasus systems for petroleum shipment;
164 km of Moskva - Donbass trunk line via Yelets for coal shipment (65).

According to the Great Soviet Encyclopedia (1933 edition), the Second Five-Year Plan set the goal of 1,794 km of electrified lines for the beginning of 1934 and electrification of additional 1,424 km during that year (66). It was estimated that by the end of 1934 the total length of electrified rail lines in the USSR (including the suburban rail lines already in operation) would be 3,273 kilometers (67). This planned figure differs slightly from the figure given in the "Electrification of Railway Transport", which stated that the total length of rail lines planned to be electrified by the end of 1934 was to be 3,700 km, of which 433 km was set aside for suburban traffic and 3,288 km for trunk rail lines (68).

Both figures appear to be inconsistent with the actual length of electrified lines as given in two Soviet official sources. According to the "Plan for 1935" the length of electrified rail lines put in regular operation in 1934 was only 379 km (69). About 200 more kilometers were being made ready for operation in the begin-

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ning of 1935 (70). In 1935 a sum of 56,000,000 rubles was appropriated for the electrification of the rail lines (71) and the length of electrified rail lines was set at 1,083 km (72). A total of 705 km were to be electrified in 1935 of which 215 km were prepared for electrification already in 1934 (73).

Soviet sources supply contradictory figures on the length of electrified rail lines in 1935. Gumilevskiy, in his 1946 book stated that 1,027 km were electrified by 1935 (74). In his 1950 book he gives a total length of electrified lines in 1935 as 1,207 km (75). The 1935 book "The USSR in Figures" revealed that the operating length of electrified railways on January 1, 1935, was 379 km (76). If 705 km be added (figure given for kilometrage of electrified lines which were to be put in operation in 1935, according to the 1935 Plan) the total would comprise 1,084 km. This figure is very close to the data in the 1936 Plan, which stated that the length of electrified rail lines in 1935 was 1,077 km, while the 1935 Plan gave the planned total as 1,083 kilometers (77).

In 1936 there were 907 km of electrified lines according to the 1936 Soviet Statistical book (78). The 1936 plan set the goal of total electrified lines as 1,619 for that year (79). This figure does not correspond with the totals for 1936 and 1935.

According to calculations in "The Electrification of Railway Transport" the percentage of electrified lines was to be 21% of the total rail network by 1937 (80).

An official Soviet source announcing the results of the Second Five-Year Plan stated that on January 1, 1938, there were 1,041 km of electrified lines in permanent operation (81), of which total 979 kilometers were placed in permanent operation during the Second Five-Year Plan period (82).

T. S. Khachaturov, in his 1939 book stated that by the end of the Second Five Year Plan period there were 1,600 km of electrified lines (83). Another noted Soviet writer on transportation, Obraztsov, stated in his 1948 book that during that period (Second Five-Year Plan) 1,496 km were electrified and that the total length of electrified lines was 1,648 km (84).

The Third Five-Year Plan (1938 - 1942) called for the electrification of 1,840 km of rail lines, mainly mountainous regions and areas with dense freight traffic, or suburban junctions (85). The plan included the electrification of Belorechenskaya - Tuapse, Samtredia - Batumi, Samtredia - Poti, Nizhnedneprovsk - Pyatikhatki, Apatity - Murmansk, second line of Kandalaksha - Murmansk and Perm' - Chumsovskaya (86).

V. N. Obraztsov, in his 1939 book on USSR railroads stated that at that time (evidently in 1939) the USSR had 1,116 miles of electrified railways, of which 198 miles were suburban lines and the remainder trunk lines (87).

In 1940 the length of electrified lines almost doubled as compared with 1935, when 1,000 km were changed over to electric traction, as stated in "The Railway Transport" (88). The railroad newspaper Gudok of 20 April 1955, stated that by 1940 there were 1,887 kilometers of electrified lines (89). This figure is very close to that given by Naporko in his 1945 book. He stated that there were 1,870 km of electrified rail lines in 1940 (90).

An official Soviet 1956 source, the Statistical Collection of the Central Statistical Administration, gave the total length of electrified lines in 1940 as 1,900 km (91). This figure was confirmed by Golovanov and Obraztsov. The former gave in his 1956 book the total in 1941 as 1,865 km (92), the latter as 1,887 km (93).

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Other Soviet sources gave slightly higher, probably just round-up, figure. Thus, V. E. Rosenfel'd, in his book on electrification of Soviet railroads, stated that before World War II the total length of electrified lines comprises 2,000 km (94). This was confirmed by Gorinov and Obraztsov. The latter stated that during the 1928 - 1941 period almost 2,000 km of rails were electrified (95).

During World War II some electrification work was continued, but was concentrated mainly on the introduction of the motor-car traction in suburban traffic (96).

During the 1941 - 1945 period more than 400 km of rail lines were electrified mainly in the Urals, near Moskva and Kuybyshev (97).

The Fourth Five-Year Plan (1946 - 1950) slated the electrification of 5,325 km of rail lines (98). As stated by B. I. Levin, noted Soviet writer on transportation problems, the length of electrified lines was supposed to increase 3.6 times over 1945 and comprise 7,363 km (99). The percentage of electrified section to the total railroad network was to increase from 1.8 per cent (in 1945) to 6 per cent by 1950 (100).

The volume of operational performance (freight and passenger traffic) on electrified lines was to increase by the end of the period 5.7 times compared with 1945, the freight shipments 8.9 times, and was to reach 76,300,000,000 ton-kilometers by 1950. The electrification of suburban sections of the main centers of the country was to increase the percentage of electric traction in passenger traffic. It was planned that electric train units had to carry 30 per cent of the total suburban passenger traffic by 1950 (101). By the end of the period, the operational volume of electrified roads of the USSR was to reach and exceed the 1945 level of electrified lines in the United States, Italy, France, Sweden and Switzerland (102).

As stated by Obraztsov, Soviet railroads were to take first place in the world in the length of electrified lines by the end of the Fourth Five-Year Plan period (103). The following objectives were set forth for electrification during that period: 2,350 km Novokuznetsk - Omsk - Chelyabinsk - Dema line; 740 km Chelyabinsk - Sverdlovsk - Goroblagodatskaya - Kizel line with a branch line to Bogoslovsk and Perm'; 1,018 km Karaganda - Akmolinsk - Kartaly line; 590 km Kirovabad - Tbilisi - Sukhumi line with branching off to Batumi; 167 km Kandalaksha - Loukhi line which was to be the continuation of the already electrified main trunk line from Murmansk to Kandalaksha (104).

According to the newspaper "Bakinskiy Rabochiy", 251 km of main lines and 61 km of suburban lines were electtified in 1948 (105), and by January 1949 about 200 km of rails were almost ready to be switched to electric traction (106).

As stated in the statistical collection published by the Central Statistical Administration of the Council of Ministers of the USSR, the length of electrified lines comprised 3,000 kilometers in 1950, as compared with 116,900 kilometers of the operational length of all rail lines (107). Naporko, in his 1954 book mentioned that during the Fourth Five-Year Plan period a number of lines were electrified including the lines in the Urals, Transcaucasus, Krivoy Rog basin, also the suburban sections of the Moskva, Leningrad, Riga, Baku and Tallin rail junctions (108).

The Fifth Five-Year Plan (1951 - 1955) slated the electrification of longer sections (109). It was estimated that during that period four times as many lines were to be electrified than during the Fourth Five-Year Plan period (110); the lines were

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located in the Urals, Siberia, the Caucasus and large junctions such as Moskva, Leningrad, Kiyev and Riga (111). As stated in Gudok, 1 March 1956, 3,900 kilometers of trackage were to be electrified during the Fifth Five-Year Plan (112). L. M. Kaganovich, First Deputy Chairman of the Council of Ministers of the USSR stated in his 1954 speech that during the 1951 - 1953 period, only 18 percent of electrified lines projected by the Fifth Five-Year Plan were put in operation (113).

As reported in "Pravda Vostoka", 10 July 1954, a total of 9,000 kilometers of electrified lines (in one-track calculation) were put in operation by that period (114). On the other hand the statistical collection published by the Central Statistical Administration of the Council of Ministers of the USSR gave the figure of 4,900 km as the total figure of lines electrified by 1954 (115).

By the beginning of 1955 the entire length of electrified rail lines increased more than 2.5-fold as compared with the pre-war level (116).

The 1955 plan for the electrification of railroads was 70 per cent over the 1954 plan (117). As stated by S. Bagayev, Deputy Minister of Railways, the 1955 rail electrification plan was completed only 62 per cent (118). However, I. Ivanov, Director of the All-Union Scientific-Research Institute of the Railroad Transport, declared that in 1955 the length of electrified lines had grown 37 per cent over 1953 (119).

In 1955 the total operational length of electrified lines was 5,400 km according to the 1956 book "The National Economy of the USSR" (120).

B. Beshchev declared that the Fifth Five-Year Plan for the electrification of railroads was not fully achieved (121). In fact the official announcement on the Fifth Five-Year Plan fulfillment revealed that the electrification plan was met by only 58 per cent (122). In his report to the XX Congress of the Party N.S. Khrushchev stated that "the leading railroaders have not given their best efforts to fulfill the electrification plan, and moreover, have not fully used the appropriations assigned for that purpose" (123). As reported in Gudok, 1 March 1956, the electrification work was carried out according to the annual plans. Annual targets were lowered and in sum comprised only 82 per cent of the original plan for the entire period (124). The Fifth Five-Year Plan slated the electrification of 3,900 km of lines, although the total of the annual plans was only 3,185 km (125). Even the lower annual quotas were not met (126).

In sum during the Fifth Five-Year period 2,300 km of lines were electrified, as stated in Pravda, 25 February 1956, announcing the results of the plan fulfillment (127) and in "Railway Transport", No. 7, 1956. However, a figure of 2,267 kilometers of electrified lines was given in Gudok, 7 March 1956 (128) and "Railway Transport", No. 3, 1956, p. 5. At present (1956) the total length of electrified lines, calculated according to the length of the contact network, comprises more than 11,000 km as stated by Golovanov (129).

During the Sixth Five-Year Plan period (1956 - 1960) 8,100 km of electrified lines are to be put in operation (130), or 3.6 times as much as in the Fifth Five-Year Plan period (131). Upon completion of the plan the total length of electrified lines is to be 13,400 km in 1960, or three times as much as in the USA and equal to the total length of electrified lines in Italy, France, England and Holland (132). The plan envisages the electrification of long distance routes, such as Moskva - Kuybyshev - Chelyabinsk - Omsk - Novosibirsk - Irkutsk and later all the way to Vladivostok (133); Moskva - Khar'kov - Donbass; Inskaya - Promyshlennaya - Belovo;

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Yasinovataya - Pyatikhatki; Belorechenskaya - Sochi - Sukhumi (134). In addition to the above mentioned routes, it is planned to convert to electric traction the suburban lines of the largest cities - Leningrad, Khar'kov, Kiyev, Stalingrad and Baku (135). The transition from steam to electric traction is to take place primarily on the most important lines in the Urals and Siberia, the gateways from the Urals to the Volga region, the central and eastern areas, and on the lines linking the central regions with the Donbass, the Caucasus and Central Asia, and within the Donbass itself (136).

N. S. Khrushchev, in his report to the Central Committee of the Communist Party, stressed the significance of electrification in the development of the national economy. Accordingly, the Central Committee of the Party drafted "The General Plan of Electrification" for the next 15 years. The plan envisages the electrification of 40,000 km of rail lines (137). Thus, during the next fifteen years the volume of electrified lines is to be equal to the total length of all electrified lines in the world. The realization of this gigantic plan will be allegedly aided by initiation of operations of the largest hydroelectric power plants on the Volga, Angara and Yenisey rivers, the construction of new powerful thermal electric power stations, development of atomic energy and creation of a unified electric power system (138).

In the years following the Sixth Five-Year Plan the change over to electric traction will take place on trunk lines connecting Moskva with Leningrad, creation of the shortest electrified route from Moskva to Sverdlovsk via Kazan', of the second electrified main line connecting the central parts of the country with the Urals via sections from Zheleznodorozhnaya - Fryazevo - Perm' - Sverdlovsk, Vspol'ye-Danilov - Vologda, Vologda - Konosha - Kotlas - Vorkuta and a number of others (139).

By 1970 the length of electrified rail lines is to amount to 30 per cent of the operational length of the entire rail network; the share of operations performed by electric traction is to exceed 50% of the total freight traffic of the country. Electrification of rail lines is to be on a scale unknown in world practice (140). Electrified lines are illustrated on Figs.: 1, 2, 3, 4, 5.

Just how much of this ambitious plan can be fulfilled may be judged by results accomplished in 1956. S. I. Bagayev, deputy Minister of Transport stated that up until then (April 1956) the rate of electrification was too slow and that only 500 to 600 km of lines were being electrified annually. In order to complete successfully the General Plan for Electrification, the rate of electrification must be greatly speeded up. The latter fact will involve many changes in the organizational structure (141).

The fact is that the 1956 plan for electrification stipulated only one tenth of work of the entire volume provided by the Sixth Five-Year Plan. The largest volume of work was slated for the last years of the period (142). The 1956 plan exceeded the 1955 plan only by 65 kilometers (143)*. In sum only 850 kilometers of rails were to be electrified in 1956, while during the remaining years of the period an average of 1,500 - 2,000 km annually (144).

As reported in Gudok, 1 March 1956, the 1956 electrification plan included stretches that had been practically finished, amounting to more than 200 km. Thus, although the total work set for 1956 - 1960 was increased, the amount planned for 1956 was considerably less than in 1955 (145). Moreover, the 1957 plan was not likely to be carried out because the appropriations for that year would be 250 million rubles short (146).

*Contrary to this "The Railway Transport" stated that the volume of electrified lines to be put in operation in 1956 was almost 2-fold over 1955 plan (P: The Railway Transport, No. 4, 1956, p. 7

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As to the progress of electrification 1956, the following was reported: In January 1956 the assignment was fulfilled on a much smaller scale than in the same month of 1955 (147). In fact in January 1956 only 3.2% of the annual plan was completed (148).

In spite of the joint order (the order was issued on the basis of the decision of the Council of Ministers of 9 April, 1956, stressing the significance of rail electrification, as stated in Gudok, 23 June 56, p. 3) issued by Beshchev, Minister of Transport, and Kozhevnikov, Minister of Transport Construction, to boost the tempo of electrification work, the plan for switching rail lines to electric traction was threatened by failure. By 1 June, 1956 the annual plan for electrification was completed only 18.6 per cent (149).

In August 1956 it was reported that the Ministry of Transport Construction completed the annual 1956 plan for rail electrification only 36 per cent (150). By 1 August 1956, 189 kilometers of electrified line had been opened for operation (151).

Results of the past 8 months showed that the 1956 annual electrification program was behind schedule and that only 40% of the program was completed (152).

The reasons for this lag are poor organization of construction work, insufficient mechanization of labor processes, and haphazard work practices. For example, of 15,000 reinforced concrete bases which were to be laid for the catenary network, fewer than 3,000 were completed (153). The work of electrification is performed by local construction organizations which work intensively only near the completion date of the task and then slow down again (154).

In 1956, as in 1955, many electrified sections could not be opened because of the delayed construction of electric power lines. The Economic Planning Administration of the Ministry of Railways does not supply adequate plans for supplementary work on electrified lines which delayed their usage. Such is the case of the Kurgan - Makushino, Kinel' - Syzran', and other lines where the roadbeds, tracks, etc., must be strengthened and station yards developed. Construction of future electrified lines is even more behind schedule. Only 5 percent of the necessary material and equipment has been allotted for the Serpukhov - Tula - Skuratovo section. At this rate it will not be opened until 1957 (155).

However, as stated in Gudok, 16 January 1957, about 1,000 km of rail lines were electrified in 1956 (156).

According to M. G. Pervukhin, First Deputy Chairman of the Council of Ministers of the USSR, and Chairman of the State Economic Committee, the appropriations allotted for rail electrification will double and 1,258 km of electrified lines will be put in operation in 1957 (157). In 1957 the primary task will be to electrify lines connecting Siberia with the Urals, the Urals with Central areas, and also a number of suburban lines near Moskva, Leningrad and Khar'kov (158). He also stated that the ration of electric and diesel traction in the total rail traffic will increase to 22% in 1957, as compared to 17% in 1956. It is expected that the development of diesel and electric traction will save about 5,000,000 tons of coal in 1957 (159).

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ELECTRIFICATION OF RAIL LINES NEAR MOSKVA

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a. Operations on Moskva - Aleksandrov line;

b. Operations of Moskva III Electric Locomotive Enginehouse;

2. Electrification of Moskva - Iksha - Dmitrov line.

C. Gor'kiy System Lines.

D. Moskva - Ryazan' System Line.

E. Moskva - Kursk - Donbass System Lines:

1. Electrification of Moskva - Serpukhov - Skuratovo route; operation of Pererva Electric Locomotive Enginehouse;

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a. Use of single-phase alternate current of industrial frequency;

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F. Moskva - Kiyev System Line.

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2. Electrification of Moskva - Rzhev route.

H. October System Line.

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A. General Information on the Development of Electrification of Moskva Rail Junction.

Moskva is the largest transportation junction of the USSR (1). Eleven railroad lines converge upon the city; ten of which enter the city directly* while the eleventh (Belt system) connects in a center all other lines within the city limits (2).**

The importance of rail electrification of the Moskva rail junction has been stressed repeatedly. Thus, Yu. G. Saushkin, in his 1953 book on Moskva discusses again the significance of the electrification of transportation system for the capital (3).

The problem of electrification of the Moskva rail junction was first brought up by the USSR government in 1924. The planning was started the same year, but actual electrification work began in 1925 on the rail section of the Northern system (4). That section extending from Moskva to Mytishchi (17.7 km) was put in operation in 1929 as the first electrified section. Double-track traffic was used there until 1933. In 1933 the third track was electrified and opened for traffic (5).

The 12 km, Mytishchi - Pushkino and 16.8 km, Mytishchi - Shchelkovo sections were electrified and put in operation in 1930. These were the very first trunk-line sections serviced by the electric motor-car traction (6). Early results of operation clearly proved the advantages of electric traction over steam. Thus, the number of pairs of trains increased 170 per cent and speed - 50 per cent (7).

The electrification of lines near Moskva was initiated as follows: the line in direction of Gor'kiy was electrified in 1933, the line in Kazan' direction in 1935 (8).

There was a plan to increase electrified lines of the suburban Moskva junction to 268 kilometers by the end of 1934 (9). However, by 1936 the actual total length of electrified rail lines near Moskva comprised only 182 kilometers, served by 258 cars accommodating 38,700 persons (10).

The electrification of the Kursk direction line was initiated in 1939; the so-called "Kurskiy diameter," the section between Setun' and Kurskiy station in Moskva, was electrified in 1944 (11).

In 1945 the Kalinin line was electrified to Nakhabino station and in 1947 the Moskva - Donbass line up to Rastorguyevo station (12). In 1947 the Moskva junction electrified lines comprised 394 km. 59 km of which were built during the World War II (13).

In order to provide better passenger service at the Moskva junction, the post-war, Fourth Five-Year Plan envisaged the change-over to electric traction of 300 kilometers of rail lines, which included sections: to Kryukovo on October system, to Aprelevka on the Moskva-Kiyev system, to Novo-Iyerusalimskaya on the Kalinin system and to Domodedovo on the Moskva-Donbass system (14). According

* These ten lines are: October, 2 separate lines of the Northern, Gor'kiy, Moskva-Ryazan', 2 lines of Moskva-Kursk-Donbass, Moskva-Kiyev, and 2 lines of Kalinin systems.

** Fig. 7 illustrates railroad lines of the Moskva area.

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to the plan the electrified sections of the Moskva junction were to secure the operation of 900 pairs of electric trains daily, as compared to 430 pairs in 1946, and about 2,000,000 passengers transported daily (15). It was also planned to organize a "Belt system" (kol'tsevoye dvizheniye) of electric train traffic as follows: Moskva Kurskaya (station) - Fryazevo - Noginsk - Monino - Mytishchi - Moskva Yaroslavskaya (station).* The plans called for electrification of the Moskva-Belt system in its entire length (16). V. N. Obraztsov, Academician and well known specialist and writer on USSR transport problems made the following suggestions in Chapter 6 of his "Selected Works" in the article entitled "The Moskva Junction Problems and Methods of their Solution": in order to improve rail operations it would be expedient to unify all freight stations of the Moskva junction under one administration and simultaneously to electrify all traffic, mechanize all yard facilities, unify operations of the neighboring stations and accordingly distribute the performance (17).

During the 1945 - 1950 period, as reported in "Vechernyaya Moskva," 230 km of Moskva suburban lines have been electrified. Four Moskva terminals were linked by an electric rail line: Moskva-Kurskiy, Moskva-Savelovskiy (at Moskva Butyrskaya station), Moskva-Rizhskiy (at Moskva Rzhevskaya station) and Moskva-Belorusskiy (at Moskva Smolenskaya station) (18).

According to Saushkin the entire "Belt" system was electrified by 1952 (19).

Large scale work on the electrification of the Moskva suburban rail lines developed in 1952 - 1953 according to plans provided by the Fifth Five-Year Plan. Suburban electric trains started operating from Moskva to Serpukhov in 1953. It was expected that electrification would reach Kashira the same year. Thus, Moskva would be connected by electric rail with two large Oka river areas located at distance of about 100 kilometers (20).

Between 1951 and 1953 a total of some 130 kilometers of rail lines near Moskva were electrified** (21). According to Saushkin most rail lines leading from Moskva were electrified by 1953 (22). This was confirmed by the Great Soviet Encyclopedia, which stated that by 1953 almost all suburban traffic was serviced by electric traction (23).

The majority of these lines comprised suburban sections of the junction, but some stretched out beyond the suburban limits, for example, the section from Moskva to Aleksandrov on the Northern system and from Moskva to Serpukhov on the Moskva - Kursk - Donbass system (24).

Rail lines at greater distances from the city are and will be electrified depending on their economical significance, i.e., the lines which carry coal, ore and other important freight to the city will have priority (25).

According to Saushkin, electrification of the Moskva long-distance rail lines should be promoted with the supply of electric power from the Kuybyshev Hydroelectric Power Plant and later from Stalingrad (26).

M. A. Chernyshev in his 1954 book stated that long-distance approach lines to Moskva were then being electrified (27). A Moskva newspaper stated that freight

* See map in Fig. 67.

** A map of the Moskva suburban rail lines electrified as of 1937, 1952 and 1953 is shown in Fig.: 6, 7.

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transportation in the Moskva junction was being electrified along with passenger service including Moskva - Serpukhov line and the 3-rd track to Valuyki on the Moskva - Kursk - Donbass system (28). The electrified sections of the Moskva junction expanded from year to year and hundreds of kilometers of contact wires stretched in all directions. In 1954 electric trains ran from Moskva to Zagorsk (Northern system), Kryukovo (October system), Zvenigorod (Kalinin system), Aprelevka (Moskva - Kiyev system), Domodedovo (Moskva-Kursk-Donbass), Serpukhov (Moskva - Kursk - Donbass) and Ramenskoye (Moskva-Ryazan' system) (29).

By the beginning of 1956 the Moskva rail junction (with exits) had more than 700 km of electrified rail lines (30), and separate electrified rail section of the Moskva junction handled daily 220,000 to 350,000 passengers. When steam traction was used on these sections they handled daily only 20,000 - to 40,000 passengers (31).

In the course of the Sixth Five-Year Plan, about 1,000 kilometers of the Moskva rail center will be electrified (32). The following rail lines are being electrified: Moskva-Ryazan', Zheleznodorozhnaya - Fryazevo - Noginsk, Klin - Kalinin, and Aleksandrov - Vspol'ye. These lines, about 500 kilometers in length, will be opened for use in 1957 and 1958 (33). The builders' present task is to install 80 kilometers of catenary net and four traction substations in 1956 (34).

In connection with further electrification of the city's rail lines it was said that, the "General Plan of Rail Electrification" and the Sixth Five-Year Plan envisage the change-over to electric traction of the entire route from Moskva to Irkutsk and later to Vladivostok (35). The Sixth Five-Year Plan stipulated the electrification of the following lines adjoining the Moskva rail junction: from Serpukhov - to Skuratovo, from Lyubertsy to Kurovskaya, from Golitsino to Mozhaysk, from Aprelevka to Maloyaroslavets, from Novoiyerusalimskaya to Volokolamsk (36).

It was planned to complete during the next few years the electrification of Moskva rail lines beyond the small Moskva-Belt system, and on some routes - beyond the large rail belt. The Moskva rail junction will be electrified in all directions in a radius of 50 - 100 km and more (37). In the years following the Sixth Five-Year Plan period the trunk line connecting Moskva with Leningrad will be electrified, as well as the shortest electrified route from Moskva to Sverdlovsk via Kazan' (38).

There are plans to electrify the Moskva - Yerevan line via large rail junctions and stations: Ryazhsk, Michurinsk, Voronezh, Liski, Millerovo, Bataysk, Tikhoretskaya, Armavir, Tuapse, Adler, and Sukhumi. This line will be connected with the already electrified line from Sukhumi to Tbilisi and Akstafa and extended to Yerevan (39).

In view of the fact that various systems make-up the Moskva rail junction, the progress of electrification and other available information was presented in this study in separate chapters, each dealing with a rail system of the Moskva junction.

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B. Northern System Lines:

1. Electrification of Moskva - Mytishchi - Aleksandrov line;

   a. Operations on Moskva - Aleksandrov line;

   b. Operations of Moskva III Electric Locomotive Enginehouse;

2. Electrification of Moskva - Iksha - Dmitrov Line.

1. Electrification of Moskva - Mytishchi - Aleksandrov Line:

There are two lines of the Northern system which can be considered parts of the Moskva rail junction. (See map on Fig. 6 & 7). One of them is directed to the north-east and runs via Mytishchi, Zagorsk, Aleksandrov toward Yaroslavl'. The other line branches off at Moskva and is routed via Iksha, Dmitrov toward Savelovo. The electrification of rails was first initiated on Moskva - Mytishchi - Aleksandrov (113 km) line and proceeded as follows:

The Moskva - Mytishchi (19 km) section was the first section of the trunk line type to be electrified in the USSR (40). Electrification work on this section was started in 1927 and completed in July 1929 (41). The temporary traffic of suburban motor-car units was opened on 3 August 1929, and beginning 1 October 1929 traffic started operating according to schedules. The section was serviced by three-car units of "S_V" series motor-cars (42). In 1929 the section had double tracks. In 1933 the third track was electrified and opened for traffic (43).

After the completion of electrification on Moskva - Mytishchi section, work was started on the Mytishchi - Pushkino (12 km) and Mytishchi - Shchelkovo sections (44). The Mytishchi - Shelkovo section is the part of the 31 km branch line from Mytishchi to Monino (45). On this line motor-car traffic was opened on the stretch from Mytishchi to Bolshevo station (7 km) by March 1, 1930 (46). By the first of October 1930 traffic was extended to Shchelkovo, some 17 km from Mytishchi (47). According to Khachaturov the total Mytishchi - Shchelkovo - Monino line was electrified during the Second Five-Year Plan period (48).

As already mentioned, the electrification of Mytishchi - Pushkino (12 km) was started after completion of the Moskva - Mytishchi section. Electric motor-car traffic was opened here on 1 July 1930, and some time later, on 1 November 1930, was extended to Pravda. The distance from Moskva to Pravda is 37 km (49). In 1931 and 1932 motor-cars of the "S" and "S_d" series were used on this section (50). According to a 1932 source the electrified rail lines of Northern system had in that year 25 motor-car units, 10 of which were in disrepair (51).

The plan for the electrification of rail lines in the USSR for 1932 - 1933 included the electrification of further part of Moskva - Aleksandrov line, i.e., 35 km Pravda - Zagorsk and 41 km Zagorsk - Aleksandrov sections, with assignment of 38 freight and 57 passenger electric locomotives (52). In 1932 the electrification of the entire Pushkino - Zagorsk stretch was completed (53). On 22 October 1934 the total Moskva - Zagorsk (71 km) stretch, electrified on 1,500 v current, served as proving trackage for the trial run of the "PB21-01" electric locomotive which was built by the Kolomna Machine Building Plant (54).

Electrification of the entire Moskva - Zagorsk - Aleksandrov line, comprising a total of 113 km, was completed during the Second Five-Year Plan period (55). This

section served later on (by end of 1946) for testing motor-car unit of "S_m" series, the first unit operating on both 1,500 and 3,000 voltage (56).

According to the Sixth Five-Year Plan the entire Aleksandrov - Vspol'ye (180 km) line is to be changed over to electric traction during the 1956-1960 period (57).

a. Operations on Moskva - Aleksandrov line

Some information was available on the operation of electric trains on this line. Thus, "Vechernyaya Moskva" reported in 1953 that during evening peak hours, starting about 6:00 p.m., electric trains run in both directions every 5 to 7 minutes on suburban lines of the Northern system. Trains pass Losinoostrovskaya Railroad Station (located 11 km from Moskva between Moskva and Mytishchi) so often at this time, that strict adherence to schedules is necessary to "squeeze in" heavy load freight trains bound from Arkhangel'sk and Kostroma (58). In one instance an electric locomotive pulled a train 1,000 tons overweight from Aleksandrov station to Losinoostrovskaya station. In the first 10 days of May 1953, electric locomotives on this section pulled a total of 109 heavy trains with 23,362 tons of extra freight (59). A total of 269 extra-weight trains were pulled by electric locomotives in May 1953 by enginemen of the Moskva Locomotive enginehouse (60).

It was reported in 1954 that electric freight locomotives operated on only one Moskva suburban line, namely, on the Moskva - Aleksandrov line (61). In 1954 the "VL-19" series electric locomotives were used for operation on this line (62). Two through trains commuted daily in both directions. During the summer season the number of trains had to be increased to five (63). It was stated in "Vechernyaya Moskva" that on this line 9-car trains were used instead of 3-car units which transported 300,000 passengers daily (64).

Inadequacies in the operations of electric locomotives on the Moskva - Aleksandrov line and faulty planning of operations were described in an article published in Gudok, 12 August 1956. It stated that this line is one of the oldest users of electric traction, and should have had considerable experience and skill in the organization of freight traffic on the Losinoostrovskaya - Aleksandrov section. However, from the beginning of 1956 locomotive crews were working without any schedules. Electric locomotives had long standing time at Losinoostrovskaya and Aleksandrov. Train movements were organized so poorly that each locomotive had about 10,000 to 13,000 kilometers of empty runs in a month (65). Systematic failure to adhere to locomotive turnaround schedules resulted in failures to fulfill the run norms (in kilometers) by the enginemen. Thus, in June 1956, out of 38 enginemen employed in servicing freight traffic, only 8 completed the norms for the locomotive runs, and in July 1956, only 9 out of 40 enginemen (66).

b. Operations of the Moskva-III Electric Locomotive Enginehouse

The press paid special attention to the performance of the Moskva III Electric Locomotive Enginehouse. This enginehouse is one of the largest enterprises of the Northern system (67). Rakov claims that its locomotive park included "VL-19" series electric locomotives operating on 1,500 and 3,000 v current (68).

In September 1953 the enginemen ran 226 heavy trains, transporting extra freight which otherwise would fill 25 normal trains. The Losinoostrovskaya - Aleksandrov section ran 7 or 8 heavy trains daily (69). The section was serviced and handled by the enginemen of Moskva III Electric Locomotive Enginehouse (70). In January 1954 the enginemen pledged to exceed the norms for the average daily locomotive runs and average actual speed. They also pledged to meet the annual shipment plan

by 25 December 1954, and the annual electric locomotive run plan by 20 December 1954. They pledged to run during 1954 at least 1,200 heavy trains and transport additionally 300,000 tons of freight. It was resolved to lengthen the run of engines between the lifting repairs up to 20,000 kilometers (71).

The volume of heavy trains on the Losinoostrovskaya - Aleksandrov section was constantly on the increase. In March 1954 the enginemen of Moskva III Electric Locomotive Enginehouse ran 582 trains and transported 158,000 tons of extra freight; in April 1954 they ran 689 heavy trains and transported 178,000 tons of freight above the norm. During the 13 days of May, more than 250 heavy trains were run (72). In 7 days of 1954 the enginemen of this enginehouse ran 4,230 heavy trains and transported 1,200,000 tons of excess freight. This was almost three times more than the volume shipped additionally during the entire 1953 (73).

In 1955 all enginemen of Moskva III enginehouse transported 1,200,000 tons of freight above the norm in heavy trains. The enginemen pledged to increase that tonnage up to 1,500,000 tons in the first year of the Sixth Five-Year Plan period. The enginemen also pledged to increase the mileage of electric locomotive runs between general repairs from 320,000 to 400,000 kilometers, the norm is 200,000 kilometers (74).

In April 1956 an electric locomotive engineman of this enginehouse ran a 3,800 ton train on the Aleksandrov - Losinoostrovskaya section. This was the heaviest train ever run on that stretch (75).

2. Electrification of Moskva - Iksha - Dmitrov Line.

The second line of the Northern system branches off the Moskva rail junction via Beskudnikovo, Lobnya, Iksha, and Dmitrov (total 65 kilometers) en route to Savelovo (76).

Electrification of this line was planned for 1954, according to "Vechernyaya Moskva," 26 January 1954. The first change-over to electric traction was to take place on a 45 kilometer stretch between Moskva and Iksha; according to the plan 1,442 block foundations were to be installed, 3,920 cu m of monolithic foundations concreted, 1,900 metal towers for catenary system erected, 32 passenger platforms built, 7.5 kilometers of new trackage laid and dozens of railroad switches installed along the rail section. The plan was to build an electric traction substation at Lobnya station and a dwelling for workers of the electrification department of that section (77). In January 1954 work was under way on the Moskva - Iksha line and block foundations were laid on Beskudnikovo - Mark section (78). This section is 4 kilometers long; Beskudnikovo station is located 10 kilometers from the Moskva-passenger Butyrskaya station (79). The "Moselelektrotyagstroy" Trust (Moskva Electric Traction Construction Trust) was in charge of the work (80).

In March 1954 it was reported that large scale work was being carried out on further electrification of the Moskva rail junction in that direction. Foundations were being laid for towers on the Moskva Butyrskaya - Lobnya section (81). Upon completion of the electrification work this section will terminate the electrification of all outgoing lines (exit lines) from the capital. In the future, the extension of these sections will be eventually electrified and will thus permit wider use of electric traction for freight traffic (82).

In May 1954 electrification work on the Moskva - Iksha line was proceeding with full speed (83), and in July, as reported in "Pravda Vostoka," the electrification work was nearing completion (84).

In December 1954 the first electric train was tested on the Moskva - Iksha section (85). As reported on 17 December 1954, regular traffic was started on the Moskva Butyrskaya - Lobnya section. Thus the electrification of all suburban routes of the Moskva rail junction was completed (86). The length of the newly electrified section is 26 kilometers. At that time it was expected that as soon as electric traction substations are put in operation, electric locomotives would operate as far as Iksha (87). The plan was that electric traffic be extended to Dmitrov in 1955 (88). A large volume of construction and erection work was to be carried out by the "Moselelektrotyagstroy" Trust in cooperation with the electrical workers of the Northern system (89).

Electric train traffic was opened on the entire 45 km Moskva - Iksha stretch on 27 February 1955; some 1,300 block foundations were laid, 1,600 metal towers for the contact network erected, and about 3,000 cu m of concrete foundations were poured; roadway and station tracks of Moskva-Butyrskaya, Lobnya and Iksha stations were reconstructed, 27 passenger platforms were built. The largest traction substation of the Moskva rail junction was built at Lobnya station. Beginning on February 28, 1955 some 42 pairs of passenger suburban trains were in daily operation on the Moskva - Iksha section (90).

As told by Lomagin, electrification of the Moskva - Iksha line completed the change-over to electric traction of all suburban service of Moskva rail junction, with electric trains operating from every station in the city (91). The next problem of railroaders, was to introduce electric traction for freight and passenger long-distance service, which in 1955 was handled by steam locomotives (92).

The electrification of the Iksha - Dmitrov section was included into the Sixth Five-Year Plan. As reported in Gudok, 1 July 1956, the first electric locomotive was run on this 20 kilometer stretch (93). The station tracks at Turist and Dmitrov stations were expanded. Complete reconstruction of Dmitrov station was planned to be terminated in August 1956. In two months (May and June 1956) some 46 kilometers of contact network were installed (94).

On July 5, 1956, the first electric train to operate over the stretch from Moskva to Dmitrov left Savelovskiy Terminal in Moskva, thus opening the section for regular traffic of electric trains (95). Prior to 5 July 1956 electric trains operated only as far as Iksha (96).

The Iksha - Dmitrov section is the first to be electrified on the Northern system in the Sixth Five-Year Plan (97).

C. Gor'kiy system lines.

The Gor'kiy system line begins at Moskva - Gor'kovskaya Terminal and is directed toward Orekhovo, via Reutovo, Zheleznodorozhnaya and Fryazevo. At Reutovo the line branches off to Balashikha, a distance of 12 kilometers. At Fryazevo another line branches off to Noginsk, a distance of 14 kilometers (98).

The electrification of Gor'kiy system lines of the Moskva rail junction (formerly named Kurskiy system) was initiated by the end of 1932 (99). In March 1933 the double track 23.6 km line from Moskva to Obiralovka (now Zheleznodorozhnaya) was put in operation (100).

A total of 75 kilometers of catenary system wires were used for this 23.6 km stretch and for the 12 kilometer stretch of electrified branch line routed off at Reutovo to Balashikha (101). The Reutovo - Balashikha branch line had one track (102)

Electric train traffic was scheduled as follows: a 6-car electric train was operating on the stretch from Moskva to Reutovo. In Reutovo the 3-car unit was uncoupled and routed to Obiralovka, while the remaining 3-car unit proceeded to Balashikha (103). Thus, in 1934 the Moskva - Obiralovka and Reutovo - Balashikha sections were serviced solely by electric trains (104). Three-car units of "S_d" series were used on both sections, built by Mytishchi Railroad Car Building Plant, as told by Rakov (105). According to the plan for the electrification of rail lines in the USSR for 1933, the Moskva - Obiralovka section was to have assigned 17 freight and 34 passenger electric locomotives (106).

Evidently electrification of Gor'kiy line was at standstill for many years. As reported in "Moskovskaya Pravda," 16 May 1956, steam locomotives were used to pull trains from Zheleznodorozhnaya further to Kupavna, Kudinovo, Fryazevo, Elektrostal' and Noginsk (107). On the section from Moskva to Zheleznodorozhnaya electric trains handle more than 30 million passengers every year (108).

Work on electrification of the line from Zheleznodorozhnaya to Fryazevo and the branch to Noginsk was in progress in 1956. As stated in "Moskovskaya Pravda," electric trains would operate as far as Noginsk in the near future. Two reinforced concrete platforms were under construction at Stop Kilometer 33-rd. By the end of 1956, platforms must be built at seven stations and stopping points. Work was being carried on (in May 1956) at Kurdonovo, Fryazevo and other points (109).

D. Moskva - Ryazan' system line.

The Moskva - Ryazan' system line branches off at Moskva rail junction and is routed in a south-eastern direction via Lyubertsy and Ramenskoye. Electrification of this line was inaugurated in 1933 when the first electric train made a run from Moskva to Lyubertsy, a distance of 21 km (110). The same year electric trains started operation on the Lyubertsy - Ramenskoye (24 km) section (111). It was planned to assign to the section 35 freight and 70 passenger electric locomotives (112).

As reported many years later, this section was the first to use a remote control system (113). As stated by Golovanov in his 1956 book, the Moskva - Ramenskoye section had 4 traction sub-stations and 3 power supply control posts equipped with remote control systems (114).

Full electrification of the Ryazan' system must have been at a standstill for a number of years. There are plans to begin electrification of the entire Moskva - Ryazan' line in 1956 (115). The Sixth Five-Year Plan envisages the electrification of 530 km of this trunk line with the Moskva - Ryazan' section as the first part to be electrified (116). In connection with the electrification of this system, more than 200 railroaders of the Moskva-sortirovochnaya (classification) enginehouse of the Moskva-Ryazan' system took a course in operating electric and diesel locomotives (117).

As reported by Gudok, 7 March 1956, work on the electrification of the Moskva - Ryazan' line was started. It was expected that electrification will permit an increase of train weights by 1,400 tons; approximately 40,000,000 rubles will be saved on fuel, and the operational speed will be increased an average of 25 per cent (118).

It was planned that the Moskva-passazhirskaya (passenger) enginehouse of this system be switched to electric traction by 1958. Preparations have already started and two-year study courses of the electric locomotives were organized (119).

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Serpukhov line and the 3-rd track to Valuyki was under way, according to a Moskva newspaper of 26 January 1954 (128).

In the middle of July 1954 it was announced that in a few days all freight and long-distance passenger trains on the Moskva - Serpukhov line would be switched to electric traction (129). Planning was under way for the electrification of the entire Moskva - Serpukhov - Skuratovo line. In general, electrification was being introduced gradually from section to section, from one steam locomotive enginehouse to another, steam locomotives being replaced by electric (130).

On July 21, 1954, all basic work on the electrification of the Moskva - Serpukhov line was completed. Test runs proved that all facilities on the line operated adequately. The transfer of freight traffic to electric traction was started and already in July 50 per cent of all freight trains were pulled by electric locomotives (131)*. It was expected that with the introduction of electric traction in freight service, operational performance of the Moskva division of this system would improve; that actual speed would increase, and the average daily electric locomotive runs would exceed steam locomotive runs by 40 - 45 km. Shipment assignments were to be carried out with a much smaller number of locomotives (132). By May 1955, electric locomotives were in full service on the Moskva - Serpukhov section (133).

As already stated, some planning for the electrification of the Serpukhov - Skuratovo line was already under way in 1954. In connection with the wider development of electrification in the Sixth Five-Year Plan period, preliminary work on that section was undertaken in 1956 (134). The work was proceeding at a very slow pace. It was planned that by June 1956 at least 33,500,000 rubles would be used; however, the work involved the expenditure of only 346,000 rubles (135).

The "Moselektrotyagstroy" and "Mosdonbasstroy" trusts were carrying out the electrification of the Serupukhov - Skuratovo line and in August 1956 another complaint was heard that electrification was proceeding at a slow rate (136).

It was admitted that there was lack of cooperation between the Ministry of Transportation and the Ministry of Transport Construction. For example, plans for the electrification of Serpukhov - Tula - Skuratovo line, which is on the main route of the Moskva - Donbass, were made as far back as 1953, but were actually approved only in 1956; in spite of the long delay, the basic problems of the construction were not solved, and much time was wasted (137).

By 31 August 1956 only 6 per cent of the annual plan for the electrification of this highly important section was completed (138).

As reported in Gudok, 7 September 1956, only 5 per cent of the assigned expenditures was used on electrification work of Serpukhov - Tula - Skuratovo line from the beginning of 1956. Pitskhelauri, chief of the "Mosdonbasstranstroy" trust was blamed for his inefficiency. A statement in the editorial indicated that with the existing progress of electrification the line could not possibly be put in operation in 1957, as planned (139).

* Fig. 8 shows an electric locomotive on Moskva - Serpukhov stretch.

Operations of the Pererva Electric Locomotive Enginehouse

Electric locomotives of the Pererva enginehouse began to pull freight trains in the second part of 1954. In 1955, the number of electric locomotives which carried out shipment operations represented only 50 per cent of the number of steam locomotives which would have been necessary for an equal task. Labor force was reduced by 75 persons. In sum, electrification effected a saving of more than 13,000,000 rubles, and reduced the cost of shipments by 2/3 in 1955 (140).

In 1955 freight and passenger shipments exceeded the quota by 9.5 per cent while the number of employed personnel was 8.7 per cent below the plan. The average daily electric locomotive runs exceeded the runs of steam locomotives by 202 kilometers. A total of 7,550 heavy trains transported about 3,000,000 tons of freight above the norm (141).

In 1956 electric locomotive enginemen of Pererva enginehouse* pledged to haul only heavy trains. In the first 10 days of January 1956, they exceeded the norm for the average daily runs by 5 kilometers, and by the end of January by 18 km. In early January the enginemen made up and transported 125 heavy trains to Lyublino station, and 195 heavy trains at the end of January (142).

2. Electrification of Moskva - Kashira - Ozherel'ye route

The other line of this system begins in Moskva-passenger Paveletskiy Terminal and runs via Rastorguyevo, Domodedovo, Barybino, Mikhnevo, Zhilevo, Kashira and Ozherel'ye to Pavelets or Uzlovaya - Valuyki. The electrification of this direction was initiated in 1946 when the first 23 km, Moskva - Rastorguyevo section was electrified. The next 14 km, Rastorguyevo - Domodedovo section was put in operation in 1947 (143). This section uses a 1,500 v current, and is served by the "EM165" and "EM167" series motor-car units built in the 1927 - 1930 period(144).

As reported in 1953, electric trains were in operation on the Domodedovo - Barybino (20 km) section (145).

The electrification work on the entire 78 km Domodedovo - Kashira line was in progress in 1954. The contact network was then already installed on the 20 km Barybino - Mikhnevo section and (as reported in January 1954) was being installed on the 26 km Mikhnevo - Zhilevo section. It was expected that electric trains were to run on the entire stretch to Kashira in 1954 (146). The electrification work was in progress in February 1954 (147).

However, electrification of this line up to Mikhnevo was completed only in January 1955 and the suburban electric locomotives started operating on the 74 km Moskva - Mikhnevo line. Construction workers pledged to complete the electrification of the remaining Mikhnevo - Kashira stretch by 1 May 1955 (148).

In fact the electrification of Mikhnevo - Kashira stretch was completed in March 1955 (149). The first electric train left the Paveletskiy Terminal on 10 March 1955. The train was made up of new "SR-3" type cars built by Riga Railroad Car Building Plant. Thus, regular traffic was opened (150). Metal towers, contact network and new platforms were built on this 40 km stretch (151).

The electrification of the total Biryulevo - Ozherel'ye line was progressing steadily in 1956. The electrification workers of "Moselektrotyagstroy" trust,

* Fig. 9 shows partial view of the Pererva enginehouse.

handling the task, had to carry out a considerable volume of work (152). By the time the 1956 summer train-movement chart becomes effective (in 1955 the summer chart became effective 25 May), all freight trains operating over the section were to be pulled by electric locomotives (153).

In spite of difficulties in the supply of metal and reinforced concrete products, the workers fulfilled the assignments. Foundations and towers for the catenary system were being erected and the enginehouse reconstructed at the Ozherel'ye station in March 1956 (154).

3. Electrification of Ozherel'ye - Pavelets Line:

a. Use of single-phase alternate current of industrial frequency;

b. Electrification work and operations on Ozherel'ye - Pavelets line.

a. Use of single-phase alternate current of industrial frequency

Electrified Soviet rail systems operate now on a 3,300 volt direct current. This type of current, adequate in the past, does not satisfy the growing demands. The task for the near future is to more than double the network of electrified rail lines and to sharply increase the weight and speed of trains (155). This means that the consumption of electric power will increase and that large capital expenditures would be required for the construction of various installations, including power supply networks, which obviously require a great deal of copper wires (156).

More efficient is the single-phase alternating current of industrial frequency. With this system of power supply the trolley voltage increases from 3,300 v to 22,000 and 25,000 v.; the expenditure of non-ferrous metal for the contact network is reduced to one third; the distance between the traction substations is more than doubled and consequently the number of substations is reduced. It also reduces the cost of substation construction and facilitates their servicing. The entire system of electric power supply thus becomes simpler and more economical (157).

The contact network of alternating current permits the utilization of electric power for lighting, mechanization of track repair work and other needs of transportation at any point of the rail line; this is impossible with the existing system. The high voltage in the traction network permits the utilization in this system of particularly high capacity electric locomotives (158).

A distinctive characteristic of a single-phase current electric traction is the possibility of simultaneous use of electric locomotives of various types and systems, while direct current traction system permits the use of only one type electric locomotive. Thus, the use of single-phase current permits further progress in the technique of operating electric locomotives of new types and systems (159).

An electric traction system based on a single-phase current of industrial frequency has been used in Hungary for a long time. In the past few years this system is being developed in other countries as well, for instance in France (160).

The USSR has also turned to the introduction of electric traction on the single-phase industrial frequency current (161). Efforts were being made by research bodies to apply single-phase alternate current for electric rail traction (162).

A number of studies have been made by the USSR Academy of Sciences to determine the economic efficiency of various systems of electric traction, and the development of the new system. Participants in this research work included representatives of technical administrations, Scientific-Research Institutes and industrial plants under the Ministries of Transportation, Communication, Electrical Equipment Industry and Electric Power Stations. The conclusions and proposals were discussed also at meetings of technical councils of these ministries. As a result, the important advantages and potentialities of single-phase current of industrial frequency were acknowledged (163).

However, as stated in "Pravda," the work of developing this new system was advancing at a very slow pace in 1955. And as a result, a number of very important operations in this field were carried out with intolerable delays (164). It was revealed that many members of the Ministry of Transportation do not favor the electrification of trunk lines in general, and especially, the electrification based on this new system. It was urged that drastic measures be taken for the promotion of the new type of current. Also, it was acknowledged that there is a need for wider development of the research and planning-designing experimental work not only in the Academy of Sciences, and in specialized scientific-research institutes, but also at the electric locomotive building plants (165).

b. Electrification work and operations on Ozherel'ye - Pavelets line

The first experimental electrified rail line in the Soviet Union to operate on single-phase alternating current of industrial frequency stretches from Ozherel'ye via Uzunovo, Mikhaylov, to Pavelets station. The line is a part of the Moskva - Kursk - Donbass system (166).

Planning for the electrification of the 137 km Ozherel'ye - Pavelets section was carried out by "Transtekhproyekt" Institute (State Planning Institute for the Research and Design of Technical Installations on Railroads) (167).

The voltage of the new contact network on the Ozherel'ye - Pavelets section is to be 22,000 v. Therefore, compared with the existing network, the weight of the contact network is to be reduced approximately by 2/3. The construction of towers for this network requires half the amount of metal needed for previous constructions (168). The structure of the traction substations is considerably simplified (169).

It was expected that the first part of the line, extending from Ozherel'ye to Mikhaylov (85 km), would be put in operation in 1955 (170). The first electric locomotives for experimental operations were built in 1955 (171).

By October 1955, "Vechernyaya Moskva" newspaper reported on the progress of electrification work of the Ozherel'ye - Mikhaylov section. The erection of metal towers for suspending the electric wires has been completed on that section. The wire itself was strung for several kilometers along the line. The "Moselektrotyagstroy" (Moskva Electric Traction Construction) Trust began the erection of the catenary system on the Purlovo - Bogatishchevo section which is located between Ozherel'ye and Mikhaylov (172). This is the ninth and last stretch of the electrified section. Over the entire section from Ozherel'ye to Mikhaylov (in addition to the stations) more than 1,120 reinforced concrete foundations, and 1,020 steel towers were erected. The installation of the catenary system has begun at Korovino and Uzunovo stations. The "Transelektromontazh" (Transport Electric Installation) Trust has already strung tens of kilometers of catenary wire and began the installation of equipment at the Ozherel'ye and Vilenski substations (173).

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It was planned that the Ozherel'ye - Mikhaylov line be put into service in 1955. The construction of the second section of the line from Mikhaylov to Pavelets (52 kilometers) was to begin after the first section goes in operation (174).

"Stroitel'naya Gazeta" reported in November 1955 that passengers on the Moskva - Saratov train, after passing the Ozherel'ye station, could see steel transmission towers stretching along the railroad tracks to Mikhaylov. Here, along the 85-km run, the builders and installation workers of the Ministry of Transport Construction of the USSR were working on the electrification of the Ozherel'ye - Mikhaylov line (175). All workers were exerting their efforts to put the line in operation during 1955. A considerable volume of work has been completed. All nine runs of the electrified rail line and four stations - Mikhaylov, Korovino, Bogatishchevo and Uzunovo were turned over for the installation of power supply network. In building the power line, workers of the "Moselektrotyagstroy" Trust have made extensive use of pre-cast reinforced concrete and prefabricated steel structures (176). At the runs alone, more than 1,100 reinforced concrete foundations* for transmission towers, made of precast blocks, and the same number of steel towers have been erected. The traction substation in Ozherel'ye was turned over to installation workers for the mounting of equipment and the substation in Vilenki was being made ready for the installation of equipment (177).

Examples of high productivity of labor were shown by some workers and their output reached almost two norms per shift. Although a great deal had been accomplished, a large volume of work remained yet, such as, for example, the installation of electrical equipment at five railroad stations, re-arrangement of high-voltage crossings, lighting and communication lines, the block signal system, installation of equipment at traction substations, etc. To put the Ozherel'ye - Mikhaylov railroad line in operation in 1955 was the pledged task of the builders and installation workers (178).

However, not until January 1956 was it announced that the Ozherel'ye - Mikhaylov section had been placed in operation. The experimental 85-kilometer section, operating on a single-phase alternating current of industrial frequency was put in service. In Ozherel'ye a power substation has been put in operation. On December 1955, the current was turned on and the first electric locomotive (179) made a trip from Bogatishchevo station and returned to Ozherel'ye (180). The Main Administration of Electrification and Electric Power Supply Service (Glavnoye upravleniye elektrifikatsii i energeticheskogo khozyaystva) announced that in the very near future the park of single-phase electric locomotives was to be boosted and that the Novocherkassk Electric Locomotive Building plant had already produced these new locomotives (181).

It was expected that regular traffic between Ozherel'ye and Mikhaylov would begin in January 1956 (182). However, as late as March 1956, "Gudok" reported that the last preparations for traffic were nearing completion. Two new 6-axle electric locomotives had arrived on the section recently (183). Nevertheless, adequate preparations for the receiving these locomotives were not made. No contact network was installed at the enginehouse. Moreover, the "Moselektrotyagstroy" Trust (Moskva Electric Traction Construction) of the Ministry of Transport Construction, which was in charge of re-equipping the enginehouse, had already spent the sum of 2,300,000 rubles appropriated for the reconstruction, but that the work had not been completed. Due to inadequate facilities at the enginehouse, the

* A total of 1,120 foundations was given, as mentioned previously by "Vechernyaya Moskva," 11 October 1955.

new electric locomotives had to be pulled by old steam locomotives (184).

The first runs of the new electric locomotives were scheduled for 23 February 1956. But, antifreeze was not available and consequently the water in the locomotives froze. Hand torches were used to heat up some parts of the new locomotives (185).

Although the route-way should have been adequately prepared to permit testing at high speeds, the Ozherel'ye - Mikhaylov route-way was not reconstructed (186). Suggestions were made to first put the basic facilities in proper condition (including facilities for sanding, lubricating and inspection), and then only let the electric locomotives to operate (187).

Figures 10, 11, 12, 13 show the decrepit state of trackage on the section.

On May 1956 "Vechernyaya Moskva" announced that for the first time in the history of Soviet railroading enginemen of Ozherel'ye enginehouse began to run freight trains pulled by electric locomotives on alternating current between Ozherel'ye and Mikhaylov. The first four electric locomotives of "NO" series, built by the Novocherkassk plant, service this section (188). Thus, through traffic of electric freight trains began on the Ozherel'ye - Mikhaylov stretch. The trains cover great distances without stops (189).

Publications of the recent date indicate that numerous inadequacies were found on this section. In August 1956 "Pravda" newspaper stated that electrification of this section with single-phase alternating current of industrial frequency was inexcusably delayed (190).

In an article published in "Gudok" 7 September 1956, A. Seredin, chief engineer of the Main Locomotive Service Administration, stated that the experimental operations of electric locomotives on alternate current were carried out on that line in very difficult conditions. Various measures were being taken to eliminate defects. Even workers from the Novocherkassk plant were brought over to the section for assistance. Steps were also taken to secure the necessary spare parts for electric locomotives (191). Two locomotives were assigned to service freight traffic while one was attached to the dynamometric car. The test program was being reviewed. The Ministry of Transportation made efforts to influence the Ministry of Electric Power Industry to take emergency measures and eliminate defects on electric locomotives operating on alternating current (192).

V. Biryukov, chief engineer of the Moskva - Kursk - Donbass system said that a number of steps were taken by the administration of the system to eliminate inefficiencies in the testing operations of alternating current electric locomotives (193). Locomotive crews now include engineers and assistants who have completed specially organized (by the administration) courses for running the new type locomotives. An experienced engineer has been assigned to the Ozherel'ye enginehouse. A group of locksmiths was trained at Pererva enginehouse for future assignment to the Ozherel'ye enginehouse for the repair of alternating current electric locomotives (194). A number of locksmiths, engineers and technicians were to go to the Novocherkassk plant to witness the installation work on the new alternating current electric locomotives. Simultaneously, at Ozherel'ye enginehouse, assembly work has been completed in the shops for the equipping and periodical repair. The inspection pit for the check-up of traction motors and running gear of locomotives was under construction (195).

It was expected that as soon as the route-way between Ozherel'ye and Mikhaylov is reconstructed the permissible speed of electric trains will be raised to the designed speed (196).

2. Electrification of Moskva - Rzhev route

The first electrified part of this route (in 1945 and 1946) extended from Moskva to Nakhabino (34 km from Moskva) and Guchkovo (39 km from Moskva) (208). This section was serviced by "S_d" series three-car electric units built by the Mytishchi Railroad Car Building and the "Dinamo" plants (209). In November 1954 the Nakhabino electric locomotive enginehouse was praised for excellent performance (210).

In 1954 it was planned that this suburban passenger line be electrified and put in operation in 1954 on the stretch from Guchkovo to Novoiyerusalimskaya (22 km) (211). In April 1954 the electrification work of that section was in progress (212). Its completion was planned for the Railroader's Day in 1954 (213).

In fact the Guchkovo - Novoiyerusalimskaya section, newly electrified was put in operation as reported in "Gudok," 4 January 1955. On January 5, 1955 the first electric train was to leave Moskva-passenger station of the Kalinin system and proceed to Novoiyerusalimskaya station. About 6 pairs of electric trains were to depart daily from the Moskva-passenger station. Passenger platforms were built at stop points at Snigiri, Manikhino, Istra and Novoiyerusalimskaya (214).

With the completion of electrification of the Guchkovo - Novoiyerusalimskaya section, the total length of electrified line on this route is 61 kilometers (215).

In accordance with the Sixth Five-Year Plan the next section from Novoiyerusalimskaya to Volokolamsk (65 km) will be electrified in the 1956 - 1960 period (216).

H. October System Line.

The October system is routed from the Moskva rail junction in the north-eastern direction via Khovrino, Kryukovo, Povarovo and Klin toward Leningrad. The first 38 km Moskva - Kryukovo section of this line was electrified and put in operation in 1950 (217).

According to Yu. G. Saushkin, it was planned to operate electric trains on the entire Moskva - Klin stretch (89 km) in 1953 (218). In June 1953 it was reported that the "Moselektrotyagstroy" (Moskva Electric Traction Construction) trust was carrying out a large volume of electrification work on this section; several dozen reinforced concrete towers have been erected for overhead wires. The stringing of the contact wire network was to begin shortly on the Povarovo - Podsolnechnaya (14 km) section (219). By November 1953 the concrete foundations and steel towers were built and erected. Contact cable was hung on the whole section except at Klin and Pokrovka railroad stations on the Podsolnechnaya - Pokrovka run. Eleven of the 18 concrete passenger platforms (stops) have been built. At Frolovskaya railroad station and "582 km" stops, platforms were erected and asphalted (220). Thus, the Kryukovo - Klin section (51 km) was ready for operation on electric traction in November 1953 (221). By January 1954 the electrification work was completed, but the traffic was not yet opened. The "Moselektrotyagstroy" trust has built 20 reinforced concrete passenger platforms and installed 1,500 towers for the contact system (222). A total of 124 kilometers of contact network wire was suspended (223) and an electric traction substation was built at the Podsolnechnaya railroad station. The line was made ready for operation late in January 1954, when the run of the first test train was scheduled (224).

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Finally, on March 10, 1954, electric traction was opened on the Kryukovo - Klin section (225). Much work was put into switching the automatic block system to alternating current; the contact network and traction substations were built and assembled. An 18-apartment house for the use of the contact network maintanance crews was built (226).

The reinforced concrete towers for the contact network were used for the first time on this section (Kryukovo - Klin). These towers did not require special concrete foundations and needed considerably less steel. The assembly of traction substations was completed in an unusually short period of time, i.e., in one and a half months. This was due to the fact that the Perovo Railroad Car Repair Plant had the control panel sets and distributors for the direct and alternate currents ready (227). In the middle of July planning was under way for the electrfication of the next section, from Klin to Kalinin (228). Evidently nothing was started in this respect so far, since a statement in a Soviet periodical of March 1956 mentioned that the section from Klin and further will eventually be electrified toward Kalinin as far as the resort area on the "Moskva Sea" (229).

In fact the Sixth Five-Year Plan envisages the electrification of the entire Klin - Kalinin line to be completed during the 1956 - 1960 period (230). As stated in "Leningradskaya Pravda" in 1958 the whole Moskva - Kalinin route will have electric traction, with the exception of switching and helper work (231).

CHAPTER III

Electrification of Suburban Rail Lines.

A. Electrification of Rail Lines near Leningrad.
B. Electrification of Rail Lines near Kiyev.
C. Electrification of Rail Lines near Riga.
D. Electrification of Rail Lines near Tallin.

A. Electrification of Rail Lines near Leningrad.

The Leningrad Rail Junction, which handles a huge volume of freight, is one of the largest junctions in the Soviet Union (1). Twelve railroad lines branch off Leningrad city, four of them toward the north, and eight toward the south (2). The rail junction is comprised of about 20 large railroad stations and a complex intra-junctional network (3).

The plan for the electrification of rail lines in the USSR for 1932 - 1933 included the change over to electric traction of the 40 km, Leningrad - Baltiyskiy Terminal - Ligovo - Petergof - Oranienbaum (also called Lomonosov) line, also the branch line from Ligovo-Krasnoye Selo to Gatchina (4). These two sections were to get 30 freight and 60 passenger electric locomotives (5).

The 1932 - 1933 plan also included the electrification of the stretch starting at Leningrad - Vitebskiy Terminal to Pavlovsk, a total of 27 km (6). This section was to be assigned 12 freight and 24 passenger electric locomotives (7).

Actually, the electrification of lines near Leningrad was initiated in 1933, when the first section on the Leningrad Oraniyenbaum line was electrified (8). This section extended from Leningrad - Baltiyskiy Terminal to Petergof, a total of 33 km. The section had traction sub-stations at Leningrad, Ligovo, and Petergof (9). Petergof is also called Petrodvorets.

Thus, in 1933 electric motor-car service was opened on the Leningrad - Petergof section (10).

The Second Five-Year Plan (1933 - 1937) stipulated the change over to electric traction of 185 km of the Leningrad Rail Junction or, in other words, of all suburban traffic of the city (11).

By 1 January 1936, there were 51 km of electrified rail lines near Leningrad (12) they included Leningrad - Oranienbaum and Ligovo - Krasnoye Selo (11 km) branch line (13).

By the end of the Second Five-Year Plan period (1937), as told by T.S. Khachaturov, the lines which were electrified included the entire (32 km) branch line from Ligovo to Gatchina (14).

During the war many rail lines near Leningrad were damaged, but in the following years they were quickly repaired and electric traction was resumed on many sections of lines, such as from Leningrad to Oranienbaum, also to Pavlovsk and Beloostrov (15).

The lines slated for electrification during the Fourth Five-Year Plan period (1946 - 1950) included 180 km of lines near Leningrad (16).

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The Fifth Five-Year Plan (1951 - 1955) provided for the electrification of suburban rail lines beginning at Leningrad Varshavskiy Terminal of Siverskaya station (69 km) of October system, (17), and of the line from the Leningrad - Vitebskiy Terminal via Detskoye Selo (Pushkin), and Pavlovsk, up to Viritsa, a total distance of 60 km (18).

Contradictory information was available on the electrification of the two lines which start off at the Leningrad - Finlyandskiy Terminal. One of these lines goes via Toksovo, Rautu and Priozersk, the other line via Beloostrov to Zelenogorsk. One source says that the two electrified railroad lines starting at the Finlyandskiy Terminal were built after World War II (19). But according to the newspaper Kommunist Tadzhikistana, The Leningrad - Beloostrov - Zelenogorsk line (50 km) was electrified in 1951 (20), while Gudok states that the electrified line Leningrad - Finlyandskiy Terminal - Beloostrov was put in service on 1 June 1952 (21). Prior to this, in March 1952 the electrification work on Zelenogorsk - Ushkovo stretch (6 km) was completed (22). As stated in Pravda, 18 May 1953, electric lines between Leningrad and the southern shore of the Bay of Finland were restored during the postwar years. Electric trains were running from Leningrad - Finlyandskiy terminal to health resorts of the Kola Isthmus (23)*.

In 1953 several newspapers recorded the progress of electrification work on the line starting at Leningrad - Vitebskiy Terminal via Detskoye Selo (called Pushkin), Pavlovsk and to Vyritsa. On 17 May 1953 an electric train started operating from Leningrad - Vitebskiy terminal to Pavlovsk, a stretch of 27 km (24). The electrification of this line was completed two and one half months ahead of schedule. Seven high platforms and a power substation have been built, hundreds of steel supports erected. The new method of suspending wires accelerated the work and the time for this operation to 1/6 of that previously required (25). Illustration (see Fig. 14) shows the first electric train leaving Leningrad - Vitebskiy Terminal enroute to Pushkin and Pavlovsk (26).

As reported in Ogonek, in May 1953, electric trains were in regular service on lines from Leningrad - Baltiyskiy Terminal to Petrodvorets (or Petergof) and Oranienbaum (or Lomonosov), also on the branch line from Ligovo to Gatchina (27).

In the Sixth Five Year Plan a total of 188 kilometers of rail sections on the October System are to be electrified (28), including Leningrad - Mel'nichnyy Ruchey (25 km), Leningrad - Peri (41 km), and Leningrad - Tosno (53 km) lines (29). Work has begun on the electrification of the Leningrad - Mel'nichnyy Ruchey suburban line (of the October system) and the branching off Pisarevka - Peri section. The total length of the sections to be electrified is 57 kilometers. This is the fourth Leningrad suburban route to undergo electrification (30).

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* Some information of a later date was available on the operations of the crews of Leningrad - Finlyandskiy electric locomotive enginehouse. The locomotive repairmen, as stated in Gudok, of 2 March 1956, p. 3, completed for the increased run of electric motor-car units between the lifting repair. They were given a lifting repair after the runs of 275,000 km, while the norm is 160,000 km. Gudok of 11 March 1956, p. 1 confirmed the information.

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As stated in Gudok, 1 May 1956, the majority of rail lines approaching Leningrad have been already electrified (31). Fast electric passenger train traffic links Petrodvorets (or Petergof), Oraniyenbaum (or Lomonosov), Gatchina, Sestroretsk and other suburban lines with Leningrad (32). During the spring of 1956 the "Sevzaptransstroy" Trust started the electrification of the suburban line to Irinovka (33). Irinovka station is located 17 kilometers from Mel'niychniy Ruchey station en route to Ladozhskoye Ozero station (34). The construction of the new electrified lines will require the excavation of 20,000 cu m of the earth a fill of more than 140,000 cu m, and the laying of more than 40 kilometers of new rails (35).

The plan for electrification also included the line from the Leningrad - Moskovskiy Terminal (October system) to Obukhovo, Tosno, Lyuban' and Malaya Vishera (total of 162 km), according to M. Mitkin, chief engineer of the Leningrad - Moskva division (36).

It is expected that in 1957 only electric and diesel locomotives will operate on the Leningrad - Moskva run of the October rail system (37).

B. Electrification of Rail Lines Near Kiyev

The Fourth Five-Year Plan slated the electrification of the suburban rail lines near Kiyev. The plan was to introduce electric traction in the first hand on Kiyev (0 km) - Boyarka (23 km) - Vasil'kov (37 km) Motovilovka (47 km) line; this line extends further to Fastov, total of 64 km. Also on Kiyev - Klavdiyevo (49 km) line, which extends further to Teterev, a total of 81 km. Later on, electric traction was to be used on to Kiyev - Darnitsa (14 km), on Motovilovka - Fastov (17 km) and Klavdiyevo - Teterev (32 km) sections. The plan included the building of pavillions, high platforms and footbridges at all stops. The construction of the suburban rail stations was to be started in 1948 (38).

In fact, during the Fourth Five-Year Plan period the electrification of Kiyev - Boyarka (23 km) was completed (39). Further section from Boyarka to Vasil'kov (14 km) was electrified and put in operation only by November 1953 (40).

Evidently hardly any progress was made in the electrification of rail lines near Kiyev during the following years. A 1955 source mentioned the fact (already known in 1953) that the Kiyev - Boyarka - Vasil'kov section was electrified (41). It also stated that the electrified railroad will be further extended to the Motovilovka station. Towers for the contact network were being constructed and the building of substations was nearing completion. Simultaneously, the electrification of Kiyev - Darnitsa (14 km) was in progress (42).

As reported in September 1956 the Kiyev - Darnitsa suburban rail line was being electrified. Passenger platforms have already been constructed. The catenary net supports were raised, and electrical equipment was being installed (43).

C. Electrification of Rail Lines Near Riga

The suburban rail line near Riga, which is routed via Zasulauk, Dubulty, Sloka and to Kemeri (a total of 45 kilometers) was electrified at the end of the Fourth Five-Year Plan period (44).

The first section extending from Riga to Dubulty (26 km) was electrified in 1950 (45). On that section there was an electric locomotive enginehouse in Riga, which was put in operation in 1951 (46), and an electric motor-car enginehouse at Zasulauk station, which is located 7 km from Riga (47).

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The next section to be changed over to electric traction extended from Dubulty to Sloka (10 km) and was opened for traffic on 16 June 1951 (48). By the end of 1951 the last section of Riga - Kemeri line, from Sloka to Kemeri (9 km) was electrified (49).

Evidently no progress was made on the electrification during the following years. In 1954 complaint was made that the movement of electric trains was organized inadequately and was much too slow (50).

In 1956 much work was put in the improvement of traffic on the suburban electrified Riga - Kemeri line. It has been made possible for Riga rail junction to handle over 300,000 passengers during the days when traffic was particularly heavy. In previous years only 100,000 passengers were transported (51).

The Sixth Five-Year Plan stipulates the beginning of rail electrification on the northern section of Riga coast line by the end of the period (52).

D. Electrification of Rail Lines Near Tallin

The electrification of rail lines near Tallin took place as early as 1924. The 11.2 km long stretch from Tallin to Peskyule was then electrified on the 1,200 v current (53). Because of inadequate appropriations the system was unable to acquire new rolling stock, and used old 4-axle, 18-meter cars which were rebuilt and re-equipped with electrical equipment ordered in Germany. Altogether 4 motorcars (M1 - M4) were ready for operations (54).

In 1940 this section, from Tallin to Peskyule, was included into the newly organized Estonian system. In 1941 the M1 - M4 motorcars were sent to the railroads of the Urals and were never used again as electric cars (55). According to Rakov, motor-cars "EM165" and EM167", which were built in 1927 - 1930 for operation on 750 v current were used on Tallin - Peskyule section (56).

During the Fourth Five-Year Plan period, the suburban rail lines of Tallin junction were electrified, as stated by Naporko (57), and the electrification work was to be further developed in 1955 (58).

Evidently no progress was made, since no additional information was found in 1955 and 1956. The chief of Tallin division expressed complaints about the worn-out rails on the division, unfit for operation of new type locomotives, and even full utilization of steam locomotives (59).

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CHAPTER IV

Electrification of Rail Sections on Stalin, Donets, and Southern Systems

A. Electrification of the Zaporozh'ye - Nikopol' - Dolgintsevo line (Stalin System); operations on the Zaporozh'ye - Dolgintsevo line.

B. Planning for the electrification of Debal'tsevo - Zverevo and Debal'tsevo - Gorlovka sections (Donets system).

C. Planning for the electrification of Yasinovataya - Pyatikhatki route.

D. Electrification of Khar'kov - Merefa - Lozovaya Line of the Southern System.

A. Electrification of the Zaporozh'ye - Nikopol' - Dolgintsevo Line

The plan for electrification of rail lines in the USSR in 1932 - 1933 included the change over to electric traction of the 182 km Zaporozh'ye - Dolgintsevo line, to which 23 electric locomotives were to be assigned (1). According to Rosenfel'd, the first section of the 84 km Zaporozh'ye - Nikopol' line was electrified and put in operation in 1934 (2).

As stated in the Plan for 1935 the entire Zaporozh'ye - Dolgintsevo line was to be ready for electric traction in 1935 (3). In fact, lines electrified during the Second Five-Year Plan period (1933 - 1937) included the single-track line from Dolgintsevo to Zaporozh'ye (4), although Golovanov stated that the line was electrified not before 1941 (5).

The section extending from Dolgintsevo to Pyatikhatki (75 km), a connecting link for the existing Zaporozh'ye - Dolgintsevo section and the planned Pyatikhatki - Nizhnedneprovsk line, was slated for electrification in the Third Five-Year Plan (6). However, in 1956, the Zaporozh'ye - Dolgintsevo line remained the only electrified line of the Krivoy Rog - Donbass route (7).

Operations on the Zaporozh'ye - Dolgintsevo line

During the post-war years there was a shortage of electric power on the Zaporozh'ye - Dolgintsevo section. At that time both steam and electric traction were used on the section (8). The interruptions in traffic were so common that even when the power supply shortages were terminated the utilization of electric locomotives remained inadequate (9). Electric locomotives were idle while steam locomotives were put in operation. Thus, in 1954 and in 1955, some 30 - 40 per cent of the entire electric locomotive park was left idle daily. Electric locomotives in operation spent 50% of the time either standing at stations, or before signals (10).

In 1954, electric locomotive enginemen of the Nikopol' enginehouse (operating on this section) hauled mostly heavy trains (11). Some 80 per cent of all enginemen used the "circular" system of runs and exceeded norms for the average daily locomotive runs. The weight norms were increased by 500 tons in one direction and by 200 tons in the opposite direction (12).

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C. Planning for the Electrification of Yasinovataya - Pyatikhatki - route.

The plan for electrification of rail lines in the USSR for 1932 - 1933 also included two other sections: Yasinovataya (Donets system) - Chaplino (Stalin system), with a planned assignment of 21 freight electric locomotives (26) and Chaplino - Zaporozh'ye (Stalin system) with 10 freight electric locomotives assigned (27).

This task was never accomplished and as reported in Gudok, 18 July 1956, it was again planned that the entire Yasinovataya - Pyatikhatki (via Dnepropetrovsk) route be changed over to electric traction during 1956 - 1960 (28). In accordance with the plan for the reconstruction of the road bed, work was started on the development of the Nizhnedneprovsk junction. The plan includes the extension of receiving and departure trackage by 850 - 900 meters - an unsatisfactory length for electric locomotive runs (29). At the present time the Nizhnedneprovsk rail junction is an uni - directional classification yard. It is planned to make it bi-directional with a total of over 40 - 45 tracks (30).

D. Electrification of Khar'kov - Merefa - Lozovaya Line of the Southern System

In 1954 plans were made for the electrification of the 25 km, Khar'kov - Merefa suburban rail line (31). This section was to be serviced by six-car electric trains built by the Riga Railroad Car Building Plant, with each unit capable of accommodating 160 persons (32). It was expected that upon change-over to electric traction the trains could cover the Khar'kov - Merefa section in one half the time than when pulled by steam locomotives and that the trains could depart from the terminal stations every 5 - 8 minutes during the rush hours (33). According to plans the traction substations on the section were to have remote control (34).

Electrification of the Khar'kov - Merefa section is to be completed in 1957 (35). The "Yuzhtransstroy" Trust was assigned to carry out the work on the section, which included the installation of 300 reinforced concrete towers for the catenary system, the construction of two traction substations, a footbridge, and other structures (36). The "Stroydetal'" plant is to produce the reinforced concrete towers and has produced some sample specimens (37).

Station tracks at Merefa were undergoing reconstruction, new switches were being installed and areas were being prepared for erection of passenger platforms (38).

However, as stated in Gudok, 21 July 56, the rate at which the electrification work on the section was proceeding was not considered satisfactory. The supply of construction materials was not adequate and no decision has yet been made concerning the choice of the current (39).

By July 27, 1956, track-laying on the approach line to the Merefa electric substation was finished. An electric terminal was being built (40), and preparations were under way for the construction of a traction substation in Novoselovka. A passenger pavillion was being built at Zelenyy Gay Station. The electrification of Merefa - Lozovaya (a distance of 123 kilometers) was completed (41). All electric substations from Kursk to Khar'kov and from Khar'kov to Lozovaya will be controlled from two dispatchers' points. The railroad stations were being equipped with electrical central control of switches (42).

On 2 August 1956, as reported in Izvestiya, the Khar'kov - Merefa section was transferring to electrical traction (43). Work on the installation of a catenary overhead supports has begun. Preparations were under way for the construction of a large reinforced concrete bridge at Merefa station (44).

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Electrifications of Sections on the Kirov System.

Electrification of the Kirov system was started in 1934 on the 94 kilometer, Kandalaksha - Apatity line and 22 kilometer, Apatity - Kirovsk branch line (1). Both stretches were put in operation in 1935 (2).

By 1939 electrification of the entire Kandalaksha - Apatity - Murmansk (278 km) line was nearing completion (3), and by 1941 the entire Kandalaksha - Murmansk line together with the branch line from Apatity to Kirovsk, was electrified (4).

The Third Five-Year Plan stipulated the electrification of the extension of the Murmansk - Apatity - Kandalaksha main line to Loukhi (5), for an additional distance of 167 kilometers from Kandalaksha to Loukhi. The plan probably was not carried out, because according to Obraztsov the Fourth Five-Year Plan (1946 - 1950) again stipulated the electrification of that section (6).

In December 1956 the electrification of Kandalaksha - Loukhi section was proposed again, for the purpose of increasing the through-put capacity of the line. At present the Kandalaksha electric locomotive enginehouse uses only 35 per cent of its capacity serving one run, and can easily accomodate more electric locomotives (7). Experience showed that by electrification of Kandalaksha - Loukhi line, it would be enough to suspend 200 km of contact network, construct 6 power substations, electric power service buildings in Loukhi station, look-out point for contact network and 6 residential buildings with 64 apartments. All this will require 41,603 thousand rubles instead of 150 million rubles as originally proposed and rejected for being expensive (8)

Electrification of Kandalaksha - Loukhi section and lengthening of tracks at intermediate stations will raise the weight norm of trains on 3,500 tons. Traffic capacity of Murmansk - Sorokskaya line will increase 2.2 times and net cost of transportation will decrease considerably (9).

CHAPTER VI.

Electrification of Caucasian Rail Lines.

A. Electrified Lines of the Systems.

B. Current Electrification Projects;
1. Belorechenskaya - Taupse - Sochi - Adler - Sukhumi Line;
2. Zestafoni - Chiatura Line;
3. Ochemchiri - Kvezani Branch Line.

C. Operations of Tbilisi and Khashuri Electric Locomotive Enginehouses:
1. Tbilisi Electric Locomotive Enginehouse;
2. Khashuri Electric Locomotive Enginehouse.

A. Electrified Lines of the Systems

The Transcaucasian system has the longest network of electrified railroad lines (1). The initiation of the first in the USSR suburban type electrified lines took place on the Baku - Sabunchi line on 6 July 1926, when the line connecting the city with the oil fields of Sabunchi and Surakhany was electrified (2). All equipment of this system, with the exception of the control equipment of the electric motor-cars, was produced by Soviet plants (3). According to Rakov, 14 motor-car units were placed in service on the Baku- Sabunchi line. They were produced by the Mytishchi plant in cooperation with the "Dinamo" plant (4). As told in "Electrification of Rail Transport", the rolling stock of the Baku - Sabunchi line consisted in 1932 of fourteen 4-axle motor-cars, 12 coupled 4-axle cars and 8 coupled 2-axle cars and a mail-baggage car (5). Already in 1932 the advantages of electric traction proved efficacious and that year the newly electrified section (20.5 km long) transported about 25,000,000 passengers - or six times as much as during the last year of steam traction (6).

In 1932 the first freight handling section of the main trunk line type was electrified on the so-called "Surami Pass", between Khashuri and Zestafoni, where the ascent grade exceeds 2% (7). The work on the construction of the catenary system, substations and high-voltage transmission lines was started on this section as early as 1928. The electrification was completed in 1932, and on 2 August 1932 the first experimental run of the "Surami type" electric locomotives, "S" series, was carried out. The official opening of traffic took place on 16 August 1932, when the "S10 - 03" electric locomotive pulled a train with government representatives aboard* (8). The total length of the electrified Surami Pass section comprised 63 km (9). The section had a very difficult route profile and dense traffic - conditions particularly suitable for utilization of electric traction. The section was supplied with low-cost electric power from the Rioni and Zemo-Avchalinskaya

*According to Khachaturov the first trunk line electric locomotives for operation on Surami Pass were imported from the USA. Several locomotives of the same type were built later by the Soviets (Khachaturov, T.S. Distribution.., 1939, p. 573).

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hydroelectric power plants (10). At first mixed electric and steam traction was used on the Surami Pass line, a fact which considerably reduced the effectiveness of electric traction. With the arrival of new electric locomotives in 1933 - 1934 the section was completely transferred to electric traction. The 42 steam locomotives ("E" and "E^u" series) operating there were replaced by 17 electric locomotives of "S_s", "S" and "S^i" series. In fact, one electric locomotive replaced two and one half steam locomotives, as stated by Rakov (11). I. S. Sal'nikov, in his article on electrification of the USSR transport, claimed that one electric locomotive does the work of three steam locomotives (12).

The plan for the electrification of rail lines in the USSR in 1932 - 1933 included the following sections: Staliniri - Zestafoni (63 km) with 20 passenger electric locomotives (15 foreign-made); Akstafa - Navtlugi (88 km) with 9 freight and 5 passenger electric locomotives; Navtlugi - Staliniri (127 km) with 17 electric freight locomotives; Zestafoni - Samtredia (61 km) with 9 electric freight locomotives; and the Borzhomi branch (33 km) (13).

In 1936 the 70 km line extending from Mineral'nyye Vody to Kislovodsk (of the North Caucasian system) was put in operation. Electrification of this line was started in 1931 (14). According to Golovanov, this line with the Beshtau - Zheleznovodsk branch, were electrified by 1941 (15).

By 1941, as told by Golovanov, the Baku - Buzovny and the Sabunchi - Surakhany lines were already electrified (16) as well as the Tbilisi - Khashuri - Samtredia (with Khashuri - Borzhomi branch) line (17).

After World War II the electric rail line from Surakhany to Kala was built (18).

As reported in "Chelyabinskiy Rabochiy" 24 September 1946, electrification of the Rioni - Tkvibuli line in the Gruzinskaya SSR was nearly completed at that time; the line from Tbilisi to Baku (60 km) was being electrified (19).

In October 1948 electrification of the Leninakan - Sanain rail line was in full progress (20). And in 1949 the Kala - Mardakyany - Buzovny electrified line was under construction; the closed ring of this line comprised 75 km (21).

According to "Chelyabinskiy Rabochiy", about 600 km of lines were to be electrified in Transcaucasus by 1950 (22).

In fact, by 1950 the length of electrified lines on the Transcaucasian system was 26 per cent of the total length of rail lines of the system. The locomotive park was increased by electric locomotives and high-powered steam locomotives (23). Electrification of the Transcaucasian system, where curves and steep grades are frequent, increased the traffic capacity 300 per cent (24).

In 1953 electrification of the Kala - Artem line was completed and on 6 May 1953 the first train arrived from Baku at the new railroad station in Artem (25). This 30 km line connects Baku with the Artem Peninsula. Formerly an island, Artem was connected before the war by a causeway with Baku and became a large industrial district. It is a new station on the Baku - Sabunchi electric railroad. The train passes the stations: Fioletov, Montin, Kushly, Stepan Razin, Surakhany, Yeni-Surakhany, Biny and Kala. At the Kala station the track runs straight to the east, to the sea and to Artem island. Previously, it turned north at Kala, to the Mardyakhany summer resort (26). Station buildingswere built at Kala II, Dyubendy, Zvarya and Artem Island, and an embarking platform at Damba (Dyke) I (27). Ten pairs of trains carrying 3,000 - 4,000 passengers were commuting daily to Artem Island (28).

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By July 1954 electrification of the Sukhumi - Tskhakaya section was nearing completion (29).

In honor of the Soviet Railroad Workers Holiday (in 1954) operations were started on the newly electrified Samtredia - Batumi line (30), and later the same year on the Tskhaltubo - Brotseula line (31).

In July 1954 almost one half of all rail lines of the Transcaucasian system was electrified (32).

As reported in August 1954, the section extending to Tkvibuli was electrified and electric locomotives began operating efficiently and without delays. Until then steam locomotives were in service there for shipment of coal, pulling trains of not more than 10 cars. There are several mines in Tkvibuli, each at a distance of 3 - 4 km from the station (33). The dispatch of empties to the approach lines and the general performance of the station workers was very efficient. Most of the coal is shipped to the central concentration plant, with the remainder going to the industrial districts of the republic (34).

In September 1954 the Samtredia - Kutaisi branch line (39 km) was electrified and the first train arrived at Kutaisi Automobile Plant on September 26. Electric trains began transporting workers of the plant to Samtredia, Tskhaltubo and Kutaisi rayons, making three trips daily with 12 stops each trip (35). A large station building was built at Kutaisi (36).

In 1954 electric locomotives operated on all sections of the Apsheron peninsula (37), and further development of electric traction on lines of the Transcaucasian system was continuously under way (38).

As stated in the Gruzinskaya SSR book, published in 1956 by the Academy of Science in the USSR, the major part of the Transcaucasian trunk line was electrified within the borders of the Gruzinskaya SSR on the Tbilisi - Sukhumi and Batumi - Samtredia lines (39).

By the beginning of 1956 there were about 1,000 kilometers of electrified lines on the Transcaucasian system (40). As told by D. Mamatsashvili, chief of the system, about 50 per cent of all main and branch lines were changed over to electric traction by July 1956 (41). Electrified rail lines to be put in service in 1956 include the Tskhakaya - Sochi line (42). The 847 km of rail lines to be electrified in 1956 includes about 139 km of Sochi - Sukhumi line of the Transcaucasian system (43).

In 1956 the Ministry of Electric Power Station of the USSR will begin electrification of the Yerevan - Sevan section (44). During the forthcoming years the electrification of the Likhaya - Rostov - Bataysk (North-Caucasian system) rail line will take place. Its purpose will be not only to increase the capacity of the lines, but also to provide testing trackage for the electric locomotives produced by the Novocherkassk plant. Now electric locomotives are sent thousand kilometers away and are tested on the rail lines of the Urals and Siberia (45).

In 1956 (reported in July 22, 1956) construction-installation work on the electrification of the Khurdala - Sumgait rail section has recommenced. In 1957, the electrification of the Alabashly - Kushchi rail section will be completed. In the future, electrification work will be continued on the Kirovabad - Akstafa, Kirovabad - [redacted]khry rail sections (46).

It is expected that by the end of the Sixth Five-Year Plan in 1960, the length of electrified lines will amount to 60 - 65% of the total length of rail lines of the system (47).

In connection with further promotion of electric traction on lines of the Transcaucasian system the construction of the Shaorskaya GES (Shaori Hydroelectric Power Plant) plays an important part. According to "Zarya Vostoka" several years ago the USSR Ministry of Transportation started building theShaori GES in the rather small Shaori Ravine in the Nakeral'skiy Mountain Range to supply power to electrified sections of the Transcaucasian system (48). A dam was built across the ravine to store water from subtropical storms, melted snow and mountain streams in the enormous Shaori reservoir. Due to the exceptionally high pressure head, the precast reinforced-concrete powerhouse and its machinery were relatively small. In April 1955 the first generator was already supplying industrial power (49) and current for the electrified sections of the Transcaucasian system (50).

B. Current Electrification Projects:

1. Belorechenskaya - Tuapse - Sochi - Adler - Sukhumi Line.

The Sixth Five-Year Plan provided for the electrification of the Belorechenskaya - Sochi - Sukhumi line (51) and plans were made to run electric trains on the entire Moskva - Sochi line, which would cover the distance in half the time (52).

It is expected that electrification of the Belorechenskaya - Sochi - Sukhumi line will improve operations (53) as the through-put capacity will be boosted and the weight and speed of trains increased (54). An automatic block system and centralized traffic control will permit free passage of all freight traffic to the Black Sea coast (55).

Electrification work on the Belorechenskaya - Sochi - Sukhumi line was started in 1955 (56). The volume of earth work was considerable, but the number of installed structures was quite insignificant (57). In fact the rate of work was so slow that in March 1956 there were hardly any workers on the construction sites (58). Evidently planning was faulty and inefficient. For example, plans for the construction of a power substation at Goytkh was changed five times and as late as March 1956, no decision had been reached concerning relocation of the petroleum pipe line located at the site of the proposed substation (59). Similar problems were quite numerous. Furthermore, serious errors in the plans resulted in many revisions and reconstructions and changes at additional cost of many thousands of rubles (60).

As reported in March 1956, some work was under way on the Belorechenskaya - Tuapse stretch, but none on the Tuapse - Sochi section. No plans were made for that section either. However, both stretches were due to be put in operation at the same time (61). Lack of machinery, such as concrete mixers, and cranes, was reported (62). Electrification work was assigned to the "Sevkavtransstroy" Trust and complaint were made that administrators of the trust failed to give their full attention to the task (63).

The situation improved in June 1956. Electrification was in progress on the Sukhumi - Gudauty section; foundations for the towers carrying the overhead lines were being laid on the Sukhumi - Adler section (64). It was planned that the experimental run of an electric train should take place on July 22, 1956 (65). In the meanwhile, electrification work on the next section, from Gudauty to Gantiadi (60 km) was continued; metal supports for the catenary system were erected and the wire strung (66).

According to Gudok, 12 August 1956, the electrification of Sukhumi - Sochi line was in full swing. Construction workers have mastered various methods of laying foundations, erecting towers and suspending the wire of the catenary system without interruptions in traffic. However, the rate of erecting substations was very inadequate. With the exception of a few sections, electrification of the main route was far behind the assigned schedules (67).

It has been planned that the Sochi - Adler section be put in operation at the beginning of 1957. However, it was reported that the rate of work was much too slow. Although the installation of the catenary system was to be completed in October 1956, in August 1956 the catenary system supports were not yet erected and the laying of foundations for the towers was not completed (68).

As reported in August 1956, construction of the electric locomotive enginehouse at Adler stopped due to lack of construction materials* (69). The building of a traction substation at Adler was not completed and the installation of equipment was proceeding in the unfinished building (70). The general planning of the substation was faulty as it was located under the high-voltage electric line. This line had to be removed (71).

In September 1956 the electrification of the Tuapse - Belorechenskaya line was in progress. According to the plan, the electrification of this 47 km line was to be completed in 1956. Over 2,000 reinforced concrete supports for the catenary system must be installed on the line (72). However, the progress of electrification was hampered by the traffic and the administrators of the Tuapse division made no arrangements to assist in the matter (73).

Workers of "Sevkavtransstroy" Trust were engaged in the electrification work on the Tuapse - Kurinskiy section (74). They pledged to complete the substations at Tuapse and Kurinskiy for the installation of the equipment a month and a half ahead of time, but were not supported in their efforts by the administrators of the Trust. They lacked equipment and thus, for example, the construction of the traction substation at Goytkh was delayed again (75). There was, as before, lack of concrete mixers, tower cranes, trucks and so on. In many instances at Tuapse manpower was used instead of machines. Moreover, the existing equipment is frequently in disrepair (76).

Three construction trains were used for the electrification work on the Belorechenskaya - Kurinskiy section in the beginning of September 1956. However, in the middle of the month this number was reduced to only one (77).

2. Zestafoni - Chiatura Line

Construction of the wide-gauge electrified line from Zestafoni* to Chiaturi (branching off at **Sharopani**) was started, as reported in August 1956 (78). This line is 36 km long and runs along the existing narrow-gauge line, now in operation on steam (79). The plan was to put the new line in operation in 1956 (80).

This line, which connects Chiaturi with the main line of the Transcaucasian system is of great importance for shipments of manganese ore to the metallurgical plants of the country and the Poti Port (81).

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* See illustrations on Fig. 15 and 16.

** Note: The electric locomotive enginehouse has been under construction in Zestafoni for the last 5 years. It is being built by "Zaktransstroy" (Transcaucasian Transport Construction) Trust (Izvestiya, 26 Dec 56, p. 1).

By August 1956, the fifth construction section of the "Zaktransstroy" Trust completed most of the work on the 17-th km of the Zestafoni - Beglevi section, and service trains already started operating there (82). On some sites construction crews were erecting towers and suspending the catenary wire (83). Workers of the fifth construction section of the "Zaktransstroy" Trust were giving excellent performance (84).

As reported in September 1956, the new 36-km line has 22 tunnels with a total length of approximately 4 km, and 19 large and over 200 small bridges (85). A total of 2,500,000 cu m of earth was used for the roadbeds and over 75,000 cu m for the retaining walls (86). A great number of special structures were built for rain-water control (87). In order to secure uninterrupted traffic on the existing narrow-gauge line, many cable-ways and suspension bridges were thrown across the Kvirila river for the transportation of construction materials (88).

On 10 September 1956 the first trains with a few cars loaded with timber and other equipment made the first trip on the newly built wide-gauge line (89). It is expected that this line will be switched to electric traction in the beginning of 1957. In September 1956 electrical workers were installing supports for the catenary system and an electric traction substation was made ready for operation (90).

3. Ochemchiri - Kvezani Branch Line

The 26 km branch line from Ochemchiri to Kvezani was electrified and put in operation in August 1956 (91). All electrification work was completed on the 10-th of August, and the first train pulled by an electric locomotive departed from Ochemchiri station on August 12, 1956 (92).

This branch line will handle coal shipments from Kvezani to industrial centers of the republic (93).

C. Operations of Tbilisi and Khashuri Electric Locomotive Enginehouse:

1. Tbilisi Electric Locomotive Enginehouse

The Tbilisi Electric Locomotive Enginehouse is the largest of its kind (94) and the basic repair base for electric locomotives of the entire Transcaucasian system (95). The enginehouse is well equipped with modern facilities and has skilled workers. However, the repair of roller bearings was inadequate. The roller bearing shop not only lacked some necessary measuring instruments, but the workers handling this type of repair, were not adequately trained for that particular task (96). The methods used by the repairmen were very primitive and inadequate. A number of repairmen was sent to Moskva for special training in roller bearing repair work. Instead they were given a course in the repair of roller bearing boxes. The Main Administration of Locomotive Service is blamed for the neglectful attitude toward electric traction (97).

The locomotive enginemen of Tbilisi proved to be quite efficient in running heavy trains (98). Thus, in two months of 1954 they ran more than 160 heavy trains. In one night, the enginemen ran 9 trains with freight above the norm and transported 2,000 tons of consumer goods (99). In three months of 1954 the enginemen ran 298 heavy trains with over 150,000 tons of above-the norm weight. About 70 regular trains would have been needed to transport this excess freight (100).

In April 1954 the electric locomotive enginemen pledged to increase labor productivity by 5 per cent over the 1954 plan; to exceed the norm for the average daily locomotive run by 8 kilometers; to exceed train speed by 1.5 kilometers; to save 2.5 per cent of electric power; to run about 2,500 heavy trains in 1954; to have 75 per cent of the locomotive crews operating according to the traffic schedules; to increase electric locomotive runs without repair to 20,000 km and of motor-car units up to 30,000 km; to complete the annual plans for lifting and periodical repairs of electric locomotives and motor-car units ahead of schedule (101).

In April 1954, the electric locomotive enginemen of Tbilisi enginehouse exceeded the norm for the average daily locomotive run by 6.2 km and the assignment for actual speed by 1.9 km. They ran 184 heavy trains and transported 87,000 tons of excess freight. Some enginemen ran trains with 555 - 566 tons of excess freight (102). In a few days of May 1954 the enginemen transported 3,238 tons of excess freight (103).

In January 1955 the Tbilisi enginemen ran 243 excess-weight trains, in March - 443, and in April - 448. Although excess-weight trains usually exceed the norm by an average of 300 tons, one train with 1,237 tons above the norm was run on the Tbilisi - Khashuri, demonstrating the unused potentialities (104).

In 6 months of 1955 (January - June) the Tbilisi enginehouse exceeded the average daily quota for electric locomotive runs by 118%, the actual speed quota by 110%, economized electric power and ran a total of 2,157 excess-freight trains. About 236 regular-weight trains (of 2,300 tons in weight) would have been needed to carry that freight (105).

During 1955 electric locomotive enginemen ran a total of 4,479 heavy trains which transported 1,000,000 tons of freight above the norm. This was 150% more than in 1954 (106). Some enginemen ran trains with 6,600 and 7,200 tons of freight (107).

The Tbilisi electric locomotive enginehouse is considered to be the most progressive enterprise in the field of speedy repairs of electric locomotives (108).

2. Khashuri Electric Locomotive Enginehouse.

Since the time when some 20 years ago the Khashuri - Zestafoni line was electrified, and the electric traction was used for hauling freight trains, the weight of trains operated by the enginemen of Khashuri Electric Locomotive Enginehouse has been doubled. The number of heavy trains has been also boosted (109). Thus, a train weighing 4,954 tons, against a norm of only 2,300 tons, was run by the crew of an electric locomotive from Khashuri to Tbilisi (110). On another section, from Zestafoni to Khashuri, enginemen of Khashuri Enginehouse ran a train weighing 2,420 tons against the norm of 1,600 tons, with a pusher locomotive over the Surami Pass (111). An example of efficient performance was given by an engineman who ran heavy trains and in 7 1/2 months of 1954 transported 12,720 tons of freight above the norm. Another engineman transported 6,088 tons above the norm during the same period. The Khashuri enginemen ran 980 heavy trains since January 1954 (reported in August 1954) (112). In nine months of 1954 the Khashuri enginemen ran 653 excess-weight trains across the Surami Pass alone, carrying 154,000 tons of excess freight (113).

CHAPTER VII.

A. Electrification of Sverdlovsk System Lines;
B. Operations of Electric Enginehouses of Sverdlovsk System.

A. Electrification of Sverdlovsk System Lines.

The plan for electrification of USSR rail lines in 1932 - 1933 included the electrification of the 149 km Sverdlovsk - Nizhniy Tagil section (1), which is a part of the main line routed from Sverdlovsk via Goroblagodatskaya, Kizel, Chusovskaya to Perm', a total of 312 kilometers; the other main line runs from Sverdlovsk via Nizhniy Tagil, Goroblagodatskaya, Verkhotur'ye, Nadezhdinsk, Krasnyy Zheleznyak (where a 20 km line branches off to Bogoslovsk) and Pokrovsk. The same plan also slated the electrification of an additional 54 km, section from Nizhniy Tagil to Goroblagodatskaya (54 kilometers) and from Goroblagodatskaya to Chusovskaya, a total distance of 181 kilometers (2).

In 1933 the Kizel - Chusovskaya section (113 kilometers) was electrified and put in operation (3). According to Rakov all steam locomotives of the "Eu" series on this single-track mountainous section were replaced in 1934 by "S_s" series electric locomotives, and steam locomotives were only used for shunting operations on large railroad stations (4).

The electrification of the Goroblagodatskaya - Chusovskaya* line was started in 1934 (5) and according to one source was placed in operation in 1936 (6), but according to Rosenfel'd - in 1937 (7).

In 1935 the Sverdlovsk - Goroblagodatskaya line was electrified and put in operation (8). As stated by Golovanov, by 1941 the entire Sverdlovsk - Goroblagodatskaya - Chusovskaya line was electrified (9), for a total length of 500 kilometers (10).

According to Obraztsov, the Fourth Five Year Plan stipulated the electrification of the entire Chelyabinsk - Sverdlovsk - Goroblagodatskaya - Kizel (740 km) line by the end of 1950 (11).

During World War II the Perm' - Chusovskaya line was electrified (12). By the beginning of 1956 the Sverdlovsk system had a total of more than 1,000 km of electrified lines (13).

The Sixth Five-Year Plan called also for the construction of a new 320 km line from Sinarskaya (Sverdlovsk system) to Krasnoufimsk (Kazan' system) (14), in order to relieve heavy traffic of the existing east - west connections of this area. This line is scheduled for subsequent electrification (15).

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* Illustration on Fig. 17 shows location near Chusovskaya Electric Locomotive Enginehouse.

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CHAPTER VIII

Electrification of the Moskva - Vladivostok Route:

A. Introduction.
B. Electrification of Kuybyshev System Lines:
   1. Electrification in the past;
   2. Electrification in the Sixth Five-Year Plan period and progress achieved so far.
C. Electrification of Ufa System Lines: Introduction.
   1. Introduction
   2. Dema - Kropachevo section;
   3. Dema - Rayevka section;
   4. Rayevka - Pokhvistnevo section.
D. Electrification of South-Urals System Lines: General Information.
   1. General Information;
   2. Berdyaush - Bakal Branch Line;
   3. Kurgan - Makushino section;
   4. Magnitogorsk - Abdulino Line.
E. Electrification of Omsk System Lines:
   1. General Information:
      a. Reduced cost of operations;
      b. Increase of through-put capacity;
      c. Weight of trains;
      d. Train speeds, runs, efficiency and other indices;
      e. Plans for 1956 - 1960.
   2. Dieselization of Makushino - Isil'Kul' section;
   3. Electrification of Isil'Kul' - Omsk section;
   4. Electrification of Omsk - Tatarskaya section;
   5. Electrification of Tatarskaya - Barabinsk - Chulymskaya section;
      a. Barabinsk Electric Locomotive Enginehouse;
   6. Electrification of Omsk - Nazyvayevskaya section, the "Vagay route";
   7. Construction and electrification of new Barnaul - Omsk Trunk Line.
F. Electrification of Tomsk System Lines:
   1. Electrification of Lines;
   2. Operations;
   3. Belovo Electric Locomotive Enginehouse;
   4. Inskaya Electric Locomotive Enginehouse;
   5. Novosibirsk Steam and Electric Locomotive Enginehouse.
G. Electrification of East-Siberian System Lines:
   1. Irkutsk - Slyudyanka section;
   2. Cheremkhovo - Irkutsk section.

A. Introduction

In electrification of rail lines in the USSR, the most important task is to commission an electrified line linking the Soviet capital with distant cities of the country (1). The most ambitious program, in its magnitude of volume and length included into the Sixth Five Year Plan is the electrification of the route from Moskva to Irkutsk, via Kuybyshev, Chelyabinsk, Omsk, Novosibirsk, comprising 5,000 kilometers in length(2). On this route, traffic moves with constant and equal intensity round the clock. The trains pass on the main line every 5 - 7 minutes. Point-to-point trains with Kuznets coal and metal, timber and grain from Siberia are routed toward the west. Trains with machinery, equipment and various industrial products are

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2. Electrification in the Sixth Five-Year Plan period and progress achieved so far.

A. Okhremchik, chief of the Kuybyshev system declared that in accordance with the Sixth Five Year Plan some 680 kilometers of rail lines on the Kuybyshev system will be electrified (11). This task is of great importance since this system is a part of the trunk line and the acceleration of line capacity is of greatest significance for freight shipments of industrial and agricultural goods from Middle Volga area and Bashkirskaya SSR (12).

A. Okhremchik expressed the expectation that the electrification of the main route will permit to increase the actual speed by 14 - 15 kilometers, and the operational speed by 16 - 18 kilometers. The weight of trains will be boosted by 1,000 - 1,200 tons, and the norms for train weight will be unified (13). At present the norms for train weight were varying on different sections of the rail system, which is a rather limiting factor. For example, a point-to-point train arriving from the South-Eastern system (Kupyansk - Inskaya) needs additional loading of some 300 tons in Penza; then, when the train arrives at Batraki, about 1,000 tons have to be taken off in order to comply with the norm weight regulations (14).

It is expected that unification of weight of trains will ease freight handling operations at most important rail junctions such as Penza, Batraki, Kinel' and Ruzayevka. In total, the through-put capacity of the main route will be boosted approximately 2-fold (15).

In connection with the progress in the electrification of Kuybyshev system, it was reported in January 1956 that some work has been started on the electrification of the overall Syzran' - Kinel' line (16). Planning and designing was under way for Kinel' - Pokhvistnevo section (17).

However, faulty planning has been admitted. Thus, even an example was given. When the plan was made for the development of Kuybyshev rail junction it lacked the design for the construction of the pedestrian tunnel-type underpass. However, the electrification work of Syzran' - Kinel' section can be started only when the construction of that pedestrian underpass would be completed (18).

As reported in Gudok, 1 March 1956, very small amount of work has been done in the electrification of Syzran' - Kinel' rail line (19). There was already danger that the section will not be put in operation in due time. It has been also mentioned that preparation work, planned to be completed in 1955, has not been carried out (20). Moreover, the construction of the power transmission line has not been yet included into the plan by the Ministry of Electric Power Plant Construction (21).

Almost simultaneously with the above information, the newspaper "Sovetskaya Litva" reported that the work on electrification has already started (22). In connection with switching of the Kinel' Steam Locomotive enginehouse to electric traction (23) a power station and a plant producing reinforced concrete structures were being built at Kinel' station (24). The contact network towers to be used for the electrification of Kinel' - Smyshlyayevka section will be produced by a plant for reinforced concrete structures which is being built now in Perevoloki, near Volga. The building of the plant and the production of towers will have to be simultaneous (25). This plant will produce the foundations for the catenary system. At the Zhigulevskoye More station the production of metal posts for the stringing of the contact wire has begun (26). A complaint is voiced that the annual plan for electrification of Kinel' - Syzran' section has been completed only 8 per cent by June 1956 (27). In July 1956 it was

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reported that on Kuybyshev - Kinel' line the installation of towers of the contact network was being carried out without interruptions in traffic (28). As late as October 1956, it was reported that the electrification was in progress, but no details were given (29).

C. Electrification of Ufa System Lines: Introduction.

1. Introduction;
2. Dema - Kropachevo section;
3. Dema - Rayevka section;
4. Rayevka - Pokhvistnevo section.

1. Introduction

The main line of this system, extending from Pokhvistnevo on the Kuybyshev system, passes through Abdulino - Chishmy - DEMA - UFA to Kropachevo on the South Urals system, a distance of 525 kilometers.

The Ufa system is the next link to Kuybyshev system in the eastward direction which represents the part of the Trans-Siberian trunk line. In its eastward direction it borders with South Urals system at Kropachevo station (30). The electrification of the Ufa system has been provided for by the postwar Five Year Plan (31). As much of it as has been accomplished will be described on the following pages, giving the information mainly for the later years: 1954 - 1956. The electrification work was carried out in small sections going from east to west.* However, in spite of the rather slow rate of electrification in the past years and even during the current year, many handicaps and unjustified delays, the program of the Sixth Five-Year Plan is rather ambitious. According to the plan the total main line of the Ufa system is to be electrified during that period (32).

2. Electrification of Dema - Kropachevo section
(in eastward direction)

The year of 1955 was marked by the initiation of electric traction on the Dema - Kropachevo Line (33). It took some four years to electrify this 170 kilometers long section (34) and five years for construction of contact network and traction substations (35). The progress of work on the electrification was reported as follows:

In July 1954, the dateline provided by the Ministry of Transport set the goal of completing the electrification of Dema - Kropachevo line by 1 October 1954, when regular traffic was due to be initiated (36). The significance of this task was stressed on many occasions, noting the importance of this line in connection with the constantly increasing freight traffic from the railroads of the Urals and Siberia (37).

However, in July 1954 it was reported that the work on electrification was very inexpedient (38). In the months of April, May and June of that year, the rate of progress was very slow (39). One of the basic reasons for this inefficiency was the fact that the traffic on the system was heavy and the construction trains had no free passage on the line (40). Consequently, the railroad workers lost more than 400 working hours in two months (41). Complaint was expressed that the chief of the railroad extended poor cooperation, evidently not realizing all the significance of electrification of the line in view of winter operations and success in freight

*Fig. 18 shows an electric train on Ufa system.

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traffic movement (42). However, several newspapers issued the statements that the line would be put in operation in 1954 (43).

In July 1954, a construction train, composed of a steam locomotive and two flat cars with cranes, was laying foundations and erecting supports for the contact network on the Ulu Telyak - Kazayak run of the section (44). However, the report of the Ministry of Transport on the progress in electrification on the Dema - Kropachevo line stated that the constructors have engaged themselves in work on the easier parts of the line (45). More complicated tasks, such as erection of the contact network towers in the mountainous areas was not initiated. Only 73 towers were erected, instead of 470, on Vavilovo - Min'yar section,* and the assignment set for Min'yar - Simskaya stretch was so far completed only 12% (46). Only light type suspension towers were erected on Simskaya - Yeral stretch; construction of heavier type, anchor towers, has not been started yet, and was constantly postponed (47). It was stated that a large volume of work has yet to be accomplished. Some 800 pits have to be dug in the mountainous areas. About 200 towers have to be erected on the Ufa - Chernikovka stretch. The work on the suspension of the contact network wire could be started on the Dema - Ufa and Ulu Telyak -- Kazayak stretches, if some 6 more towers be erected without delay (48). Nevertheless, the supervisors of the construction units delay the operations (49).

A complaint was expressed that in general better organization in work is badly needed. That the construction projects require specialized and skilled workers which are not available (50). In another case, it was admitted that this has become the "bottleneck" on the line (51).

Some two months later improvement was noted as stated in Gudok, 7 September 1954. It was announced that a large amount of work was being carried out on Dema - Kropachevo section. Towers for the contact network were erected on six stretches of the main line (52).

For illustration see Fig. 19.

In October strong criticism was again expressed. The program of electrification was reported to be extremely slow (53) in spite of the fact that a considerable amount of money was allotted and all necessary material was provided for the task; electrification of the Dema - Kropachevo line, development of stations and junctions, reconstruction of the right-of-way, construction of platforms and yards progressed inadequately (54). The plan for the reconstruction of the right-of-way was not fulfilled. Only 25-30% of the total work on the construction of container platforms have been completed at Salavat and Tuymaza stations. For no reason at all, the building of such platforms was discontinued in the summer at Dema station. The building of storages at Naryshevo, Karlaman and Urman stations was badly delayed (55).

Early in December 1954 however, hope was expressed that the time was nearing when the Dema - Kropachevo section would be put in operation (56). The railroaders of Dema Steam Locomotive Enginehouse made all necessary preparations for the repair of electric locomotives (57). Finally, on 8 December 1954, electric power was switched on at Kropachevo - Simskaya section. Traction substations were adequately prepared and electric locomotive "VL-22" type made the first testing trip successfully (58). Shortly thereafter, electric traction was initiated further (westward direction) to Vavilovo** (59). On New Year's Eve 1955, electric trains began operating on Kropachevo-Chernikovka section (60).

*See illustrations on Fig. 20.
**For illustration see Fig. 21.

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As reported in Gudok, 25 February 1955, electrification of the complicated and mountainous Dema - Kropachevo rail line was nearing completion. Electric locomotive utilization on the line resulted in the increase of weight of trains. Thus, trains routed from Dema (in eastward direction) to the South Urals system were loaded with 300 - 400 tons more than before. In general the movement of trains was considerably speeded up due to the reduction of stops at the intermediate stations and boosted speeds (61).

It was revealed in March 1955 that although more than a month passed since electric traction was initiated on the Dema - Kropachevo line, the schedules for train traffic were not changed, and even old schedules were not adhered to. Signalization system was operating poorly and in total - electric locomotive enginemen did not have the chance to utilize new type locomotives to their full capacities (62). Several months later a rather contradictory statement was published in Gudok, 10 November 1955. It revealed the management of the Ufa system estimated that since the introduction of electric traction on the system, the traffic on runs was increased 7—10 kilometers per hour, the weight of through-trains increased by several hundred tons, the cost of hauling was greatly reduced as well as the number of locomotive crews (63). It was expected that "VL-22^{m}" type electric locomotives will be replaced shortly by more high-powered electric locomotives (64).

Nevertheless, a 1956 source revealed that although Dema - Kropachevo line was electrified over a year ago, various defects have not been corrected until the present time (65).

Thus when the electrified Dema - Kropachevo section was put in operation, the uncompleted work comprised in its equal value in 34,000,000 rubles. On that section the electrification of Cherniikovka - Benzin branch, for example, has not been completed. Also some dwelling houses at Dema terminal were not finished. (66)

The reconstruction of Dema enginehouse was scheduled several years ago when the electrification work on the Dema - Kropachevo line was just started. The building of an electric engine machine shop, shops for periodical and lifting repair of electrical locomotives and some others were entrusted to "Ufimtransstroy" Trust. However, none of these objects have been built yet.

Complete disorganization and chaos exist on the construction sites. There is also a lack of material (67).

3. Electrification of Dema - Rayevka section (westward direction)

The electrification plan for 1955 included the Dema - Rayevka section (68) which is some 105 kilometers long (69). Although it took about 4 years to electrify the Dema-Kropachevo line, it was declared that Dema - Rayevka section will be completed in less than 1 1/2 years (70). According to the established dateline the section is due to be put in operation in the second quarter of 1956 (71).

The progress on electrification was reported as follows: In April 1955, the first 70 towers for the contact network were erected on the Dema - Yumatovo stretch (72), and foundations for traction substations were laid in several places (73).

As reported in November 1955, the work on the section was nearing completion. The distance between Dema and Rayevka is some 105 kilometers, as previously mentioned, but some 326 kilometers of contact network wire are to be strung over the tracks on the section (74). By spring 1956 some 450,000 cubic meters of earth must be moved,

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56 kilometers of track must be laid at stations, and 186 sets of switches must be installed, plus the construction of 27 technical buildings and 25 dwelling houses (75). On the section from Dema to Rayevka, 3,790 posts must be erected for the catenary system (76).

On 1 March 1956, Gudok reported that only 50 per cent of the electrification plan was completed on Dema - Rayevka section at that time (77). The suspension of wires on Yumatovo - Alkino stretch was started with 7 months delay (78). The assembling work has been also delayed (79). Although not much time was left until the date line when the section is due to be put in operation, work has not been started on building high-voltage electric transmission line which will supply electric power to the Dema-Rayevka section (80). The "Ufaelektroset'stroy (Ufa Electric Network Construction) Trust was in charge of that project (81).

A long article, entitled "Lagging in Electrification Work on Railroads Should be Eliminated" and written by M. Burdin, chief of the Service for Electrification and Electric Power Management Service of the Ufa system was published in Gudok, 3 March 1956. M. Burdin declared that the plan to put the Dema - Rayevka section in operation on electric traction by the end of 1955 had failed (82). Moreover, the established program was completed by only 50 per cent. He blamed the administrators of the "Ufimtrasstroy" (Ufa Transportation Construction) Trust of underestimating the significance of electrification of this line (83). He also was free to admit that very scant attention was given to the project by the higher organizations as well. For example, during the ten months of 1955, no one attended the construction sites of the line, neither the representatives of the Main Administration of Railroad Construction of the Volga Area and Central Asia nor the representative of the Ministry of Transport Construction (84).

The shipments of construction materials (such as metal for contact network supports, bricks, lumber, cement and others) was entirely too slow and inefficient. Some three units of construction trains were forwarded to the site of electrification work, but without adequate equipment, or skilled workers (85). Consequently, many changes in plans were permitted and resulted later in serious defects. For example, all foundations for traction transformers were built some 40 centimeters higher than it was required at the traction substation in Klyucherovo. All 40 foundations had to be rebuilt. Another example: a total of 20 defective contact network supports had to be replaced on Dema - Yumatovo stretch (86). Both, the quality of work and the rate of work was very poor. Thus, the construction of the traction substation at Klyucherovo was stopped for 6 months, and so were many other examples (87).

The fact is that (in March 1956) only one traction sub-station, out of five, has been turned over for assembling work (88). Concrete has not been laid for about 200 foundations for the contact network and several hundreds of metal supports still have to be installed on various stations (89).

According to M. Burdin, in general the whole system of construction organization is quite cumbersome. The main organization of this construction project is the "Ufimtransstroy" (Ufa Transportation Construction) Trust which heads all other trusts connected with the work: "Transelektromontazh" (electric assembly), "Transenergomontazh" (power assembly), "Transsignalstroy" (signal construction), "Transsvyaz'stroy" (communication), "Transtekhmontazh" (equipment), "Transvodstroy" (water supply) and "Mostotrest" (bridge building). The administrations of these trusts are located in Moskva and all are subordinated to various main administrations of the ministries of transportation and transport construction. The solutions for even small, very small problems must wait until decisions are reached and forwarded from Moskva. This was,

according to M. Burdin, the cause of delays occurring in the electrification work on the Ufa system (90).

Two months later, in May 1956, it was reported that the Dema - Rayevka section of the Ufa system was due to be put into operation by October 1956. However, in May 1956, only two electric substations were being assembled. The construction of the other two substations had not even been completed when the installation of equipment was initiated. A lag in the electrification work was also reported in June 1956, which provoked anxiety in connection with the scheduled opening of traffic on Dema-Rayevka section in September 1956 (91). In order to put this section in operation in the fall of 1956, great expediency would be necessary to fulfill the task (92).

The "Ufaelektroset'stroy" Trust is in charge of the construction of high voltage (some 105 km) transmission lines. The plans for it were approved in September 1954 and the appropriations for metal were received only in the beginning of 1956 - at the time when, according to initial plans, electric locomotives should already have been in operation. It is quite evident that the whole organizational structure of electrification work is faulty and inexpedient (93).

There are many inadequacies in the electrification work on this section, and a number of projects have not been completed while others have not even been started. The situation at some stations may serve as vivid examples: the development of facilities at Chishmy and Yumatovo stations have not been carried out; the towers at Yumatovo were not erected properly thus preventing the passage of electric trains (94).

On 3 October 1956, the Dema - Rayevka electrified rail line was opened for regular traffic (95).

For illustration see Fig. 22, 23.

4. Rayevka - Pokhvistnevo section

The electrification of the 250 km Rayevka - Pokhvistnevo was slated to begin in 1956 (96). However, this project was not included in the plans of design organizations in time. By early 1956 the designs were not even approved (97). The suggestion was made that all preparatory work such as reconstruction of right-of-way should take place before the actual electrification is started (98). It was reported that in the second half of 1956 the Isetskiy plant of "Stal'most" (steel bridge) Trust must produce 2,000 reinforced concrete towers for the contact network on Rayevka-Pokhvistnevo of this system and also for Kurgan - Makushino of the South-Urals system (99). Nevertheless, a complaint was made that the plant had not received necessary material although all other preparations were made for the commencement of production (100).

As reported in Gudok, 16 May 1956, this section of the Ufa system must be put in operation in 1957. The complications incurred in the work on electrification were mainly due to some delays in allotment expenditures (101).

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D. Electrification of South - Urals System Lines: General Information

1. General Information
2. Berdyaush - Bakal Branch Line;
3. Kurgan - Makushino Section;
4. Magnitogorsk - Abdulino Line.

1. General Information

The main line of this system extends for 746 kilometers from Kropachevo via Berdyaush - Zlatoust - Chelyabinsk - Kurgan and Konovalovo (last station on the system) to Makushino on the Omsk system.

The South-Urals system is one of the many links of the Trans-Siberian trunk line. It is one of the most rapidly developing transportation systems in the country (102), and one of the most difficult in the topographical conditions of the route on the overall Trans-Siberian trunk line (103). According to a 1954 source, the total main trunk line of this system is subject to be reconstructed and switched to electric traction (104).

In 1955, electric locomotives were in operation on sections from Chelyabinsk to Dema, as stated by Vycherevin in his 1955 book on basics of Soviet railroading (105). The Kropachevo - Chelyabinsk section* was already electrified by 1953 (106) with the Chelyabinsk - Zlatoust part of it using electric traction since World War II (107).

There were many complaints about the inefficiency in operation of this electrified stretch. The deplorable state of Zlatoust electric locomotive enginehouse was reported in Gudok in October 1954. The information revealed that one of the buildings of the enginehouse had not been repaired for several years, it had no roof and the walls were partially disassembled (108). Minimum repair of electric locomotives was carried out in the lifting repair shop which is much too small for the purpose (109). The schedules for repair of locomotives were carried out inadequately with the enginehouse lacking necessary spare parts for the repair of electric locomotives. The conditions at the Chelyabinsk and Kropachevo enginehouses were just as bad; these two enginehouses serve as turnaround points for the Zlatoust electric locomotives (110). Complaints were expressed that the Main Administration for Electrification and Power Industry did not extend any assistance (111).

It has also been mentioned that the enginemen and railroaders did not have adequate training in the operation and maintenance of electric locomotives (112). However, in spite of this fact, it was reported that in 1953 the electric locomotive enginemen of the Zlatoust enginehouse ran some 12,869 heavy trains and transported 1,500,000 tons of freight in addition to the quotas. In 10 months of 1954, they ran 23,454 heavy trains and transported 6,300,000 tons of additional freight. Each engineman runs trains with some 200 - 300 tons of excess freight. But, the goal of the enginehouse is to teach the enginemen to run trains with 500 - 800 tons of excess freight (113). It is estimated that about 70 per cent of all trains are usually heavy-duty (114). As has already been mentioned, a part of the South-Urals system is one of the hardest for train operations on the total route. This part is serviced by the Zlatoust enginemen. The operations were eased in 1955 by the arrival of Soviet built 8-axle high-powered electric locomotives which were put in use here. The new locomotives are manned by experienced enginemen who carefully study their "behavior" and report their observations to the designers (115).

*For illustrations see Figs. 24, 25, 26.

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In all, since the commencement of electric haulage on this road the number of heavy trains had increased 10-fold as compared with 1950. The enginemen are competing to achieve 2 million ton/kilometers per locomotive every 24 hours (116).

2. Electrification of Berdyaush - Bakal branch line

In 1954 electrification work was in progress on Berdyaush - Bakal branch line which is 52 kilometers long (117). This work was carried out in a very inefficient manner, as reported and stated by E. F. Kozhevnikov, Minister of Transport Construction at an All-Union meeting of Soviet constructors. He blamed for this poor performance Loginov, chief of the Chelyabinsk Construction Administration which is engaged in that task (118).

In another case V. P. Yegorov, chief of the Signalization and Communication Service of the South-Urals system declared that due to improper planning and financial allotments for the development of station on Berdyaush - Bakal section, the work on this project has been delayed (119), and he expressed his anxiety concerning completion of electrification work on this stretch (120).

3. Electrification of Kurgan - Makushino section

In 1954 planning was under way for the electrification of Chelyabinsk - Kurgan - Makushino (Omsk system) line (121). The completion of electrification on the Kurgan - Makushino section was due in 1956 (122). Plans for the electrification provided also the reconstruction of the right-of-way and extension of lines (123).

However, as reported in 1956, very slow progress was made in the electrification of Kurgan - Makushino section (124) and moreover, it was revealed that actually all work was suspended on the section (125). The reinforced concrete towers to be used on this section must be produced by the "Stal'most" plant in Iset'. As reported in Gudok, 18 July 1956, the plant at that time had not yet received necessary material for the production, although all necessary preparations had been made for the commencement of production (126).

The electrification program involving the expenditure of some 23,000,000 rubles was assigned to be completed in the first half of 1956. However, only work involving some 7,000,000 rubles was fulfilled during the period ending June 1956. Construction sites lack bulldozers and other equipment as well as construction materials. None of the approach lines to the traction substation have been finished (127). By July 1956, eleven traction substations were being erected. The builders have promised to open half of the electrified section for operation by the end of 1956 (128).

4. Electrification of Magnitogorsk - Abdulino line

According to the Sixth Five Year Plan the Magnitogorsk - Abdulino trunk line, which will be 512 kilometers long, will be constructed and electrified during that period (129). Much hope has been expressed in connection with this task, since the electrification of the line will help to reduce the length of shipments of Magnitogorsk metal to the central districts of the country by at least 500 kilometers (130).

Judging by the recently published statement in Pravda, on 7 September 1956, the work on electrification of this line is much more expedient than on other sections of the South Urals system. It was reported that in 1956 the construction of the electrified trunk line, Magnitogorsk - Sterlitamak - Abdulino, had commenced. This line will link by the shortest route the Kuzbass and the Urals with the Volga Area. Over 30 kilometers of tracks have already been laid. "Magnitogorskstroyput'" Trust is handling the construction work (131).

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E. Electrification of Omsk System Lines:

1. General Information:
   a. Reduced cost of operations;
   b. Increase of through-put capacity;
   c. Weight of trains;
   d. Train speeds, runs, efficiency and other indices;
   e. Plans for 1956 - 1960.
2. Dieselization of Makushino - Isil'Kul' section;
3. Electrification of Isil'Kul' - Omsk section;
4. Electrification of Omsk - Tatarskaya section;
5. Electrification of Tatarskaya - Barabinsk - Chulymskaya section;
   a. Barabinsk Electric Locomotive Enginehouse;
6. Electrification of Omsk - Nazyvayevskaya section, the "Vagay route".
7. Construction and electrification of new Barnaul - Omsk Trunk Line.

1. General information on the effectiveness of electric traction on the system.

a. Reduced cost of operations
b. Increase of through-put capacity
c. Weight of trains
d. Train speeds, runs, efficiency and other indices
e. Plans for 1956-1960

1. General Information

The main line of the Omsk system extends for 582 km from Makushino via Petropavlovsk, Isil'Kul', Omsk, Tatarskaya, and Barabinsk to Kokoshkino; and for 423 km on the so called "Vagay route", which branches off at Omsk in northwestern direction toward Sverdlovsk.

The Omsk rail system is one of the most important links of the Trans-Siberian trunk line (132). On its western leg, the line borders with the South-Urals system and on the eastern leg with the Tomsk system (133). At Omsk a trunk line branches off via Vagay to Sverdlovsk also called the "Vagay route"(134).

The electrification of the Omsk system was started comparatively recently (135). Although in 1946, I. Sal'nikov, Chief of the Central Railroad Electrification Administration at the Ministry of Railroads and first directory of Railway Services, stated that the electrification of the 1,500 km railroad line between Novosibirsk and Chelyabinsk was one of the largest projects of the Fourth Five Year Plan, it was expected to speed up the movement of Kuznetsk coal to the Urals and the Western regions. By 1946 the route was surveyed, and locations of all service substations and other auxiliary structures were determined (136).

The first electric locomotives started operating on the Omsk system in 1954 (137). In 1955 it was expected that electrification of the major portion of this system would be completed during the next few years (138). Thus, Siberia and the Urals would have an electrified rail line extending for 2,500 km (139).

The electrification of the Omsk rail system was carried out in an east-west direction, as were many other sections of the Trans-Siberian route (140). In April 1956 the last steam locomotive was taken off the trunk line. Electric and diesel locomotives are now running the 1,000 km distance from the foothills of Southern Urals to

Novosibirsk (141). In May 1956 the main line of the Ural Mountain - Siberian route was served by the following types of locomotives, in an eastward direction: steam locomotives from Chelyabinsk to Makushino on the South Urals system, diesel locomotives from Makushino to Isil'Kul' (142), electric locomotives from Omsk to Novosibirsk on the Tomsk system (143).

So far five sections of the Omsk system were changed over to electric traction: Chulymskaya - Barabinsk (171 km), Barabinsk - Tatarskaya (155 km), Tatarskaya - Omsk (169 km), Omsk - Isil'Kul' (138 km) and Omsk - Nazyvayevskaya (144 km) (144).

The progress of electrification, and the operational aspects of the separate sections of the system are discussed in chapters dealing with the particular sections.

Some information was given on the conditions of the trackage and right-of-way facilities on the Omsk system. At one time it was reported that a total of 500 km of the line was reconstructed, providing crushed-stone ballasting and heavy-duty rails (145). According to Gudok, 16 March 1956, "R-50" and "R-65" type rails were used for this purpose on a number of rail sections (146). However, the tracks have not been lengthened at any stations and no provisions were made for the capital repair of station tracks (147).

Administrators of the Omsk system requested many times the Main Traffic Administration and the Main Administration of Track and Structures to lengthen the station tracks and were promised that these tracks would be extended by 850 - 1,050 meters by the end of the Sixth Five Year Plan (148). No action was taken in this respect by 16 March 1956.

Simultaneously, Golikov, chief of the system, declared that almost all stations were equipped with train-control devices, locomotives with two-way radio communication systems and automatic stops (149). Automatic block systems were introduced on the main line, and automatic car stops and switches were centralized (150).

Although electric operation of the Omsk system started in 1954, not a single steam locomotive enginehouse was reconstructed or adequately prepared for the rapair of this new type locomotive by March 1956 (151). The chiefs of the enginehouses were blaming the Main Administration of Locomotive Management and the Ministry of Transport Construction for this state of affairs (152).

As to the need for reconstruction of stations and facilities, it was revealed that as late as May 1956 the rail center of Omsk was barely capable of handling existing traffic loads. Reconstruction and complete electrification of the station should have been completed in 1955, but at the rate it was progressing, the work would not be finished until the end of 1956 (153). With the changeover of the Omsk - Isil'Kul' section to electric traction the Omsk rail center and the entire route was placed into a different traffic pattern. The so-called by-pass tracks for all eastbound traffic, routed to Moskovka station, have not been electrified thus far. It will be necessary to route the trains through the classifieation and passenger stations which are not prepared to handle the entire car flow and it will be impossible to provide the continuous movement of switching steam locomotives under the existing traffic load. As a result, trains will lay over for hours at Kulomzino station, which is located only 5 km west of Omsk (154).

a. Reduced Cost of Operations

The advantages and high efficiency of electric traction were confirmed through experience gained on the Omsk system (155). A considerable volume of information was gathered for a graphical comparison of steam and electric traction (156).

After electrification of the main route, the shipment cost of gross ton/kilometer was reduced by more than one half. The daily cost of operating and maintaining electric locomotives was 222,000 rubles less than the cost of operating and maintaining steam locomotives. It was thus estimated that three years of operational savings paid for the cost of electrifying this line (157).

A comparison of operational costs of steam and electric traction on the Omsk system are given below: (158)

Cost per 10,000 ton/km gross	steam traction (in rubles)	electric traction (in rubles)
Wages of locomotive crews	6.84	3.08
Fuel for steam locomotives and electric power for electric locomotives	19.43	12.80
Lubricating and lighting of locomotives	0.52	0.04
Wages of train crews	1.56	1.41
Wages of train car mechanics	1.27	0.89

According to Pravda of 28 March 1956, fuel consumption on the Omsk system was reduced by two **thirds** since its electrification (159).

b. Increase in Through-put Capacity

Since the changeover of the Omsk system to electric traction the through-put capacity of rail sections and stations has increased considerably (160). The intervals between the passage of trains on sections was reduced 40 - 50 per cent and thus the line capacity increased 50 - 60 per cent (161). As compared with the pre-war period, freight traffic on this system increased almost four times (162).

According to Pravda of 28 March 1956, the new type of traction, new equipment and facilities stepped up the volume of shipments 72 per cent during the past years (163). Of the total volume of shipments, 51 per cent was hauled by electric locomotives (164), while diesel traction was used for 25 per cent (165). It was expected that by the end of 1956, 98 per cent of trains would be pulled by electric and diesel locomotives (166).

The length of trains has also increased. Thus the length of a train on this system is now twice the length of an average train on USSR railroads (167), an average of 240 axles (168).

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c. Weight of Trains

Electrification of the line permitted an increase in the weight of trains. According to Gudok, 12 February 1956, in the first quarter of 1955, the average weight of a freight train increased 1.5 times (169). It is expected that during the coming years (Sixth Five Year Plan) the weight of trains on the Kuzbass Urals line will be increased up to 5,000 tons and of point-to-point trains carrying coal up to 6,000 tons (170). However, it was stressed that in the past winter (1955-1956) due to freezing weather, the weight of trains had to be reduced to the old norms. In connection with this fact the westward exits of the Omsk rail system became bottle-necks (171). The fact that some sections of the South-Urals system still used steam traction hampered the regular movement of trains (172).

The use of "VL-22" electric locomotives (and "TE-3" diesel locomotives), now operating on the Omsk system will permit an increase in the weight of trains to 5,000 - 6,000 tons (173). A serious obstacle to this increase may be the condition of station tracks, already mentioned in this chapter, which should be lengthened accordingly (174).

d. Train speeds, Runs Efficiency and other Indices

After the heavily travelled Omsk - Novosibirsk route was electrified, the speed of trains including stops (operational speed) was increased by 50 per cent; the average daily locomotive efficiency index was doubled (175). As a result of the increase of daily runs the number of locomotives was reduced (176).

Shestakov, chief engineer of the Omsk system stated that the actual speed of trains between stops also increased 50 per cent (177). According to Gudok of 10 August 1956, electrification and reconstruction of the total Novosibirsk - Omsk route made it possible to raise train speeds up to 100 kilometers per hour on the runs and to 70 kilometers per hour on the station trackage (178).

Actually, all operational indices were bettered. The average actual speed of the "VL22^{m}" electric locomotive was 39 per cent higher than that of the "SO^{k}" steam locomotive* (179). The replacement of the "SO^{k}" steam locomotives by "VL-22^{m}" electric locomotives on the Chulymskaya - Omsk section permitted to increase the actual speed (without stops) an average of 9 km per hour (180); the operational speed was 45 per cent higher, the average daily locomotive run was boosted from 318.1 to 567.2 kilometers, the average daily productivity of locomotives increased to 1,375,000 ton/kilometers gross (from 318,000), the average weight of a train rose from 2,339 tons to 2,516 tons, and the locomotive turnaround time was reduced by 11.2 hours (181).

It is expected that by 1960 the actual speed on the Omsk system will be increased 26 per cent, and sectional speed by 44 per cent (182).

e. Plans for 1956 - 1960

According to K. Golikov, chief of the Omsk system, this rail system should have no difficulties in expansion and meeting of the targets of the Sixth Five Year Plan (183). He declared that the Omsk system is continuously being equipped with modern facilities on a large scale (184). The lines are increasing and branching off more and more (185). The Sixth Five-Year Plan foresees the completion of a second track on the Omsk - Vagay line now and electrification of the entire stretch (186).

*This type locomotive was used on Isil'Kul' - Omsk section prior to change over to electric traction. (Gudok, 16 March 1956, p.)

2. Dieselization of the Makushino - Isil'Kul' Section

This 272 kilometer section was converted to diesel traction in 1955. As mentioned before the Makushino - Petropavlovsk - Isil'Kul' section of the Omsk system is serviced now by diesel locomotives which replaced "SO^{k}" steam locomotives in May 1955 (189). It was planned that this section would use diesel traction for three years more, and then it would also be switched to electric traction (190). In 1956 some preparations to that effect should have been taken. Some courses and training were initiated to prepare the railroaders for operation procedures on electric traction lines (191). Detailed information on operations of this section is beyond the scope of this study, and will be described in a special report dealing with the development of diesel traction in the USSR.

3. Electrification of the Isil'Kul' - Omsk Section

As mentioned before, the electrification of the Omsk system was carried out in a westerly direction. Thus electrification of the 138 kilometer Isil'Kul' - Omsk section was initiated at Omsk. Electrification of the Omsk - Isil'Kul' section was included into the 1955 railroad electrification plan (192). According to B. Beshchev, this project was scheduled for completion in 1955 (193) a statement confirmed by several other publications (194). However, by the end of 1955 electrification of the section was not yet completed (195).

Only in January 1956 the Omsk - Isil'Kul' section was prepared for the change-over to electric traction (196). But, the Ministry of Construction of Electric Power had not yet strung the power line across the Irtysh River near Omsk to provide electric power for the section (197). There was a delay of 4 months in installing the wires on the Ozero - Kamyslovskoye - Kukharevo stretch located on this section (198).

According to Golikov, chief of the system, the completion of the transmission line was postponed until early May 1956. He also declared that each day of delay resulted in a loss of about 100,000 - 120,000 rubles. The blame was put on the lack of cooperation between the following three ministries: Ministry of Transport, Ministry of Electric Power Plants, and the Ministry of Construction of Electric Power Plants (199).

It was reported in the middle of January 1956, that a high-voltage electric power line was being constructed on the Omsk - Isil'Kul' section. Supports, 100 meters high, were being built on both banks of the Irtysh River which is one kilometer wide in this area (200). The erection of towers, suspension of the contact network and construction of substations was completed on 9 February 1956 (201). The power sub-stations on the Omsk-Isil'Kul' section were located 25 kilometers apart (202).

P. Fayev, chief of the electrification service of the Omsk system explained the causes of unexpected difficulties and complications which arose with the electrification of the Omsk - Isil'Kul' section in an article published in Gudok, 7 February 1956. He stated that the reason why the Omsk - Isil'Kul' section could not be supplied with electric power from the Omsk Electric Power system was the faulty installation of the power step-up transformer at the Omsk electric power plant (203). When the installation of the transformer was almost completed (December 1955) it was discovered that the transformer was of a different voltage and not intended for the Omsk plant but for another purpose (204). Thus, the switching on of the current was postponed. The blame for this error fell entirely on Asmolov, deputy chief of the Main Administration of Electric Power Plants and Networks of the Eastern Regions, Ministry of Electric Power Stations (205).

P. Fayev also stated that the section was ready to be put in operation in February 1956 (206). The testing of the contact network was in process in the beginning of February and preparations were then being made for the transmission of the alternate current to the automatic block system devices (207). Five traction sub-stations (from a total of six) were ready to receive electric power. Piketnoye, the sixth sub-station, and the last, was almost completed (208).

On 5 April 1956, the work of hanging the 110 kilovolt electric power line across the Irtysh River was completed (209). Nine hundred meters of wire were stretched across the Irtysh River (210). The construction of the high voltage transmission line over the Irtysh River was entrusted to Gidromontazh" Trust of the Novosibirsk section. Specialized electric welders and assemblers from Kakhovka Kuybyshev, Narva and other places were engaged in this work (211).

Finally, on 30 April 1956, the operation of electric locomotives began on the Omsk - Isil'Kul' section. In one day all steam locomotives operating on the section were replaced with electric locomotives. Many locomotive engineers completed daily runs of 600 - 650 kilometers instead of 550, the kilometers provided by the norm (212). With the electrification of the Omsk - Isil'Kul' section, steam locomotives have been completely removed from operation on the main line of the Omsk system. (213).

4. Omsk - Moskovka - Tatarskaya Section

The changeover to electric traction on the 13 km Kulomzino - Omsk - Moskovka suburban section took place in 1954 (214). As reported, an electric locomotive enginehouse was under construction then and was even nearing completion at Moskovka station, located 5 kilometers from Omsk (215). This small station, of the past became a rail junction (216); however, two years later, the chief of the Moskovka enginehouse declared that in spite of all preparations for electric traction, not a single shop of this enginehouse prepared to handle electric locomotives and that servicing of locomotives was performed "under the clear sky." (217)

Electrification of the whole Omsk - Tatarskaya section was continued in 1955. As reported in March of that year, the installation of the last contact network supports was at that time nearing completion on the entire 170 kilometer section between Omsk and Tatarskaya (218). High voltage electric wires were also strung and installed (219).

Finally, in July 1955 the electrification of the Omsk - Tatarskaya section was completed (220). On 13 July 1955 regular passenger traffic on electric traction was started. The first train began operating on 14 July 1955 (221). There was some delay in receiving electric locomotives although they were due to be delivered at the section in October 1954 but they arrived only in the beginning of July 1955 (222).

After the electrification of this section, the labor force was reduced by about 1,500 employees, and labor efficiency increased 17.9 per cent simultaneously with a reduction of shipping costs by one third. (223).

5. Tatarskaya - Barabinsk - Chulymskaya Section

Electrification of the Trans-Siberian trunk line between Barabinsk and Tatarskaya* (155 kilometers) was completed in 1954, according to Izvestiya, of 29 October 1954 (224). Since then regular passenger and freight traffic was considerably accelerated (225).

The electrification work on the 171 km of the Chulymskaya - Barabinsk section was in progress in 1953, as reported in Trud, of 24 November 1953 (226), and it was expected that the operation of electric trains would start soon (227). However, it was not until the beginning of 1954 that electric locomotives were first introduced on this section (228). Thus, by the end of 1954 electric locomotives were in service in freight and passenger traffic on the Tatarskaya - Barabinsk - Chulymskaya line (a total of 326 kilometers) (229).

All electrified sections (Omsk - Tatarskaya - Barabinsk - Chulymskaya) were reconstructed, new rails laid and the road beds ballasted with crushed stones (230).

The advantages of electric traction on the Tatarskaya - Barabinsk - Chulymskaya section were very convincing and, as a matter of fact, were quoted on many occassions as exemplary (231).

Use of improved types of locomotives made it possible to increase the speed and weight of trains (232). The introduction of "VL-22m" electric locomotives, to replace the "SOk" steam locomotives permitted an average increase in speed-excluding--stops of 9 kilometers per hour, and simultaneously allowed a 500-ton increase in the unified weight norm of freight trains (233).

As reported in Gudok, of 10 August 1956, the average actual speed (excluding stops) has increased up to 50 kilometers per hour on the total Tatarskaya - Barabinsk - Chulymskaya stretch (234) and the operational speed (speed including stops) was accelerated by 46 kilometers per hour (235).

The longest run between Barabinsk and Chulymskaya secures now (August 1956) complete cycle of electric locomotive turnaround without rest periods for the locomotive crews at Chulymskaya station. The circular system ("kol'tsevaya yezda") of locomotive runs is being used here by 95 per cent of locomotives (236).

a. Barabinsk Electric Locomotive Enginehouse

Full information was available on the operations, condition of facilities and success of electric traction at the Barabinsk enginehouse. This information comes mostly from Myl'nikov, chief of Barabinsk electric locomotive enginehouse who made a special report on this subject to the Collegium of the Ministry of transport in Moscow (237).

The Barabinsk electric locomotive enginehouse, largest enterprise on the entire Omsk system (238), handles freight on the densest route of the line (239). Since the introduction of electric traction on nearby sections the enginehouse has been

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*All information concerning electrification of this part of the line was always referred to in the eastward direction.

re-equipped and shops were organized for periodical repair of electric locomotives and other repairs (240). The building formerly used for technical inspections of steam locomotives, was remodeled for servicing electric locomotives (Illustrations are shown on Figs. 27, 28, 29, 30)(241). The shop for lifting repairs of electric locomotives was reconstructed (Illustration on Fig. 31) (242).

Barabinsk electric locomotives serve the entire Tatarskaya - Barabinsk - Chulymskaya section and now use the "circular" system of locomotive runs (243). Since the change-over to the "circular" system the Tatarskaya enginehouse became the turnaround enginehouse for Barabinsk locomotives (244). This system is considered by Soviet railroaders as the most expedient in electric traction and it was reported that it permitted the reduction of the labor force on that particular section by 650 men(245).

Since electrification the capacity of the line, and safety of traffic have improved considerably and the cost of shipment reduced (246). The volume of operations performed by the Barabinsk enginehouse increased greatly, and in 1955 amounted to over 40 billion ton/kilometers gross, as compared with 18.7 billion ton/kilometers in 1950 (247). In 1955 electric locomotives of the Barabinsk enginehouse handled 40 per cent greater volume of operations as compared to the volume handled by steam locomotives in 1953 (248). Introduction of electric locomotives permitted a reduction of the locomotive parts by a ratio of 2 1/2 to 1 (249).

All operational indices have improved; in the first quarter of 1955 they were all exceeded (250). The average daily run of the entire locomotive park was exceeded by 25 kilometers (251) and since 1950 the total electric locomotive run doubled (252).

In 1955 the running speed of a freight train was accelerated by 16 km/hr, the average daily locomotive run increased by 305 kilometers, while the total locomotive turn-around was reduced by 14.2 hours (253). In October 1955 the electric locomotives of the Barabinsk enginehouse completed the plan for the locomotive run by 109.6 per cent and shipment plan calculated in ton/kilometers gross by 103.8 per cent (254). The assignment for the average daily run for October alone was exceeded by 8 kilometers, the running (actual) speed by 2.6 km/hr (255).

The productivity of each electric locomotive was brought to 1,235,000 ton/km daily, which is considerably over the norm in February 1955 (256). In the fourth quarter of 1955 the average daily locomotive productivity accounted to about 1,500,000 ton/kilometers gross (257), and in July 1956 it was brought up to 2,000,000 ton/kilometers (258).

In April and May 1956 the average daily electric locomotive run of Barabinsk locomotives was 700 kilometers, but the most successful enginemen brought it up to 800 kilometers (259).

With the introduction of electric traction on the Barabinsk division, the weight norms of trains within the division (handled by Barabinsk locomotives) were increased as compared with steam traction by 600 tons in an easterly direction and by 800 tons in the westerly direction (260). In practice, however, the weight norms were smaller which could be improved by lengthening of receiving and departure yards at Tatarskaya station, serving as turnaround point for Barabinsk locomotives (261). It was reported that in spite of systematic haulage of heavy-duty trains, there are many with weights below the norms. Thus, in 1955, about 7 per cent of all trains which passed through Barabinsk division were below the weight norms. These trains, if loaded to the assigned norms, could transport an additional 724,000 tons of freight (262).

There were also some reports concerning the movement of heavy trains. In January 1955 enginemen of the Barabinsk enginehouse ran 1,720 heavy trains carrying 477,237 tons of freight above the norm (263). In three months of 1955 (January, February, and March) 4,412 heavy trains were hauled, transporting 1,280,000 tons of freight above the norms (264).

In four months of 1956 the average weight of a train was boosted to 2,548 tons, as compared to 2,055 tons in 1955 (265).

6. Electrification of Omsk - Nazyvayevskaya Section

The entire 428 km line from Omsk to Vagay (junction station with the Sverdlovsk system) is to be electrified (266) during the Sixth Five Year Plan period. The electrification of the first part of this line from Omsk to Nazyvayevskaya (149 km) is due to be placed in operation in 1956 (267). However, in 1955 electrification work on this section was completely stopped and even the labor force was transferred to other sections of the system (268).

Progress in this electrification work was noted later in 1956. It was reported in March 1956 that the electrification of Omsk - Nazyvayevskaya section was under way. Six traction sub-stations were under construction (269). Crews of the electric - assembling train No. 702 were installing the contact network on a number of stretches (270). According to the plan the crew of this train must complete the work on the section in the fourth quarter in 1956 (271). So far however, the work was carried out very inefficiently. The construction of traction sub-stations and erection of supports was much too slow (272). The Ministry of Transport Construction was blamed as too lenient toward construction workers, who do not fulfill their assignments in due time (273).

In April 1956, a meeting was held by the administrators of the Omsk system, presided over by Golikov, chief of the system. The meeting was called to discussion of the extremely slow rate of electrification work on the Omsk - Nazyvayevskaya section (274). The section, was supposed to be put in operation in October 1956. However, in 4 months of 1956 only 20 per cent of the annual plan for electrification was fulfilled (275). The electrification of this section depends greatly on the "Kuzbasset'stroy" Trust, which was assigned the task of completing the construction of 150 km of network. Very little was accomplished so far and the situation may improve only if the Novosibirsk plant delivers the towers and foundations on time (276).

In May 1956 the situation improved and the construction workers pledged to complete the building of traction sub-stations and contact network by August 1956 (277). The traction sub-stations at Petrushenko was expected to be ready for operation one month ahead of schedule, at Kochkovatskiy station - two months ahead of schedule, and at Dragunskaya three months ahead of schedule. The construction program for the first quarter of 1956 was completed successfully (278).

A temporary construction yard was built at Nazyvayevskaya station for the production of foundations for the contact network towers (279).

The double-track sections from Lyublinskaya to Turn-out point No. 53 and from Nazyvayevskaya to Turn-out point No. 48 were turned over for assembly work. The section between Kochkovatskiy station and Turn-out point No. 48 was expected to be turned for assembling in the very near future (280). The pouring of concrete for the contact work towers at Nazyvayevskaya, Lyubinskaya, Dragunskaya and Petrushenko stations was carried out according to plan. Simultaneously the installation of metal-structures was taking place at the Nazyvayevskaya and Lyublinskaya stations (281).

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However, it has been admitted that difficulties existed in the beginning of 1956 and that some have not yet been eliminated. Thus, there were many delays in the installation of anchor towers on the sections. Well-drilling at Petrushenko and Novo-Kiyevskiy stations has not yet been started. Water necessary for construction was transported from the neighboring stations (282).

In June 1956 the installation of foundations and supports at Kulomzino station was completed (283). The double-track run between Kulomzino and Turn-out point No. 56 was turned over for installation work (284).

In July 1956 the electrification of Turn-out point No. 54 and Lyublinskaya stations was in progress (285).

In July 1956 electrification of the 144 kilometer section from Omsk to Nazyvayevskaya was progressing steadily. A stretch of track 105.7 kilometers long and 9 stations (out of 13 to be electrified on the total stretch) have been completed except for the stringing of the catenary wire, which was under way in July 1956. Six traction substations, including those at Dragunskaya, Novo-Kiyevskaya, and Kochkovatskaya, were also being erected ahead of schedule (286).

In August 1956 all sections and stations on the Omsk - Nazyvayevka stretch were turned over for installation work on the contact network. The electrification workers pledged to open the traffic of electric trains a month ahead of schedule (287).

The basic work on the entire Omsk - Nazyvayevskaya section was carried out ahead of schedule. Out of a total of 144 kilometers of trackage (from Nazyvayevskaya to Kulomzino) 105.7 kilometers and 9 stations out of 13, were made ready for the installation of the contact network (288). All 6 sub-stations, including Dragunskaya, Novo-Iyerusalimskaya and Kochkovatskaya stations were slated for installation work ahead of schedule (289). An illustration showing the suspension of the contact wire on Omsk - Nazyvayevskaya section is included on Fig. 32, 33. (290).

It is expected that as soon as the Omsk - Nazyvayevskaya - Vagay section is electrified, the weight of trains will be increased up to 6,000 tons and that the double headed traction on the total route will be eliminated. Some sections of the route will be dieselized and changed to electric traction some time later (291).

Construction of the new electrified rail line from Omsk to Nazyvayevskaya was completed on 5 November 1956. A few days later electric locomotives were expected to begin operations.

The line was placed in operation ahead of time thanks to the efficiency of the construction workers. The Nazyvayevskaya line was the fifth section of the Omsk system to switch to electric traction (292).

The first electric train was run on the Omsk - Nazyvayevskaya section on 15 November 1956, beginning the regular freight and passenger traffic on electric traction. Now the electrification of the Omsk system is almost complete. About 100,000 rubles will be saved by the introduction of electric traction on the Omsk - Nazyvayevskaya section (293).

Some illustrations are shown on Figs. 34, 35 and 36.

7. Construction and Electrification of New Barnaul - Omsk Trunk Line

The decision to build a new trunk line from Barnaul to Omsk was based mainly on the fact that the estimated mining of coal in the Kuzbass would rise 1 1/2 times (a total of 80,000,000 tons annually) by the end of the Sixth Five Year Plan period and would require additional transportation facilities (294). The double-track electrified line from Omsk to Novosibirsk thus will be overburdened by heavy traffic and construction of the new line will ease the situation (295).

It is expected that construction of the new line (total length of 775 km) will be started at its central section near the Kamen'-on-Ob' section, where an Hydroelectric Power Plant will be built in compliance with the Sixth Five Year Plan Period (296). This power plant will supply electric power to the new railroad extending from Barnaul to Omsk via Kulunda which will operate on electric traction (297).

The planning of the line was given to the "Sibgiprotrans" and "Lengiprotrans" Institutes (298).

The earth work has been started on the 230 kilometer long section from Karasuk to Kamen' (299).

The magnitude of the total construction of the trunk line may be judged by the fact that it required over 15 million cu m of earth work for dams and excavations, mainly for crossings of the Ob' and Irtysh rivers, involving 350 pipes, a number of various size bridges, construction of 4 stations with enginehouses and 40 intermediate stations, and a great number of turn-out trackage (300).

F. Electrification of Tomsk System Lines:

1. Electrification of Lines;
2. Operations;
3. Belovo Electric Locomotive Enginehouse;
4. Inskaya Electric Locomotive Enginehouse;
5. Novosibirsk Steam and Electric Locomotive Enginehouse.

1. Electrification of Lines

The main line of the Tomsk system starts in Chulymskaya and via Novosibirsk and Tayga it extends to Mariinsk on the Krasnoyarsk system; a major branch line of this system connects Novosibirsk via Inskaya and Belovo with Novokuznetsk, the center of Kuzbass coal basin and metallurgical industry of this area (301).

Electric traction was introduced on the Tomsk system on sections of the main line and the branch line to Kuzbass before World War II (302). Suburban traffic is also serviced by electric trains (303).

During the Second Five Year Plan the double-track mountainous Belovo - Novokuznetsk (141 km) section was electrified. This line carried Kuznetsk coal and Urals ore (304). According to V. E. Rosenfel'd this line was electrified in 1937 (305). There was a plan to electrify the following sections of this line in 1932-1933:

Usyaty - Polysayevo (124 km) with 20 freight and 2 passenger electric locomotives assigned;

Topki - Kemerovo (38 km) with 7 freight and 1 passenger electric locomotive assigned;

Kemerovo - Anzherka (117 km) with 7 freight and 1 passenger electric locomotive assigned;

Topki - Polysayevo (111 km) with 6 freight and 3 passenger electric locomotives (306).

Apparently this goal was never accomplished, since according to a reliable 1946 source the length of electrified lines of the Tomsk system still amounted to only 141 kilometers in 1946 (307).

According to Pravda, of 23 August 1955, the section of the main line from Chulymskaya to Novosibirsk and the line from Novosibirsk to Inskaya were (recently) electrified (308). Gudok reported the existance of an electric locomotive enginehouse at Inskaya in 1952 (309) with its electric locomotive turnaround point at Chulymskaya station (310). In 1951 Chulymskaya also served as turnaround point for locomotives from the Novosibirsk Steam Locomotive Enginehouse (311). The electric locomotive enginehouse at Novosibirsk was registered in 1953 with the simultaneous operation of a steam locomotive enginehouse at this station (312).

Apparently the section from Inskaya to Belovo was serviced (and probably still is) by steam locomotives. In 1951, steam locomotive enginehouses and an electric locomotive enginehouse were in operation at Belovo station (313). The assumption that the Inskaya - Belovo stretch still operates on steam traction may be supported by the fact that the 1956-1960 Plan call for the electrification of the line between Promyshlennaya and Belovo (314). Promyshlennaya is located on the stretch between Inskaya and Belovo, 203 km from Inskaya and 86 km from Belovo.

2. Operations

The enginemen of the Tomsk system have become well known for efficient operation of electric locomotives (315). High powered electric locomotives are used on the lines of this system (316) and since 1950 "VL22^{m}" electric locomotives started servicing this line (317).

The electric traction convincingly proves its advantages over steam traction. While previously these sections hampered the operations of the line, now, after electrification, they successfully handle increased freight traffic. The conversion to electric traction permitted higher speed and increased weight of trains (318).

The haulage of heavy trains was also successful. Thus, in 5 months of 1953 all railroaders of the Tomsk system ran 460 heavy trains pulled by electric locomotives (319).

By 1955 the system transported 2 1/2 times as much freight as before the war (320).

In 1956 the railroaders of the Tomsk system gave the following pledge to be fulfilled in 1956: to increase the average daily electric locomotive run by 40 kilometers above the plan and by 61 kilometers above the figure for 1955* (321); they expected to achieve this by extending electric locomotive runs from 800 to 1,000 kilometers

*In June 1955 some enginemen were bringing the runs of electric locomotives up to 400,000 kilometers. (Gudok, 7 June 1955, p. 2).

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without stops at enginehouses for servicing (322). As measures for improvement it was decided to organize technical inspection points for electric locomotives with sanding and lubricating services near arrival and departure yards (323). The railroaders pledged to put in operation to the plan 250 electrically centralized switches and introduce a radio system on 25 electric locomotives (324), and to train 2,535 railroaders including 235 locomotive enginemen (325).

Some illustrations are shown on Figs. 37, 38 and 39.

3. Belovo Electric Locomotive Enginehouse

The Belovo electric locomotive enginehouse is located at the largest railroad junction of the Kuznetsk Coal Basin (326). It services Novokuznetsk - Belovo rail section of the Tomsk system (327).

This enginehouse ships coal and metals by the main Kuzbass trunk line. Formerly, after each 150,000 km electric locomotives had to undergo lift repair. Recently some locomotives have run 352,000 km between lift repairs demonstrating that the average run could be extended to 300,000 km (328). One crew drove an express freight train weighing 1,400 tons above the norms from Belovo to Usyaty without overheating the locomotive (329).

Efficiency of Belovo enginemen is outstanding. D. P. Indukayev, has published a booklet on the increase of electric locomotive runs between repairs. The entire booklet is devoted to practices of the Belovo electric locomotive enginehouse and operations on the Belovo - Novokuznetsk section (330).

It has been also mentioned that the practices and experience of the best enginemen of the Belovo enginehouse were compiled in instruction form to be used by other enginemen (331).

4. Inskaya Electric Locomotive Enginehouse

It was reported that the Inskaya electric locomotive enginehouse was giving efficient performance in 1954 (332); the railroaders started hauling heavy trains (2,500 tons) with single-headed locomotives (333). In 1955 the railroaders of the enginehouse introduced a new system for better locomotive maintenance which resulted in reduction of repair operations (334).

In the first quarter of 1955 Inskaya electric locomotive enginehouse received an award for efficiency (335).

As reported in January 1956, the electric locomotive enginemen of the Inskaya enginehouse exceeded the average daily locomotive runs by 40 to 50 km. (336).

5. Novosibirsk Steam and Electric Locomotive Enginehouse

Novosibirsk, Inskaya and Belovo electric locomotive enginehouses are the largest enginehouses on the Tomsk system. Some information on their performance and operations was available and is given below:

Novosibirsk is one of the largest rail junctions of the Tomsk system (337) with steam and electric locomotive enginehouses (338). Novosibirsk railroaders service freight and passenger traffic on many sections of the Tomsk system, to Barabinsk and Tayga (339), which are the most important connecting points of the Urals and Siberia with the Far East (340).

The Novosibirsk railroaders were very efficient in 1954 (341) and they received an award for their performance (342). The freight haulage was fulfilled by 109 per cent; the average daily locomotive run exceeded the norm by 42 kilometers and the assignment for actual speed was exceeded by 2 kilometers. During the winter months the rolling stock was duely prepared for operations (343).

In 1955, electric locomotive enginemen of the Novosibirsk enginehouse introduced a new system of locomotive utilization which consisted of running locomotives with reduced volume of repair (344).

G. Electrification of East - Siberian System Lines:

1. Irkutsk - Slyudyanka section;
2. Cheremkhovo - Irkutsk section.

1. Electrification of Irkutsk - Slyudyanka section

This system is using basically steam traction so far, the only exception being the newly electrified Irkutsk - Slyudyanka section, which was constructed by 1950, to bypass the line along the shore of the Baykal Lake.

In the Sixth Five-Year Plan, all of the western section of the East Siberia Railroad system will be electrified (345).

The first section of the East Siberian rail line to be electrified comprises about 134 km (346). Construction of the electrified Irkutsk - Slyudyanka* section was begun as soon as the Irkutsk Hydro-Electric Power Plant, the first on the Angara River, began operations (347). The new line starts at Irkutsk near Raya station and runs to the south along the valleys of small rivers to Goncharovo station. Then it rises sharply through the tayga, crosses the Khamar-Babanskiy Mountain Range and descends to Lake Baykal where it joins the Trans-Siberian trunk line at Slyudyanka station (348).

The new line shortens the route from Irkutsk to Slyudyanka by 40 km (349). It is equipped with an automatic block system, centralized switch control and locomotive signaling (350). As reported in February 1956, all of the basic electrification construction and installation work with some insignificant exceptions, has been completed. Steel towers have been installed, the contact wire has been strung and several traction substations have been set up along the entire length of the new line (351). The traction substations located at Bol'shoy Lug and Goncharovo stations were already in operation in February 1956 (352). The remaining substations were expected to go into operation shortly. All of the substations will receive power from the local "TES" (Thermal Electric Power Plant) until the Irkutsk GES (Hydroelectric Power Plant) is completed (353).

The training of railroaders for operations on electric traction was started on this system a long time ago (354). A total of 170 electric locomotive enginemen, 155 helpers and many repairmen of locomotives and catenary systems have been specially trained at Irkutsk, Leningrad, and other technical schools (355).

*According to Tariff Handbook No. 4, 1954, p. 190, the distance between Irkutsk-I station and Slyudyanka II is 122 km.

As reported in June 1956, about 5,000 young workers were expected to arrive in Irkutsk to work on the reconstruction of the Irkutsk junction, Alzamay, Kuytun, Tulin, Nizhneangarsk, and Polovina stations, and electrification of the Irkutsk - Slyudyanka rail line (356).

After testing electric locomotives, suburban trains started operating on Kaya - Bol'shoy Lug section in February 1956 (357). When electric power is furnished to the Irkutsk junction, electric traction will be used also for freight traffic (358).

Electric traction operation was started on the newly electrified Irkutsk - Slyudyanka section in the second half of 1956 (359). The old section of the railroad (east from Irkutsk towards the Baykal Lake), was expected to be flooded as soon as the Irkutsk Hydroelectric Power Plant is placed in operation (360). Recently, some 10 high-powered "N-8" electric locomotives produced by the Novocherkassk plant have arrived on this line for operation (361).

An illustration shows electrified section of the Irkutsk - Slyudyanka line (362).

In October 1956, it was reported that the first suburban electric train began regular service between the Irkutsk-I and Irkutsk-2 station on 5 October 1956 (363). Sixteen electric motor cars will be used for suburban traffic. Four of these have been delivered, two of which are already in service in Irkutsk (364).

2. Electrification of Cheremkhovo - Irkutsk section

The plans are that the Cheremkhovo - Irkutsk section will be electrified as soon as the Irkutsk Hydroelectric Power Station is put in operation; later the remaining western route to Tayshet will be electrified also (365).

As reported in July 1956 the planners of "Sibgiprotrans" completed the survey of the 123 kilometer section from Irkutsk to Cheremkhovo, which is the next link of the system to be electrified (366).

The plan includes the construction of 5 traction sub-stations and as many transformer substations (367). Remote control posts will be established on the total Irkutsk division. Simultaneously, with the electrification of the section the right-of-way will be repaired and the length of trackage on separate sections will be extended and new dwelling houses will be built (368). The Irkutsk electric locomotive enginehouse will be reconstructed and will service all freight, passenger and suburban traffic on both runs: Irkutsk - Slyudyanka and Irkutsk - Cheremkhovo (369).

All preparations were made to have trained railroaders. Thus, there are 35 enginemen and 69 assistant enginemen trained at the railroad technical school in Irkutsk. One hundred thirty-two more enginemen and 50 assistants are taking courses without interrupting their employment (370).

In October 1956 preparations were being made for electric motor car service on the 63-km Irkutsk - Podkamennaya rail section. Motor car section will operate on the Irkutsk - Cheremkhovo rail section after it is electrified (371).

CHAPTER IX.

Electric Locomotive Rolling Stock:

A. Problems and Tasks of the Electric Locomotive Industry.
B. Development of Electric Locomotive Production.
C. Production Data.
D. Electric Locomotive Repair Plants.
E. Motor-cars and Their Development.
F. Production Chart.

A. Problems and Tasks of the Electric Locomotive Industry.

A. Alekseyev, member-correspondent of the USSR Academy of Science, declared that the Soviet rail transport faces great problems. The speed of freight and passenger traffic must increase at least two-fold. In solving that problem the electrification of rail systems and the transport electric machine building will play a very significant part (1).

The Sixth Five Year Plan provides for the production of not less than 2,000 electric locomotives (2). The question is - will the Soviet industry be in the position to cope with such a task.

Soviet publications give considerable attention to the problems of electric locomotive building. B. Beshchev, the Minister of Transportation stated that many problems concerning the production of electric (and Diesel) locomotives must be solved expediently (3).

However, P. Muratov, chief of the Tomsk system stated in August 1955 that the Ministry of Transportation and its Main Administration for Locomotive Services still consider the steam locomotive the basic type of locomotive in railroad transportation. This administration continues to develop and equip steam locomotives even though it is known that electric locomotives are more efficient and economical (4). Long experience of operating electric locomotives on numerous sections of the USSR rail lines proved the effectiveness and high safety of this type of locomotives (5). However, the capacities of the new locomotives are not yet fully utilized in relation to their turnaround and the increased weight of trains (6). Uninterrupted operation of power supply facilities has not been achieved (7).

Serious deficiencies in the construction of electric locomotives can be explained only by the insufficient attention to developing and perfecting electric traction (8). P. Muratov also said that it is hard to explain, for instance, why steam locomotives have a design speed of 100 km or more per hour while freight electric locomotives have only 75 km. Complete utilization of the tractive power of an electric locomotive is often limited by over-heating of the motor windings. The use of modern motor insulation material would greatly increase the capacity of the motors. Transmission gears of electric locomotives often break down. The problem of improving their durability has not been solved. In the process of replacing steam by electric locomotives unproductive expenditures for the construction of new enginehouses and other installations are incurred. Meanwhile the greater part of the existing steam locomotive enginehouses and auxiliary shops could be used for electric traction equipment (9).

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Of interest also is a statement of F. Mulyukin, chief Economic Planning Administration of the Ministry of Transportation, who stated that simultaneously with the creation of new type of locomotives the problem of more economical utilization of steam locomotives should not be disregarded (10). According to M. Mulyukin steam locomotives will still play an important part in the freight traffic operations in 1960. Scientists and research workers and engineers were called upon to continue their work on the modernization of trunk line steam locomotives, by equipping them with new devices (11).

There are considerable inadequacies in the organization of the scientific research work concerning development of electric and diesel locomotives (12). For example, the Institute of Complex Transportation Problems (Institut kompleksnykh transportnykh problem) of the USSR Academy of Science, does not actively participate in the creation of new type locomotive operating on alternate current (13). The Ministry of Ferrous Metallurgy and the Ministry of Electric Technical Industry were blamed for not being able to handle the production of some types of new equipment and materials necessary for electrified railroads, as stated by N. Lomagin*, who was at that time chief of the Main Administration for Electrification and Electric Power Management (14).

As reported in Pravda 5 August 1955, electric locomotive building plants of the Ministry of Electric Technical Industry have failed for years to conduct serious work on the creation of new, more modern electric locomotives and equipment which would answer the present day requirements in operations (15). It is admitted in Gudok that the electrification of railroads is hampered because of poor operational characteristics of electric locomotives (16).

I. Ivanov, director of the All-Union Scientific Research Institute of Rail Transport said that electric traction motors which are being built now in the USSR (in 1956) are of much inferior quality than the best foreign models. Use of insulating materials he said, which permits a 20% increase of engine capacity and extends the length of operating time, is carried out at an exceedingly slow pace (17).

According to I. Ivanov the delays in the development and production of new equipment for electric traction is due to the fact that the Ministry of Electrical Industry and the Ministry of Transport Machine Building have failed to develop specialized scientific-research and design organizations which would adequately handle the problems connected with the development of electrical equipment and rolling stock (18). Both of the above mentioned ministries were accused of being inefficient in bringing Soviet rail technique up-to-date (19). Little attention was given to the quality of electric locomotives and other equipment (20).

As stated in Pravda on 15 June 1956, the construction of improved electric locomotives definitively requires a better system of material supply to the plants (21). For example, while special-quality organo-silicon insulating varnish is necessary for modern electric motors, the organization of its production is quite inadequate (22). The Ministry of Ferrous Metallurgy is inefficient in supplying electric locomotive building industry with high magnetic permeable steel. Such quality steel is of the greatest importance for the reduction of locomotive weight and

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* N. A. Lomagin retired in accordance with the decision of the Minister of Transportation, as reported in Gudok, 13 June 1956. He was replaced by A.I. Tishchenko, who was previously chief of Electric Locomotive Division of the Main Locomotive Service Administration.

for the lower cost of electrical machinery. However, only very small quantities of this steel are being produced and the quality requires considerable improvement (23).

The Novocherkassk plant, the only one currently producing electric locomotives (24) is in need of alloy copper. This kind of copper was in production for quite some time. However, in spite of the continuous and endless correspondence between the ministries of Electro - Technical Industry and Non-Ferrous Metallurgy the problem of actual deliveries of this copper to the Novocherkassk plant has not been settled (25).

The Ministry of Electro-Technical Industry was blamed for neglecting to take steps in the development of the Novocherkassk plant to bring it to its designed capacity and to expand it further (26). As mentioned before the Novocherkassk plant is the only one producing electric locomotives. No steps were taken for the construction of electric locomotives at any other plants, as stated by A. I. Seredin* and E. G. Trubitsyn, in an article (27) published in "Railroad Transport," No. 8, 1955. The necessity of creating new electric locomotive building plants was stressed again in 1956 by I. Ivanov, director of the All-Union Scientific Research Institute of Rail Transport, who stated that wider application of electric traction in rail transport will necessitate considerable development of the existing plants and construction of new electric locomotive-building plants (28). As stated by A. I. Seredin the Novocherkassk Electric Locomotive Building Plant must be enlarged and a new electric locomotive plant will be built (29). There was no indication as to the location of the proposed new plant.

Concerning the reconstruction of the Novocherkassk plant, its fundamental rebuilding was started after World War II, but had not been completed in 1956 (30). As reported in June 1956 there were delays in the reconstruction of metallurgical, steel-smelting, machining and electrical shops, also in the construction of the laboratory-experimental facilities, completion of the testing trackage for the new locomotives (31). According to I. Ivanov, the very fact that up to the present time the Novocherkassk plant lacks such experimental base where the basic testing of electric locomotives could be conducted is a serious shortcoming (32). Probably all the delays were caused by many changes in the plans for reconstruction of the plant. As reported in 1956, the recent plan has not been approved (33).

A. I. Seredin revealed that in order to increase the production of electric locomotives by the Novocherkassk Electric Locomotive Building Plant, cooperation between this plant and the Voroshilovgrad plant must be promoted on a wide scale. The Voroshilovgrad plant must produce the mechanical part of the 8-axle "N8" and "VL23" series electric locomotives (34). He also stated that the question of including the Novocherkassk plant into the system of the Ministry of Transport Machine Building is a vital and urgent matter to be solved (35).

The urgent need of high-powered electric locomotives was revealed in a statement by D. K. Minov and P. K. Denisov, who admitted that due to the lack of such electric locomotives the USSR electrified rail lines use more and more double-headed and even triple-headed traction for haulage of trains 4,500 tons in weight (36).

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* In 1956 A. I. Seredin became chief engineer of the Main Locomotive Service Administration of the Ministry of Transportation. (Railroad Technical Equipment, No. 2, 1956, p. 4).

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B. Development of Electric Locomotive Production

The introduction of electric traction on the Soviet rail lines necessitated the organization of electric locomotives production within the country (37). Simultaneously, with the electrification of the Surami Pass (Surami Pereval), the very first section in the USSR, efforts were made for the creation of an electric locomotive building base (38), which would design and produce electric locomotives for operations at the Pass (39).

In 1929 the Moskva Electric Machine Building Plant "Dinamo" im. S. M. Kirov began designing an electric locomotive with the following characteristics: 132 ton weight on drivers, 1,200 mm wheel diameter of $0\text{-}3_0\text{-}0+0\text{-}3_0\text{-}0$ axle arrangement for operation on 3,000 v current and a regenerative braking system (40). At the same time the "Kuybyshev" Kolomna Machine Building Plant started production of body parts (41). In June 1932 electric equipment components for locomotives were produced by the "Dinamo" plant (42) and in August of the same year, the Kolomna plant completed the mechanical part (43). Installation of electrical equipment was carried out by the "Dinamo" plant. The first electric locomotive "S_s11 - 01" type (for illustration see Fig. 40) produced by Soviet plants passed the testing runs in November 1932, and later was sent for operation on the Surami Pass (44).

Simultaneously with the development of the "S_s" type electric locomotive, the "Kirov" Moskva Electrical Machine Building Plant "Dinamo" and the Central Locomotive Designing Office (TsLPB) started the designing of a freight-passenger electric locomotive with the $0\text{-}3_0\text{-}0+0\text{-}3\text{-}0$ axle formula (45). This electrical locomotive received the "VL19-01" designation, where VL stands for Vladimir Lenin and the number 19 indicated the axle load on rails (46).

The number which follows the type designation indicates the consecutive number of the locomotive produced (47).

The "Dinamo" plant and the Kolomna plant completed the building of this electric locomotive in three months. On 6 November 1932, the first Soviet-built main line electric locomotive "VL19-01" (for illustration see Fig. 41, 42) left the "Dinamo" plant grounds and was sent to Surami Pass for testing operations (48). The serial production of "VL19" electric locomotive was started two years later, in 1934 (49), the construction quantities have been improved (50) (for illustration see Fig. 43 & 59) (51).

The electric locomotives of "VL19" type were built in the USSR from 1934 to 1938 (52).

Beginning in 1947, "DPE-400B" traction engines were installed on electric locomotives of VL19 series during their overhall repair. Thus modernized electric locomotives received new designation of "VL19m", with 3,200 hp capacity, 20,000 kg of tractive effort and 43.5 km/hr speed (53).

In April 1934 the "Kuybyshev" Kolomna Machine Building Plant completed the building and assembly of the first Soviet-built passenger electric locomotive which received the PB21-01 designation. The designing was carried out by "Dinamo" plant in cooperation with "Lokomotivproyekt (Locomotive Designing Office) (54). This locomotive was made to develop a running speed of 87 miles per hour (55).

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It was during the summer of 1935 that the "Dinamo" plant* started designing 6-axle electric locomotives which received "SK" (Sergei Kirov) designation; this locomotive was the intermediate type between "VL19" and "S_s" locomotives (56). (For illustration see Fig. 44). The production of this type of electric locomotive was limited to only four units (57): the first one produced in 1936 and three others in 1938, then its production was discontinued (58).

In 1936 the plants ("Dinamo" in Moscow and Kolomna Plant) started production of "VL19" electric locomotives for low voltages, with a very complicated lay-out and two group switchers, and without rheostatic braking system (59). Twelve such electric locomotives were produced in 1936-1937: VL19-67,76,77,80 in 1936 and VL19-94, 96, 97, 102, 106, 107, 110, 115 in 1937 (60). In 1938 six more electric locomotives of VL19 type operating on two voltages were produced (61).

The "Dinamo" plant, in 1936, produced 6-axle electric locomotives with a rating identical to the "VL19" and "S_s" series. The locomotive received "SK-01" designation (For illustration see Fig. 44). In 1938 three more locomotives of this type (SK-02, SK-03, SK-04) were produced after which their production was terminated (62).

New electric motors were installed on the "SK" locomotives in 1938 at the "Dinamo" plant and they were given the "SKu" designation. In Russian the letter "u" means "reinforced" (63).

The Kolomna and "Dinamo" plants designed a modernized version of the "S_s" type electric locomotive during the first half of 1938 (64). During September of that year, the first electric locomotive of this new type was completed and received the "VL22" designation. (For illustration see Fig. 45) (65). The "VL22" electric locomotive is the best of the prewar period (66).

The "Dinamo" and Kolomna plants produced the first experimental single-phase direct current high-powered passenger electric locomotive (67) equipped with mercury-arc-rectifer for conversion of the 20,000 v alternate current from the network into direct current on the locomotive (68). The locomotive was tested at the end of 1938 and some defects were eliminated. In 1940 the locomotive was run on the testing trackage of the Scientific-Research Institute of the Railroad Transport and a number of changes and improvements were introduced. In 1941, however, the locomotive having the designation of "OR22-01" was dismantled (69). (See Fig. 46).

After World War II the decision was made to produce a freight electric locomotive with a 0-3o-040-3o-0 axle arrangement, with 132 t weight on drivers (70). In June 1946 the "Dinamo" plant built the first post-war electric locomotive which received "VL22[m]-184" designation (71). The "VL-22[m]" electric locomotive has a 22-ton axle weight, a maximum speed of 75 km/hr, and a designed tractive force of 27,700 kilograms (72). (See Fig. 74).

Beginning in 1947 the serial production of "VL22[m]" series electric locomotive was introduced at the "Budennyy" Novocherkassk Electric Locomotive Building Plant (73) which, following wartime destruction, was rebuilt as an electric locomotive building plant (74). The plant received its electric equipment components from the Moskva "Dinamo" plant (75).

*Evidently the production of electric locomotives was carried out by only these two plants, electric equipment being produced by "Dinamo", and the mechanical part by Kolomna plant. The installation of electric equipment was done at "Dinamo" plant.

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According to Rakov, in his book on locomotives in the USSR, the electric locomotive of "VL22^{m}" series was found inadequate for operations on steep grades on which traction capacities and traffic speeds should be boosted. The locomotive could not be used for single headed pulling of excessively heavy trains (76).

On 12 February 1956 it was stated in Gudok that the "VL22^{m}" electric locomotive was more productive than the steam locomotive. It is estimated that this engine replaced three "E" type or two "FD" type steam locomotives (77).

In 1952 the "Budennyy" Novocherkassk Electric Locomotive Building Plant designed an 8-axle electric locomotive of 2(0-2$_o$-0+0-2$_o$-0) type for operation on 3,000 volt D. C. current (78).

In March 1953 the Novocherkassk plant produced the first experimental 8-axle electric locomotive which received "N8-001" designation (for illustration see Fig. 47, 48 and 75). Its weight on drivers comprised 191.2 t, the weight per single driving axle - 23.9 t, and the design speed of 90 km per hour (79). In operation on 3,000 v in the contact network, the drawbar pull is 35,300 kilograms, speed 42.5 km/hr and 5,560 horsepower capacity. The capacity of this locomotive exceeds that of the "VL22^{m}" locomotive by 73 per cent (80), the speed by 19 per cent, and tractive force by 45.2 per cent (81).

During July 1953 - February 1954 period the "N8-001" electric locomotive was tested on the Surami Pass and on the South-Urals system (82). Its tractive and dynamic qualities were found satisfactory. However, during these tests, some inadequacies were revealed, such as "surges" of current on separate positions of the main handle of the controller, and many others. Since all deficiencies could be eliminated the decision was made to build an experimental group of such 8-axle locomotives with a reduction of weight per driving axle to 22.5 tons (83). This electric locomotive has the highest capacity of all types produced by the USSR (84). Each of its axles is equipped with a powerful electric motor, which permits to haul trains exceeding 3,500 tons on ascending grades at a speed of over 40 kilometers per hour (85).

In June 1954 the Novocherkassk Plant produced two "NO-1001" type experimental single-phase direct current electric locomotives. (For illustration see Fig. 49, 50, 51). (86).

A 95 kilometer experimental trip on the test trackage of the All-Union Scientific Research Institute of the Rail Transport was made in July 1954 by the "NO-1002" electric locomotive (87).*

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* According to Zheleznodorozhnyy Transport, No. 7, 1956, p. 9, these two locomotives, which later started operating on Ozherel'ye - Mikhaylov section of the Moskva-Kursk-Donbass system, must be improved by the constructors of the Novocherkassk Electric Locomotive Building Plant and in cooperation with the specialist of the Main Administration of Locomotive Management and All-Union Scientific-Research Institute of Rail Transport. Moreover, V. A. Gornyk, Deputy Minister of Transport, suggested to use the practice and experience of the foreign countries in a much wider manner. (Zheleznodorozhnyy Transport, No. 7, (July 1956, p. 9).

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In 1955 the Novocherkassk plant completed the designs for a 6-axle main line electric locomotive. The plans were finished three months ahead of schedule (88). The new 4,300 hp electric locomotive received the "VL23" designation. This locomotive surpassed the capacity of "VL-22^{m}" by more than 30 per cent. Its tractive force exceeds that of the "FD" steam locomotive 200 per cent at a speed of 70-80 kilometers per hour (89). The locomotive is 20 per cent lighter in weight as compared to the "VL22^{m}" (90), and can haul heavy freight trains with a speed of 100 km per hour (91).

By January 1956 the last units were installed in the "VL-23-001"* electric locomotive at the Novocherkassk plant, and it was tested for three days starting on 13 January 1956 (92). This locomotive was produced in an exceptionally short period of time. Tests have shown that it had excellent operating features (93).

By the end of January 1956 this locomotive was sent to Moskva. Simultaneously the plant was finishing the assembly of the second "VL-23-002" locomotive (94) which was completed and forwarded to Moskva on 14 February 1956 (95).

As reported in "Zheleznodorozhnyy Transport" one of the "VL23" type locomotives was forwarded to the South-Urals system for testing operations (96).

In accordance with the Sixth Five Year Plant the serial production of "VL23" 6-axle electric locomotives will be started in 1957 to replace presently produced "VL22^{m}" (97). The serial production of 8-axle "N8" of 5,700 hp capacity electric locomotives was started in 1956, at the Novocherkassk Plant (98). See Fig. 57, 58.

In 1956 the designers of the Novocherkassk plant and specialists of the Ministry of Electric Power Industry should have worked out plans and designs for a 4,500 hp passenger electric locomotive of 140 - 160 km/hr design speed (99). This locomotive should be able to pull a train consisting of 15 all-steel cars with a capacity of 1,000 tons.

It has been estimated that this electric locomotive will permit an almost two-fold increase of passenger train speeds (100). The first experimental model of this type will be produced by the Novocherkassk plant in 1957 (101). In accordance with the Sixth Five-Year Plan the Novocherkassk plant will produce three types of freight locomotives and one type of passenger locomotive during that period (102). Of great interest is the planned serial production of main line electric freight locomotives to operate on a single phase alternate current (103). Experimental units of this locomotive already have been built by the Novocherkassk plant (104), and in February 1956 were undergoing tests (105). As reported in the booklet entitled "New Type of Traction," published by the USSR Academy of Science, there are indications that the use of single phase alternate current electric locomotives may be extended to industrial transport as well (106).

As to locomotives used in industry, it has already been mentioned that several types of electric locomotives were created for use in metallurgical plants and mining industry (107). Among them some experimental units of the "12 ARVI" type were produced by the Aleksandrovskiy Machine Building Plant (Aleksandrovskiy mashinostroitel'nyy zavod im. Voroshilova), their design being worked out by "Giprouglemash" (State Institute for Planning and Designing of the Coal-Machinery Industry) (108).

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*For illustration see Fig. 52, 53, 54, 55, 56.

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The production of industrial electric locomotives is beyond the scope of this report, and the details on the production and performance of the Novocherkassk Electric Locomotive Building Plant will be discussed in a separate study. Electric locomotive production figures, found in Soviet open sources, are given in the next chapter.

C. Production Data

The production of electric locomotives began in the USSR in 1932 (109) when the "V. V. Kuybyshev" Kolomna Machine Building Plant and the "Dinamo" Electrical Machine Building Plant produced the first Soviet-designed and Soviet-built electric locomotive (110). In 1932 only 1 electric locomotive was produced (111). According to the statement of V. Iz'yurov published in "Electrification of Rail Transport" in 1932, the planned production capacity of the Kolomna and Dinamo plants, the only ones producing electric locomotives in the USSR at that time, could be brought up to 24 units in 1932* (112). The electric locomotive park at that time was exceedingly small and consisted mainly of imported electric locomotives (113). According to numerous sources 15 electric locomotives were ordered from the USA and Italy (114). Eight units were ordered from the General Electric Company and received in 1932; seven were ordered from an Italian firm and were received later -- 3 units in 1933 and 4 units in 1934 (115).

According to an official source, the electric locomotive park consisted of 30 electric locomotives in 1933 (116). In 1933 a total of 17 electric locomotives were produced in the Soviet Union (117).

The above figures differ considerably from the obviously exaggerated planned figures given in the "Electrification of Rail Transport" by V. Iz'yurov, published in 1932, according to which the USSR electric locomotive park was supposed to consist of 167 units in 1933. This total should have been comprised of planned production of 110 units by the Kolomna and "Dinamo" plants and 50 units by the Kashira Electric Plant**, which was under construction in 1932, plus additional 7 locomotives to be imported from Italy (118).

According to Rakov's 1955 book 21 electric locomotives of the "S_S" type were produced during the 1932 - 1934 period (119). It is not clear how the production was distributed through these years. It is known, though, that the annual plan called for the production of 40 electric locomotives (120) and according to official sources only 19 electric locomotives were actually produced in 1934 (121); some were of "VL19" type, the serial production of which was started during that year (122). In 1934 the entire Soviet electric locomotive park comprised only 48 electric locomotives (123).

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* Production of electric locomotives constituted a fraction of the total output of both plants.

** No record has been found on this plant in any available source. One could conclude that the plant was never completed as an electric locomotive producing establishment and that no electric locomotives were produced there.

The above actual figures could be again compared with the estimate given by V. Iz'yurov. He stated that the production of electric locomotives should amount to 510 electric locomotives in 1934, i.e. 110 locomotives were to be produced by the Kolomna and "Dinamo" plants and 410 units by the projected Kashira plant (124).

The 1935 annual plan called for an output of 50 electric locomotives (125), but only 38 electric locomotives were actually produced, or 76 per cent of the plan (126).

The 1935 plan called for an electric locomotive park of 98 units (127)*. This figure would be very close to the sum of the locomotives produced - 75 units -, and the 15 units imported from abroad.

While the 1936 annual plan called for the production of 62 electric locomotives (128), only 48 were actually produced (129). In 1937 only 32 electric locomotives were manufactured (130), a figure far short of the planned output of electric locomotives as slated by the Second Five Year Plan. The plan set the goal of annual production at 150 electric locomotives by 1937 (131). The goal of the entire Second Five Year Plan (1933 - 1937) was to produce 350 electric locomotives (132). Obviously the goal was not fulfilled.

According to Rakov's book of 1943 the total number of electric locomotives produced during the 1932 - 1938 period was 172 units, of the following types:

21 electric locomotives of "S_s" type, their serial numbers ranging from "S_s11-01" to "S_s11-21";

1 electric locomotive of "PB21-01" type;

4 electric locomotives of "SK" type, the serial numbers ranging from "SK-01" to "SK-04";

1 electric locomotive of "SK^u-05" type;

145 electric locomotives of "VL19" type, their serial numbers ranging from "VL19-01" to "VL19-145" (133).

If 15 imported electric locomotives are added to this total one may assume that the Soviet electric locomotive park consisted of only 187 units in 1938.

As stated by Rakov and Ponomarenko in their 1943 book, during the 1938 to 1941 period some 33 electric locomotives were produced of the "VL22" type, the only type produced since 1938 when the output of "VL19" was terminated (134). Their serial numbers ranged from "VL22-146" to "VL22-179" (135). Evidently the serial numbers of "VL22" took over the consecutive number of the last "VL19-145" produced in 1938.

The exact distribution according to annual production of electric locomotives in this period could not be established, except for 1940, when, according to an official Soviet source, the production of electric locomotives comprised only 9 units (136). The State Plan for the Development of the National Economy of the USSR for 1941 set the goal of producing 10 electric locomotives (137).

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* While L. Gumilevskiy in his 1946 and 1950 books, stated that there were only 84 electric locomotives in service in 1935 (Gumilevskiy; "The Railroad", 1950, p. 324, and his 1946 book, p. 306).

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If 33 electric locomotives produced during the 1938 - 1941 period were to be added to the park of 187 estimated for 1938, one could assume that by the beginning of World War II the electric locomotive park consisted of 220 units.*

The production of electric locomotives ceased during the war period following 1941, with additional 4 units built sometime in 1941, since the first electric locomotive built after World War II (June 1946) had the serial number of "VL22^{m}-184" (138).

It is known that the serial production of "VL22^{m}" was started in 1947 and the production base was switched from the Kolomna plant to the Novocherkassk plant, although the electric locomotive equipment was still produced by the "Dinamo" plant (139). The goal of producing 10 electric locomotives in 1947 was set by the plan for the Novocherkassk plant (140). The entire Fourth Five Year Plan (1946 - 1950) slated for production of 555 main line electric locomotives (141), and was apparently intended for the Novocherkassk plant, which is described in 1947 as the only one producing main line electric locomotives (142).

According to B. I. Levin and his book "Ways of Railroad Transportation Reconstruction in the Post-war Stalin Five-Year Plan Period," during the 1946 - 1950 period the USSR railroad transport was enriched by new type locomotives. In accordance with the plan the Ministry of Transport Machine Building created after the war, was given a target to increase the annual production of electric locomotives to 220 units by 1950 (143). However, according to an official 1956 source only 102 electric locomotives were built in 1950 (144).

In compliance with the directives of the Nineteenth Communist Party Congress the Fifth Five Year Plan (1951 - 1955) stipulated the beginning of intensive production of electric locomotives (145). No information was available for the 1951 to 1953 period to determine the volume of produced locomotives.

However, according to the announcement of the Central Statistic Administration of the Council of Ministers, 158 electric locomotives were produced in 1954 (146), and in the first half of 1955 the electric locomotive production was 122 per cent over the same period of 1954 (147).

In 1955 there were produced 194 electric locomotives (148). Evidently this number included the four new 8-axle 5,700 hp electric locomotives produced by the Novocherkassk plant, as reported by I. Ivanov, director of All-Union Scientific Research Institute of Rail Transport (149).**

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*Compare this figure based on the actual production and park figures from comparitively reliable sources with the statement of A. G. Naporko in his book "Outlines of Development of Rail Transportation," 1954, pp. 157-8. He stated that during all pre-war Five Year Plan periods the electrification of rail lines permitted the release of 4,000 steam locomotives. Considering an equivalent performance of three steam locomotives replacing one electric (the highest evaluation) the above figure would indicate a park of 1,000 units, what seems to be an exaggeration even when including electric car sections, used in suburban traffic of Moskva, Baku, and some other cities.

** By February 1956 the first eight 5,700 hp 8-axle ("N8") electric locomotives were already built and operating in the Ural Mountains and Siberia. (Gudok, 11 February 1956).

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According to results of the Fifth Five-Year Plan announced in Pravda, 25 April 1956, relatively few electric locomotives were produced in the Fifth Five Year Plan and there were many difficulties in the introduction and utilization of them by railroad lines (150).

The directives of the Sixth Five Year Plan call for the production of 2,000 electric locomotives, including 400 eight-axle, 5,700 hp units (151). This total production is apparently intended for the Novocherkassk plant, as stated in "Railroad Transport", No. 4, 1956 (152).

According to B. Sh. Tabachnik, chief engineer of the Glavelektromashprom (Main Administration of the Electric Machine Building Industry) of the Ministry of Electro-Technical Industry of the USSR, it is planned to produce 20 "N8" 8-axle electric locomotives in 1956, in addition to a large group of "VL22" electric locomotives (153). Also, 11 electric locomotives operating on alternating current will be produced during 1956 (154).

According to the Directives of the XX Congress of the Communist Party of the USSR, the annual production of electric locomotives will amount to 550 units by 1960, and calculated in percentage to 1955 - to 284 per cent (155), and in percentage to 1940 - to 61 times as much* (156). In short, the production of electric locomotives in 1960 will increase three-fold as compared to 1955 (157).

P. Abroskin, director of the Novocherkassk plant, stated that the cooperation of the Voroshilovgrad plant, which can produce mechanical parts for electric locomotives, can increase the annual production from 550 (as stipulated by the plan) to 1,000 units (158). The production can be boosted by 40 per cent in the improved production organization, reconstruction of the plant (159), and better utilization of existing capacities (160). It is expected that the Novocherkassk plant will produce almost 2 electric locomotives daily by 1960 (161).

The need in electric locomotives, as stated in "Railroad Transport" in 1946, will amount to 10,000 units by 1960 (162). The actual conditions reflected in figures given in connection with the 20th Anniversary of the Novocherkassk plant in May 1956 are short of this goal. The total production of this plant of "VL" locomotives was 1,000 units by May 1956 (163). In addition this plant produced four "N-8" locomotives in 1955 and four in two months of 1956 (164) and several "VL23" locomotives since the beginning of their production in January 1956. If we add the pre-war park of 224 units (assuming that all of them are still in operation), and include the total planned production of 2,000 units (165) for the 1956 - 1960 period, the maximum total park for 1960 would not exceed 3,235 units.

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* This corroborates the figure of 9 electric locomotives produced in 1940, and 194 in 1955.

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Whether the ambitious plan for the Sixth Five Year Plan period to produce 2,000 locomotives can be fulfilled may be judged by the poor production results in the first half of 1956. As published in Pravda, 2 August 1956, and according to a communication from the Central Statistical Administration of the USSR Council of Ministers, 105 electric locomotives were produced during the first six months of 1956, which amounts to 112 per cent as compared to the same period of 1955* (166).

As announced by the Central Statistical Administration the locomotive building industry produced 216 trunk line electric locomotives in 1956 (167).

D. Electric Locomotive Repair Plants

As far back as 1954 L. M. Kaganovich, First Deputy Chairman of the Council of Ministers of the USSR, stated at a meeting of the railroad workers convention of 8 May 1954, that the repair of electric locomotives (and diesels) was an acute problem and that a repair base should be created (168).

In 1956, a similar statement was made by A. A Paramonov, chief of the Main Administration of the Locomotive and Railroad Car Repair Plants of the Ministry of Transport, who said that in connection with the wide development of electric traction proper locomotive repair bases should be created (169).

According to the Sixth Five Year Plan the whole system of electric locomotive repair will be re-organized, as stated by V. A Garnyk, Deputy Minister of Transport** (170), and an adequate repair base created (171). It was planned that during that period the Novosibirsk, Tbilisi, Ulan-Ude and Zaporozh'ye plants would be reconstructed and prepared for the repair of electric locomotives. The construction of a new Chelyabinsk plant should be completed also(172). During the following years (Seventh Five Year Plan period) the Ufa, Sverdlovsk and Yaroslavl' plants would be reconstructed for the same purpose (173). It has been estimated that the number of electric locomotives subject to plant repair by 1960 would increase 4 times as compared with 1955, and 10 times by 1965 (174).

B. Podshivalov stated that existing plants could handle the load of electric locomotive repair. The only problem being in the distribution of repair plants. For example, not a single electric locomotive repair plant was planned for the entire route from Moskva to Irkutsk (175). Electric locomotives scheduled for repair have to cover great distances to get to the repair plants and then back to their enginehouses (176). The suggestion was made by B. Podshivalov that it would be more advantageous to reconstruct the Perovo plant (now engaged only in repair of motor-car units) and Michurinsk Steam Locomotive Repair Plant for the repair of electric locomotives (177).

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* According to this percentage the first six months of 1955 would show a production of 94 units, and the first six months of 1954 would show 77 units.

** V. A. Garnyk, declared that Soviet-produced electric locomotives can easily operate some 1,500,000 kilometers without plant repair. However, their actual runs between capital repair is limited to 540,000 km due to necessity for the repair of traction motors. In its turn, the limitations of the traction motors are caused by bad quality of insulation, which disintegrates after the run of 300,000 - 400,000 km. Similarly the collectors of traction motors, are worn out after 200,000 km runs. V.A. Garnyk compared collectors used in foreign countries which can operate without repair some 1,500,000 km. (Zhel. Transport, No. 7, 1956).

As reported in Railroad Transport, No. 4, 1956, the Tbilisi Locomotive Repair Plant has been adapted for the repair of electric motor-car units. It has been planned that the October Railroad Car Repair Plant in Leningrad would be converted for a similar purpose and should start new operations in 1957 (178). It was planned that in later years, the Kiyev Railroad Car Repair Plant and Krasnoyarsk Steam Locomotive Repair Plant would both switch to the repair of electric rolling stock (179). The Khar'kov and Molotov Steam Locomotive Repair plants will be reconstructed for the capital repair of traction engines and other electrical machines (180).

E. Motor-cars and their Development

The electric motor-car traction in the USSR was initiated in 1926 in the suburban passenger traffic when the first motor-cars started operating on the Baku - Sabunchi rail line (181).

Soviet suburban electrified lines, as a rule, are serviced by three-car electric units made up of one motor-car and two trailer cars. The electric suburban trains are usually made up of two or three units, that is they are comprised of six-car and nine-car compositions. According to K. Molchanov, three-car trains are not used on the USSR rail lines as they do not secure through-put capacity of lines, therefore the four-car electric trains are more advantageous (182). During 1956 the largest volume of suburban electrified lines were serviced in the USSR by nine-car electric trains, however it has recently become necessary to apply twelve-car electric trains (183).

The most intense suburban motor-car traffic found in the USSR is near large cities; mainly large industrial centers, where approximately 100-250 pairs of trains operate daily. It is planned that motor-car traction will be developed on a very wide scale so that by 1965 it will be used in such large industrial centers as Khar'kov, Dnepropetrovsk, Stalino, Rostov, Kuybyshev, Ufa, Kiyev, Sverdlovsk, Perm' and Chelyabinsk (184).

Motor-car trains were operating on 1,200 volt current when they were first introduced on the Soviet suburban rail lines in 1926. Some time later 1,500 volt current was used (185). In his book on the development of rail transport in the USSR, Naporko stated that all motor-car units produced in the USSR before World War II could operate only on 1,500 volt current (186).

There are three basic series of motor-car units operating on the USSR rail lines; "S_s^f", "S^r", "S_d". For illustration see Fig. 60, 61, 62 (187).

Production of motor-car units was initiated in 1926, when the first motor-cars were built by the Mytishchi Railroad Car Building Plant (188). For illustration see Fig. 63. The electrical equipment was supplied by the Moskva "Dinamo" plant (189). About 1929 the "S^v" (See Fig. 64, 65) series of motor-cars were produced and in 1931 the "S_d" series motor-cars were initiated (190). Three-car units of "S_d" series were produced by the Mytishchi plant from 1932 to 1941 (191). For illustration see Fig. 72.

In the mid-thirties the Mytishchi Railroad Car Building Plant underwent reconstruction (192).

The decision was made to use 3,000 volt current in 1933; in this connection the designing of motor-cars operating on both 1,500 and 3,000 volt current was started in 1935 (193).

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After World War II the basic producer of motor-car units in the USSR was the Riga Car Building Plant, formerly known as "Vairogs" plant. A producer of freight cars before the war, it switched to the production of street cars and electric train cars after the war (194). According to "Zheleznodorozhnyy Transport", 1947, the Riga Car Building Plant was put in operation in early 1947, after being destroyed during the war (195).

According to Rakov, the Riga Plant was engaged in the installation of new equipment on "S_d" and "S_v" series motor-cars, as the old equipment was completely worn out. Simultaneously the plant started the construction of the mechanical part for new three-car units and the assembling of electrical equipment for them. The electrical equipment was produced for operation on both 1,650 and 3,300 v current by the "Dinamo" plant and was identical to that used on the "S^m" series motor-car units (196). See Fig. 73.

The first motor-car unit was produced by the Riga plant in the beginning of 1947 and received the "S^r" series designation, which stands for: "S" - Severnaya (Northern type) and "r" - constructed by Riga plant. For illustration see Fig. 60 & 66. The first testing run was carried out on 17 April 1947 on the Moskva-Strunino section of the Northern system (197).

In 1949 the production of electrical equipment was partly switched to Riga Electrical Machine Plant (198). According to I. V. Abramov, in his book entitled "Paths of Technological Progress in Soviet Machine Building," the Riga plant was said to manufacture complete units for electric cars (199).

In order to increase the speed of traffic of the suburban electrified trains, the All-Union Scientific-Research Institute of the Rail Transport worked out the design of new type motor-car units for lines electrified by direct 3,000 volt current (200).

Beginning in October 1952 the Riga Railroad Car Building Plant and Riga Electrical Machine plant started to produce three-car units, adapted for operation only on 3,000 volt current. These units, designated as "S^r_3" series (number stands for 3,000 volts) differed from "S^r" series by simplified and modernized electrical equipment (201).

During March - April 1953, the "S^r_3 1160" series motor-car unit was given a test run on the Riga - Kemeri section of the Baltic system. For illustration see Fig. 62 (202).

The 1953 the design department of the Riga Railroad Car Building Plant completed the plans for the motor-car units operating on 3,000 v direct current and with a speed capacity of 130 km/hr. (203). The electrical equipment for this unit was designed and produced by the "Dinamo" Plant im. S. M. Kirov in Moskva, and the Riga Electrical Machine Building Plant. The mechanical part of the unit and the assembling of the electrical equipment was done by the Riga Railroad Car Building Plant (204).

New motor-car units were equipped with a perfected control system, electrical-pneumatic brakes which permitted increased speed and improved the safety and traffic conditions (205).

In early January 1955, the newly constructed motor-car unit "SN" (see illustration Fig. 67, 68, 69) arrived in Moskva and made several test trips on the testing trackage of the All-Union Scientific Research Institute of Rail Transport, and later on

the Moskva - Klin section of the October system. The speed of the motor-car unit on Kryukovo - Moskva section was brough up to 120 km/hr (206).

In January 1955 several publications stated that the Riga Car Building Plant completed the building of the first three motor-car units (207). This event was widely publicized by the Soviet press. "Kazakhstanskaya Pravda" stated that the capacity of the electric motor was boosted up to 1,000 horse power (208). The units were equipped with comfortable seats and improved ventilating system. Technical qualities were boosted, the construction of the trailer motor-car trucks improved (209). The new electric units were to be in service mainly on rail sections which have high platforms for passengers. Preparations were being made at the plant for the serial large-scale production of these new electric units (210).

Information was published in the July 1955 issue of Trud which revealed that the Riga Plant had recently built two experimental motor-car units operating on alternating current with a speed of up to 130 km/hr, which is 50 km over the speed of electric trains presently in service. It was planned to use the new electric train units in 1956 for the suburban traffic in Moskva and Leningrad (211).

The January 28, 1956 issue of Gudok reported that the suggestion was made that the Riga Electrical Machine Building Plant completely take over the production of traction equipment for the electric motor-car units and thus relieve the "Dinamo" plant of the task (212). M Gruzov, deputy Minister of the Electrical Technical Industry was in favor of this suggestion although complaints were made previously that the plant simply refused to use modern methods of assembling electrical equipment. There was and still is the tendency to use outdated systems and methods, which result in unnecessary increases in weight of the motor-car rolling stock (213).

In connection with the noticeable lag which occured at this plant, the Ministry of Electro-Technical Industry (in cooperation with the Ministry of Transport) started to develop the system for rheostatic-regenerative braking to be used for motor-car units. The Riga plant was excluded from participating in the development of these systems as well as in the testing of the equipment for the experimental cars (214).

Evidently lagging at the Riga plant caused some adverse publicity which drew attention to the main administrations. V. Samokhvalov, chief Technical Administration of the Ministry of Transport declared that the Technical Administration of the Ministry of Transport had made recommendations to the Car Building Administration of the Ministry of Transport Machine Building and to the Riga Plant for the improvements to be made in testing methods of the electric cars, efforts in the reduction of weight and many others (215).

In a letter, published in Gudok, I. Petrovskiy, chief engineer of the Main Car Administration of the Ministry of Transport Machine Building, acknowledged and admitted the deficiencies in the construction of the new electric motor-car trains, and inadequacies in the organizational structure. He stated though, that steps were taken by the administration of the plant to eliminate these inadequacies. Thus, efforts were made to reduce the weight of motor-cars, so as to reduce the weight of a ten-car train by 22.5 tons (216).

In a February 1956 meeting of the designers and technicians of the Riga Car Building Plant, and the specialists from Riga "REZ" (Riga Electrical Machine Building Plant), shortcomings holding up the production of new electric rolling stock were discussed and plans were made for perfecting the construction of the electric motor-car units (217).

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In 1956, in connection with the wider development of the suburban passenger traffic in the industrial centers, the locomotive building industry planned to produce a new type of motor-car unit with 130 km/hr design speed and improved pick-up capacities, as compared with the presently operating and existing motor-car units (218). According to Gudok, 11 February 1956, the Riga Car Building plant had at that time almost completed the design of a new electric train unit made up of five cars and five trailers. It was planned that three such trains would be produced and tested in 1956 (219).

In accordance with the Sixth Five Year Plan*, the Riga Car Building plant will produce improved motor-car units for the suburban passenger traffic during that period. As mentioned before, the plant has suffered a number of setbacks. In the design and production of electric train test models, shortcomings appeared during the testing which made it impossible to accept the sections for serial production (220).

It was reported in September 1956, that during the first 8 months of that year, the electrified main railroad lines had received an extra 80 series-produced electric sections from the Riga car construction plant. Recently the construction of motor-car sections produced by the plant has improved sharply.

The construction of a new type of electric train, the ER-5, is planned for the near future. A new type of elastic mounting is planned for the traction motor which will soften the jar from rail joints and will prolong engine life. The transmission from the motor to the reducer will be a disc-torsion clutch (221).

The 21 September 1956 issue of Gudok reported that the Riga Railroad Car Building Plant must produce the first "ER-1" type electric motor-car train by 7 November 1956. The new type motor-car is 4 tons lighter in weight than the one now serially produced. The "ER-1" electric unit will be made up of 10-car composition.

The "ER-1" motor-car train has only one trailer car following each motor-car while the motor-car unit which is now in serial production has two trailer cars following each motor-car. The new train will accomodate 1,056 passengers. One hundred thirty kilometers per hour will be its maximum speed.

Due to the approaching deadline for this design, the work at the plant was in full swing. Simultaneously the work on the construction of 8-car electric train "ER-5" type was also speeded up (222). For illustration see Fig. 70, 71.

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* Concerning the repair of motor-car rolling stock, the Sixth Five Year Plan foresees the repair of electric motor-car units at: Perovo plant, "Pamyati revolyutsii 1905 goda," at October plant (in Leningrad), at Tbilisi Locomotive Repair Plant, at Krasnoyarsk Steam Locomotive Repair Plant and in the workshops at Perm', as reported in Gudok, 8 September 1956.

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F. Production Chart

Years	Planned Production	Actual Production	Park	Remarks
1932	24(2)	1(1)	1 + 8 = 9(3)	
Second 5 Year Plan 1933-1937	350(22)			
1933	160(7)	17(4)	30(5)	167(6)
1934	40(8)	19(9)	48(10)	510(11)
1935	50(12)	38(13)	75 + 15=90(15)	98(14)
1936	62(16)	48(17)	120(18)	
1937	150(21)	32(19)	152(20)	172(23)
Third Five Year Plan 1938 - 1942				187(23a)
1938				
1939				
1940		9(24)		
1941	10(25)	33(26)		220(27)
World War II				5(20)
Fourth Five Year Plan 1946-1950	555(28)			5(29)
1946				
1947	10(30)			
1948				
1950	220(31)	102(32)		

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F. Production Chart Cont'd.

Years	Planned Production	Actual Production	Park	Remarks
Fifth Five Year Plan 1951-1955				
1954		158(33)		
1955		194(34)		
Sixth Five Year Plan 1956-1960	2,000(35)			
1956	(36)	Jan-Jun = (40) 105 105		
1956		216(41)		
1960	550(37)			2(38) daily
1960				10,000(39)

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Production Chart

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1) M: Rakov, "Locomotives of the USSR Railroads," 1955, p. 321
also: M: "National Economy of the USSR," 1956, p. 56

2) Planned production in 1932 according to Izyurov. (P: Electrification of Rail Transport," No. 10, 1932, p. 6).

3) Probable figure: 1 - produced, and 8 - imported in 1932. (Rakov, 1955, p. 318).

4) M: Plan for 1935, published in 1935, p. 512

5) M: Plan for 1935, p. 512. This figure is very close to the one derived by addition of locomotives produced and imported: 18 + 8 + 3 = 29.

6) Locomotive park for 1933 as estimated by V. Iz'yurov. (P: Electrif. Rail Transport, 1932, No. 10, p. 6)

7) Planned production estimated by V. Iz'yurov: 110 locomotives to be produced by Kolomna and "Dinamo" plants and 50 by projected Kashira plant. (P: Elec. Rail Trans., 1932, No. 10, p. 6)

8) Planned production. (Plan for 1935, p. 512)

9) M: Small Soviet Encyclopedia, No. 7, 1938, p. 975 also:
M: Plan for 1935, p. 512

10) M: Plan for 1935, p. 624

11) The 1934 production as estimated by V. Iz'yurov, (P: Electrif. Rail Trans. No. 10, 1932, p. 6)

12) M: Plan for 1935, p. 512

13) M: Plan for 1936, p. 415

14) M: Plan for 1935, p. 624

15) Probable locomotive park, made up of the sum of all produced locomotives, plus 15 imported locomotives.

16) M: Plan for 1936, p. 415

17) M: Small Soviet Encyclopedia, No. 7, 1938, p. 975

18) Sum of locomotives produced and imported.

19) M: National Economy of the USSR, 1956, p. 56

20) Probable locomotive park; summed all production data plus imported locomotives.

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21) Goal set by the plan. (M: Second Five Year Plan, 1934, p. 456)

22) Goal set for entire Second Five Year Plan period. (M: Second Five Year Plan period, 1934, p. 252)

23) Sum of all locomotives produced during 1932 - 1938 period. (M: Rakov and Ponomarenko, "Elektrovoz," 1943, pp. 38-40)

23a) Sum of all locomotives produced and imported. (M: Rakov and Ponomarenko, "Elektrovoz," 1943, pp. 38-41)

24) M: National Economy of the USSR, 1956, p. 56

25) M: State Plan for Development of National Economy of the USSR in 1941, p. 43

26) Data on locomotives produced during 1938-1941. (Rakov and Ponomarenko, 1943, p. 41)

27) Sum of 187 (see - 23a of text) and 33 (see 26) added.

28) Entire goal set by the Fourth Five Year Plan. "M: B. I. Levin, "Ways of Railroad Transportation Reconstruction in the Post-War Stalin Five-Year Plan, 1949, p. 14

29) Probable production during 1941-46 period. For details see text and reference (20)

30) Goal set for 1947 annual production of Novocherkassk plant. (N: Trud, April 11, 1947)

31) Target for 1950 production. (P: Planovoye Khozyaystvo, Jul-Aug 1946, p. 25)

32) M: National Economy of the USSR, 1956, p. 56

33) M: National Economy of the USSR, 1956, p. 56

34) Ibid

35) Goal for entire VI-th Five Year Plan Period. (N: Gudok, 12 Feb 56, also M: Notebook of the railroad propaganda workers, No. 3, February 1956, p. 2)

36) Planned production of 20 units of 8-axle and 11 alternate current locomotives, plus unknown number of "VL" type locomotives. (Gudok, 5 Apr 56), also P: Zheleznodorozhnyy Transport, No. 4, 1956, pp. 27-30)

37) M: National Economy of the USSR, 1956, p. 60

38) Planned daily production figure of Novocherkassk plant. (Gudok, 11 Feb 56)

39) Requirement for electric locomotives, in 1960. (P: Zhel. Transport, No. 7, 1946, p. 17)

40) Produced in 6 months of 1956. (N: Pravda, 2 Aug 56), also N: Turkmenskaya Iskra, 3 Aug 56)

41) Annual 1956 production figure (Turkmenskaya Iskra, 2 Feb 57, p. 2)

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1) Gudok, 1 Mar 56, p. 3

2) Ibid

3) Gudok, 1 Mar 56, p. 3

4) Kaganovich, Speech of the XX Congress of the Communist Party, 18 Feb 56, p.16

5) L. M. Kaganovich, To Improve the Operation and Organize a New Upswing of the Rail Transport, 1954, p. 70

6) Pravda, 25 Feb 56, pp. 8-9

7) Gudok, 1 Mar 56, p. 3

8) Gudok, 16 May 56, p. 2

9) Gudok, 1 Mar 56, p. 3

10) Gudok, 23 Jun 56, p. 3

11) Ibid

12) Gudok, 7 Sep 56, p. 1

13) Pravda, 5 Aug 55, p. 4

14) Gudok, 7 Sep 56, p. 1

15) Golovanov, 56, p. 39

16) Sixth Five Year Plan for Development of the National Economy of the USSR, 1956, p. 41

17) Ibid

18) Great Soviet Encyclopedia, Vol. 63, 1933, Moskva, p. 489

19) Results of the Second Five Year Plan Fulfillment, 1939, p. 35

20) Ibid

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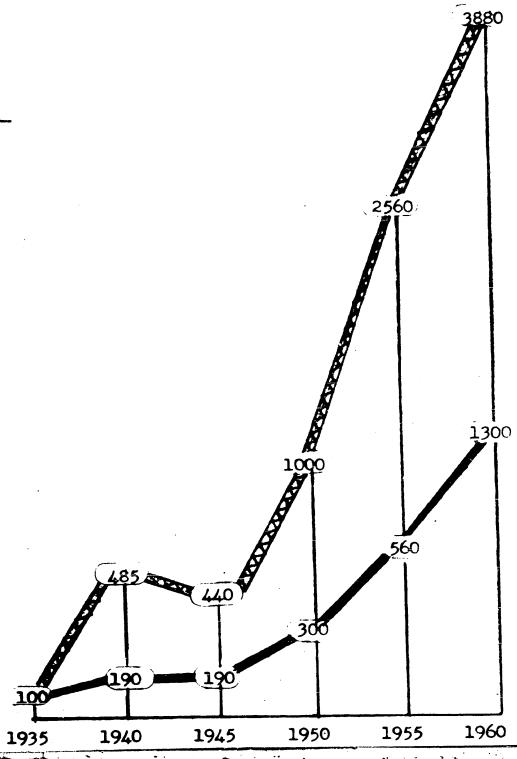

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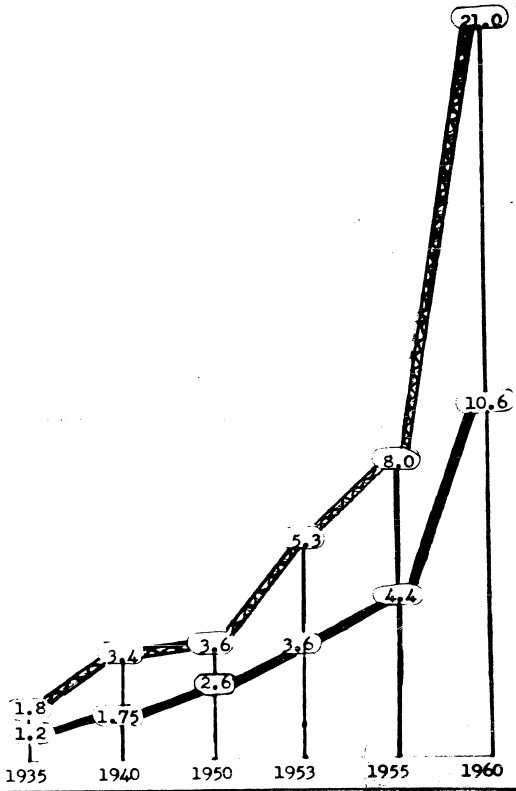

No. 2

Fig. 1 - Freight traffic on the electrified lines, calculated in ton-kilometers increased 8.8 times in 1955 as compared to 1940. The growth in length of electrified lines and the performance carried out by locomotives is shown on the attached diagram, No. 1

Diagram No. 2 shows the percentage of electrified lines to the total length of rail network and the freight traffic.

SOURCE: Golovanov, 1956, p. 9.

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LEGEND:

New rail lines

Second track

Electrified rail lines

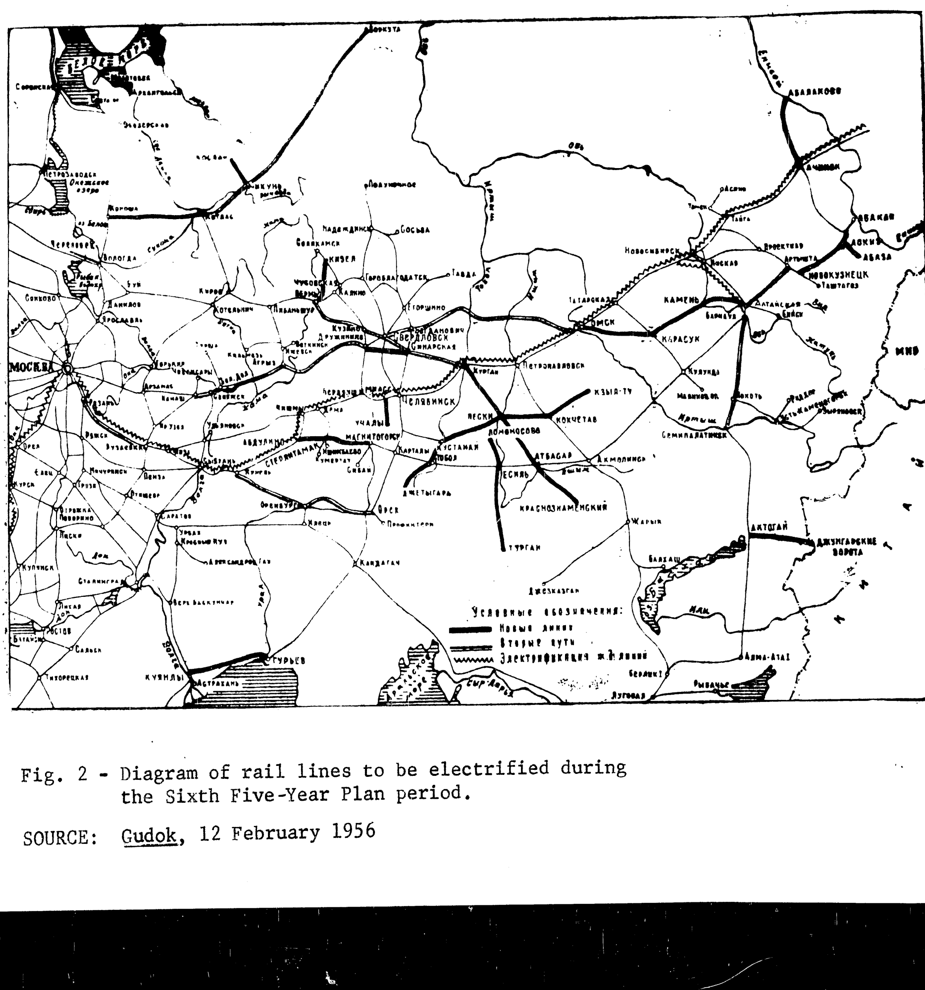

Fig. 2 - Diagram of rail lines to be electrified during the Sixth Five-Year Plan period.

SOURCE: Gudok, 12 February 1956

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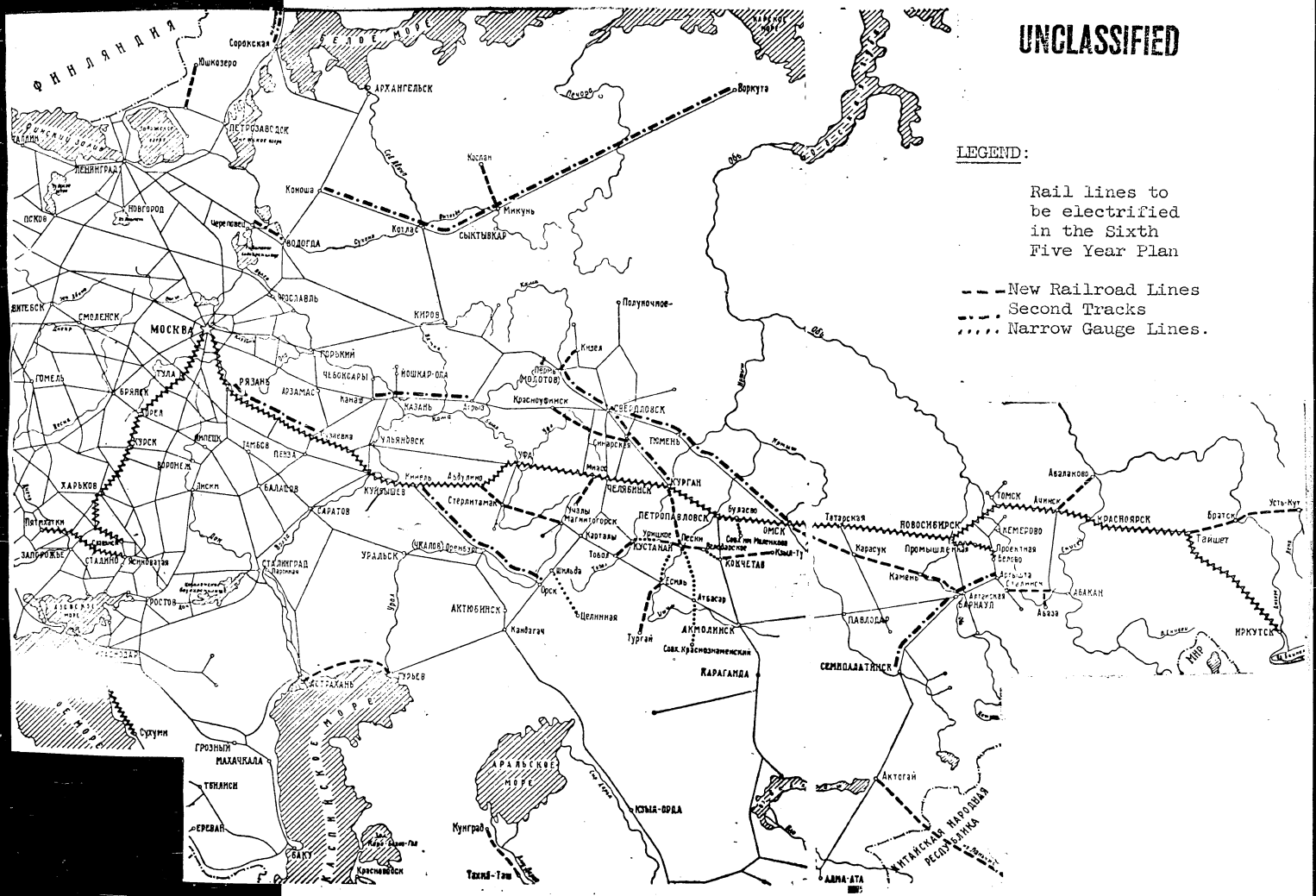

LEGEND:

Rail lines to be electrified in the Sixth Five Year Plan

- - - New Railroad Lines
. . . . Second Tracks
. . . . . Narrow Gauge Lines.

Fig. 3 - Map showing rail lines to be electrified during the Sixth Five-Year Plan.

SOURCE: Zhelezodorozhnii Transport, No. 3 (March 1956), pp. 48 - 49.

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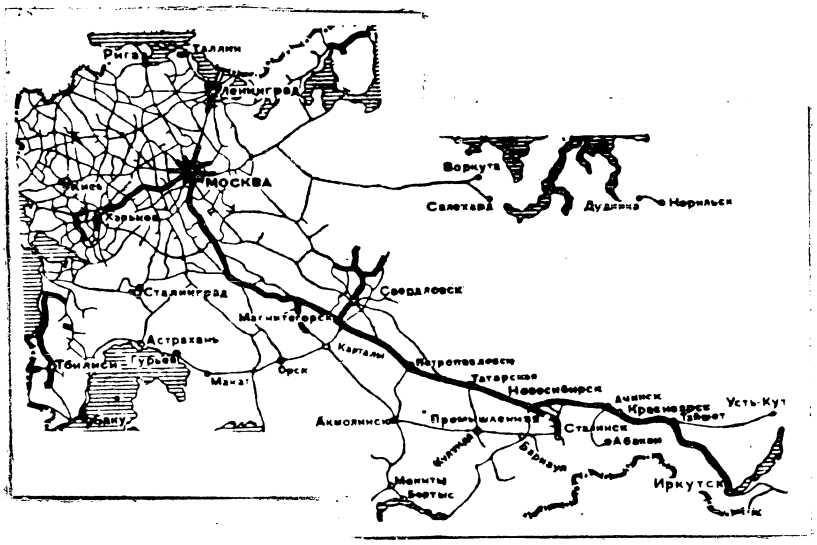

Fig. 4 - Map of rail lines (solid lines) to be electrified by 1960

SOURCE: Gudok, 27 January 1956.

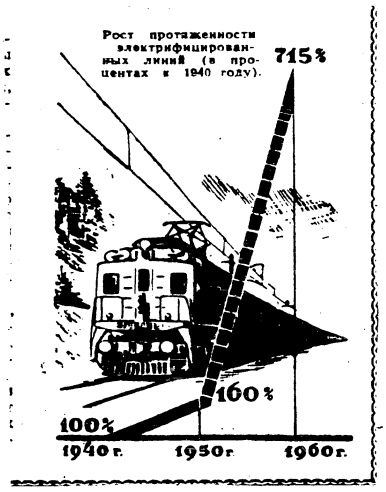

Fig. 5 - Diagram showing the growth of electrified rail lines from 1940 to 1960 (in per cent).

SOURCE: Gudok, 27 January 1956.

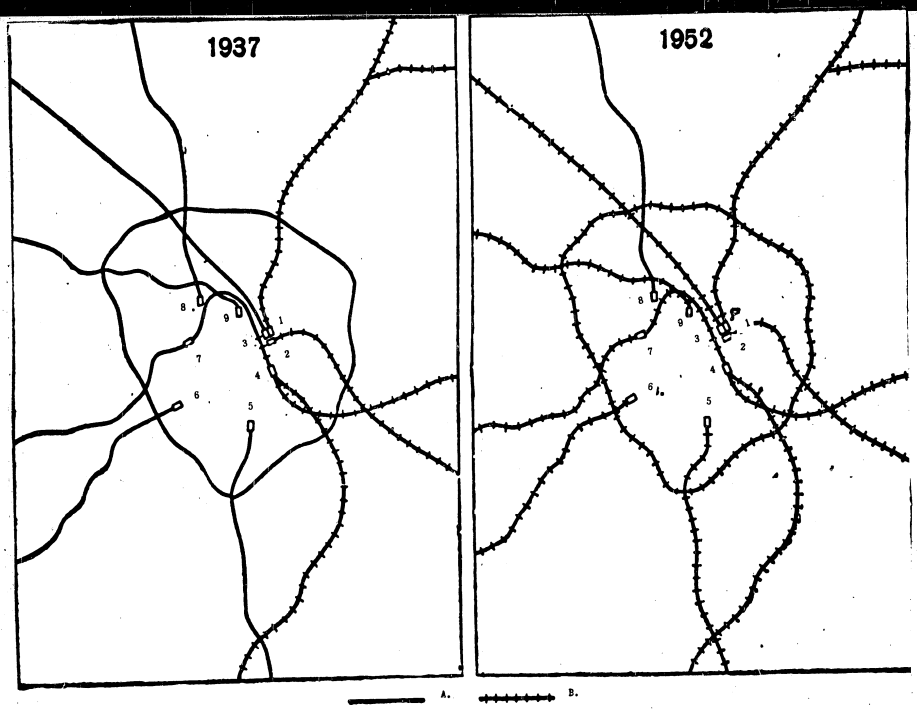

DIAGRAM OF THE DEVELOPMENT OF THE MOSCOW RAILROAD SYSTEM FROM 1937 TO 1952

A. RAILROAD LINES ON STEAM TRACTION. B. RAILROAD LINES ON ELECTRIC TRACTION.

1. YAROSLAVSKIY TERMINAL (YAROSLAVL'): 2. KAZANSKIY TERMINAL (KAZAN'): 3. LENINGRADSKIY TERMINAL (LENINGRAD): 4. KURSKIY TERMINAL (KURSK): 5. PAVELETSKIY TERMINAL (PAVELETS): 6. KIYEVSKIY TERMINAL (KIEV): 7. BELORUSSKIY TERMINAL (BELORUSSIAN): 8. SAVELOVSKIY TERMINAL (SAVELOV): 9. RIZHSKIY TERMINAL (RIGA).

Fig. 6 - Diagram
SOURCE: Saushkin, 1953, p. 62

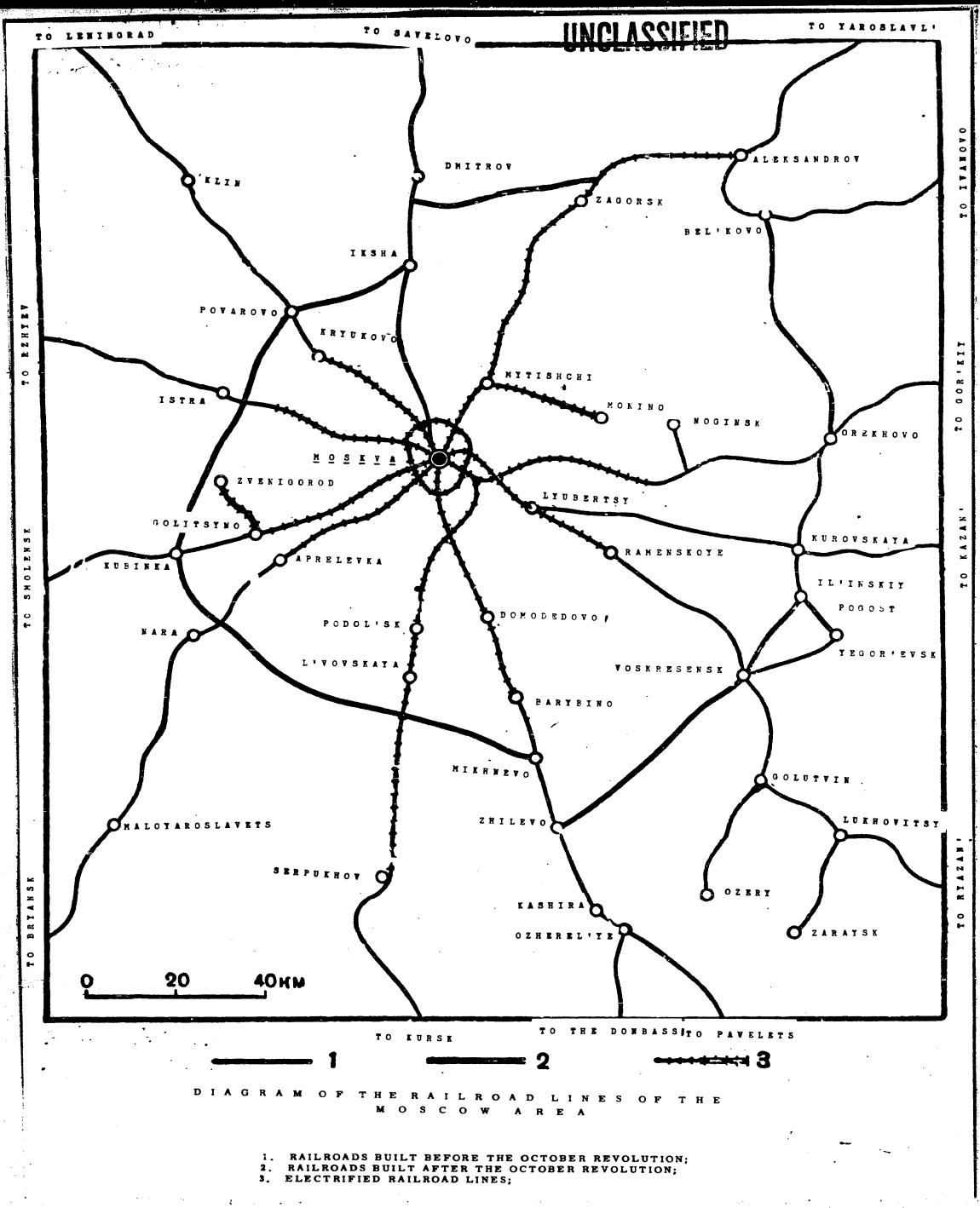

DIAGRAM OF THE RAILROAD LINES OF THE MOSCOW AREA

1. RAILROADS BUILT BEFORE THE OCTOBER REVOLUTION;
2. RAILROADS BUILT AFTER THE OCTOBER REVOLUTION;
3. ELECTRIFIED RAILROAD LINES;

Fig. 7 - Diagram

SOURCE: Saushkin, 1953, p. 62.

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Fig. 8 - Photo shows an electric locomotive [redacted] pulling a train on the Moskva - Serpukhov stretch of the Moskva - Kursk - Donbass system.

50X1-HUM

SOURCE: Gudok, 18 May 1955, p. 2.

Fig. 9 - At Pererva electric locomotive enginehouse on the Moskva - Kursk - Donbass system.

SOURCE: Gudok, 9 March 1956, p. 2.

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Fig. 10 - Photo shows condition on tracks to the locomotive repair and servicing shop on the Ozherel'ye - Uzunovo stretch.

Fig. 11 - The first locomotives using single-phase alternate current of industrial frequency could not be placed in enginehouse due to lack of facilities and were left for several days on the tracks of the Ozherel'ye - Uzunovo stretch

SOURCE: Gudok, 7 March 1956

Fig. 12 - Old fashioned and primitive system of sanding new single-phase alternate current electric locomotive on Ozherel'ye-Uzunovo stretch

SOURCE: Gudok, 7 March 1956.

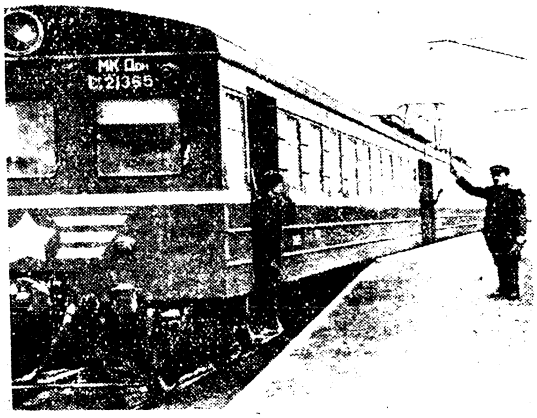

Fig. 13 - Electric train leaving Kashira station

SOURCE: Gudok, 30 March 1956.

Fig. 14 - View of the first electric train departing from the Vitebskiy Terminal in Leningrad for Pushkin and Pavlovsk.

SOURCE: Ogonek, 31 May 1953, p. 10

Fig. 15 - Preparing lumber for the roof of the new enginehouse at Adler station.

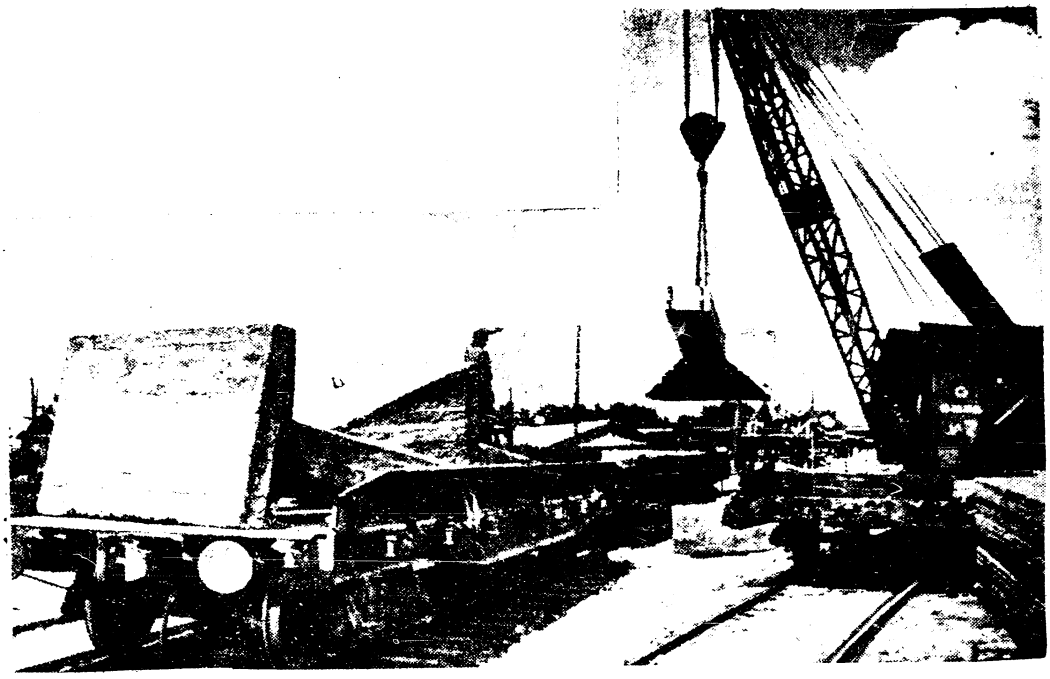

Fig. 16 - Loading foundations for reinforced concrete supports produced at Belorechenskaya

SOURCE: Gudok, 28 June 1956, p. 1.

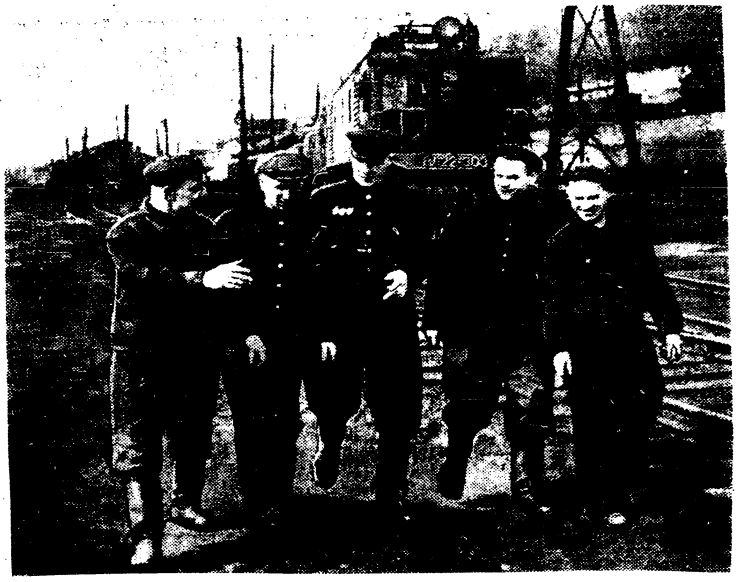

Fig. 17 - Near Chusovskaya Electric Locomotive Enginehouse (Sverdlovsk System).

SOURCE: Gudok, 29 April 1955, p. 1.

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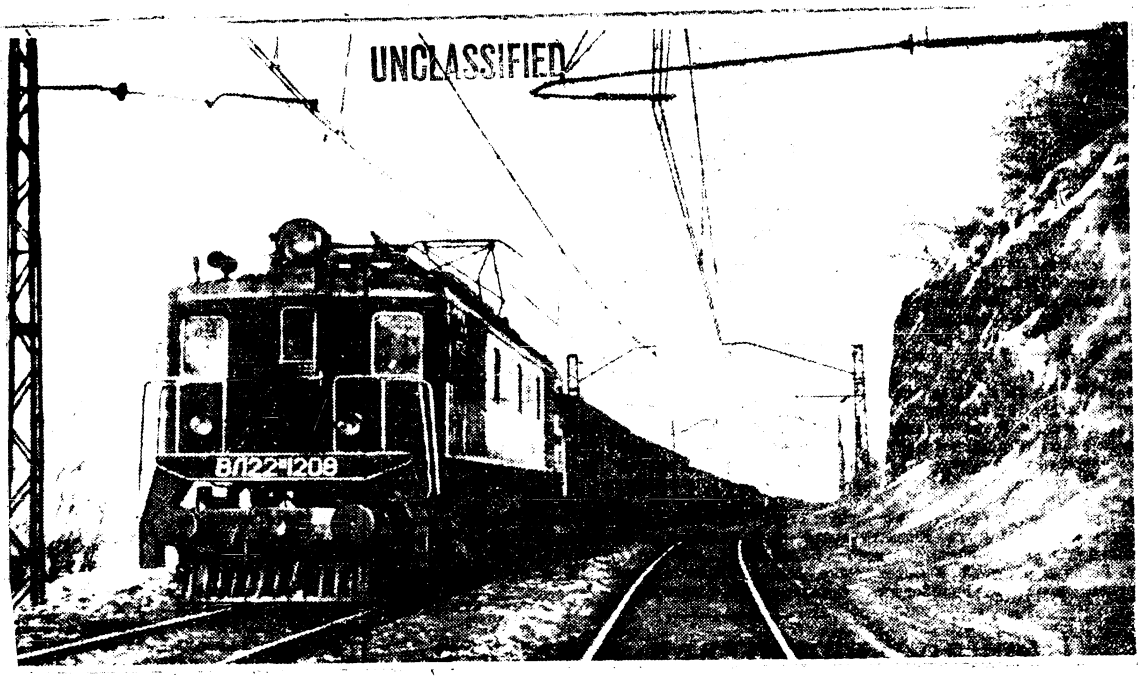

Fig. 18 - An electric train pulling a heavy duty train on the Ufa - Chernikovka stretch.

SOURCE: Gudok, 25 February 1955.

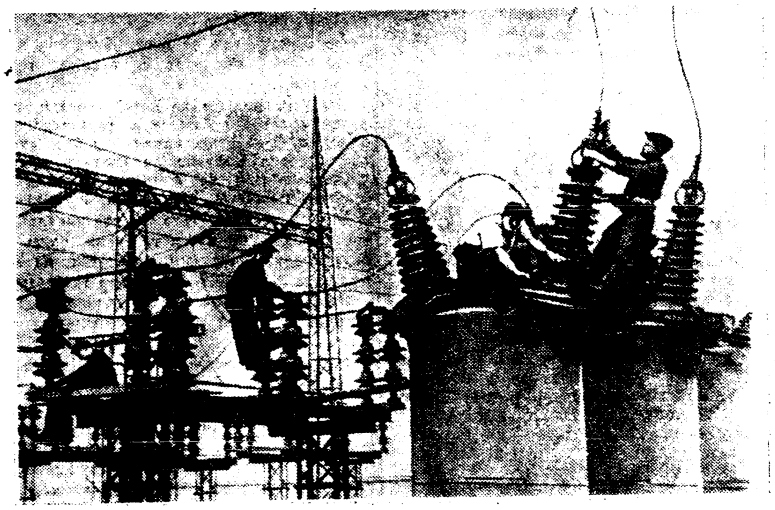

Fig. 19 - Electrification of the Dema - Kropachevo line: installation of oil circuit breaker of the electric sub-traction station at Dema.

SOURCE: Gudok, 19 September 1954.

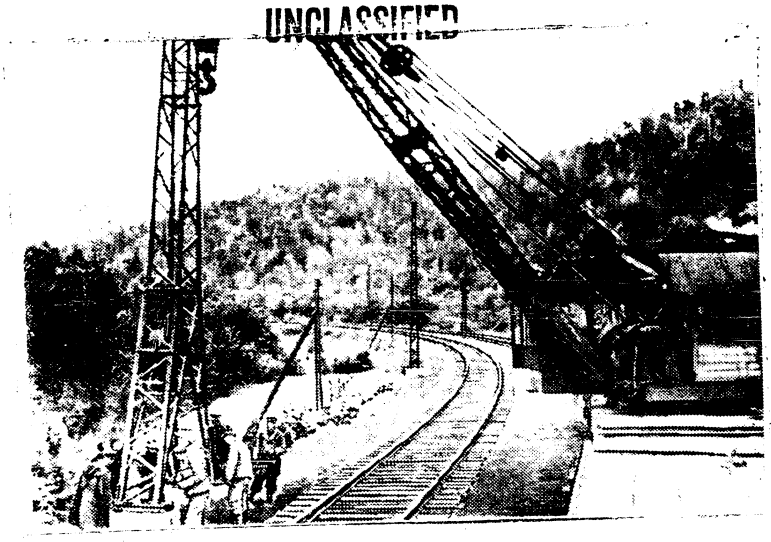

Fig. 20 - The installation of an anker tower on the Vavilovo - Min'yar stretch.

SOURCE: Gudok, 19 September 1954.

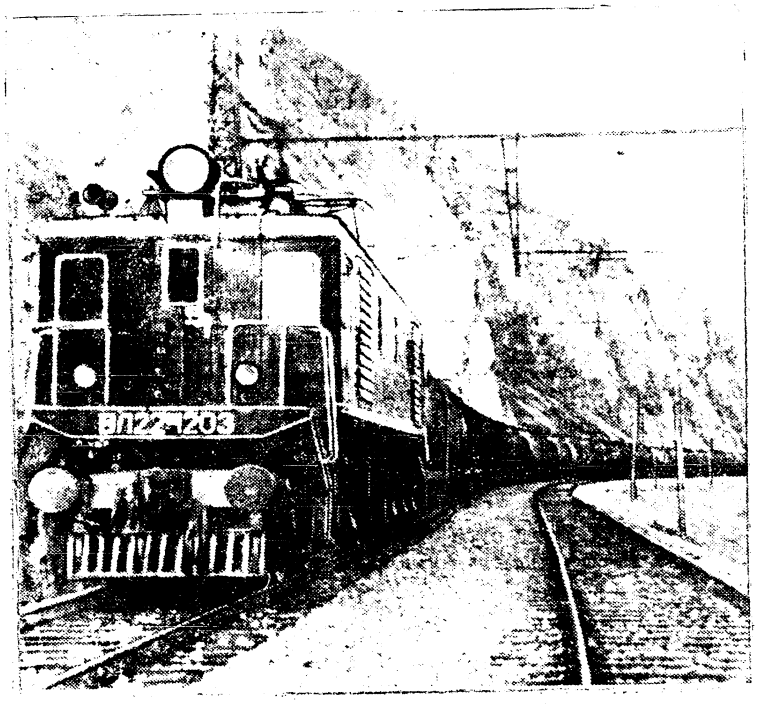

Fig. 21 - [redacted] electric locomotive pulling a heavy duty train on Vavilovo - Min'yar stretch of the Ufa system.

SOURCE: Gudok, 10 November 1955.

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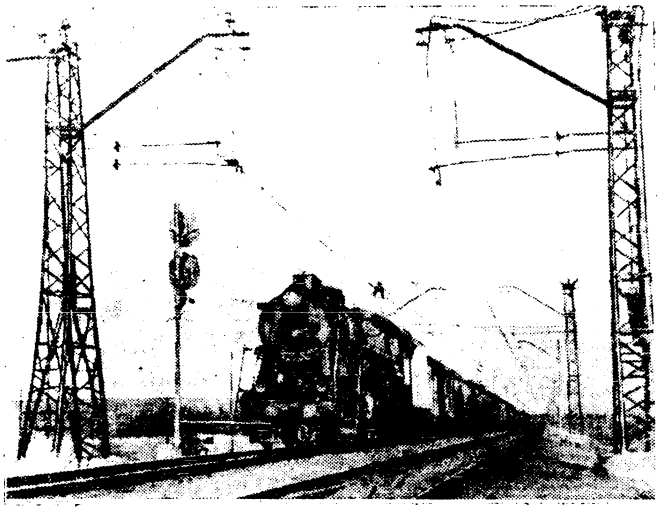

Fig. 22 - Electrified section on the Dema - Rayevka line.

SOURCE: Gudok, 12 August 1956, p. 1

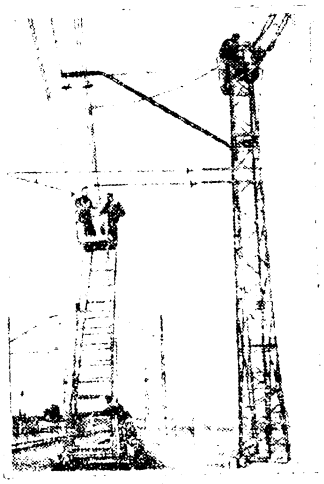

Fig. 23 - Installation work on a run near Rayevka Station on the Dema - Rayevka Electrified section of the Ufa system.

SOURCE: Gudok, 12 July 1956, p. 3.

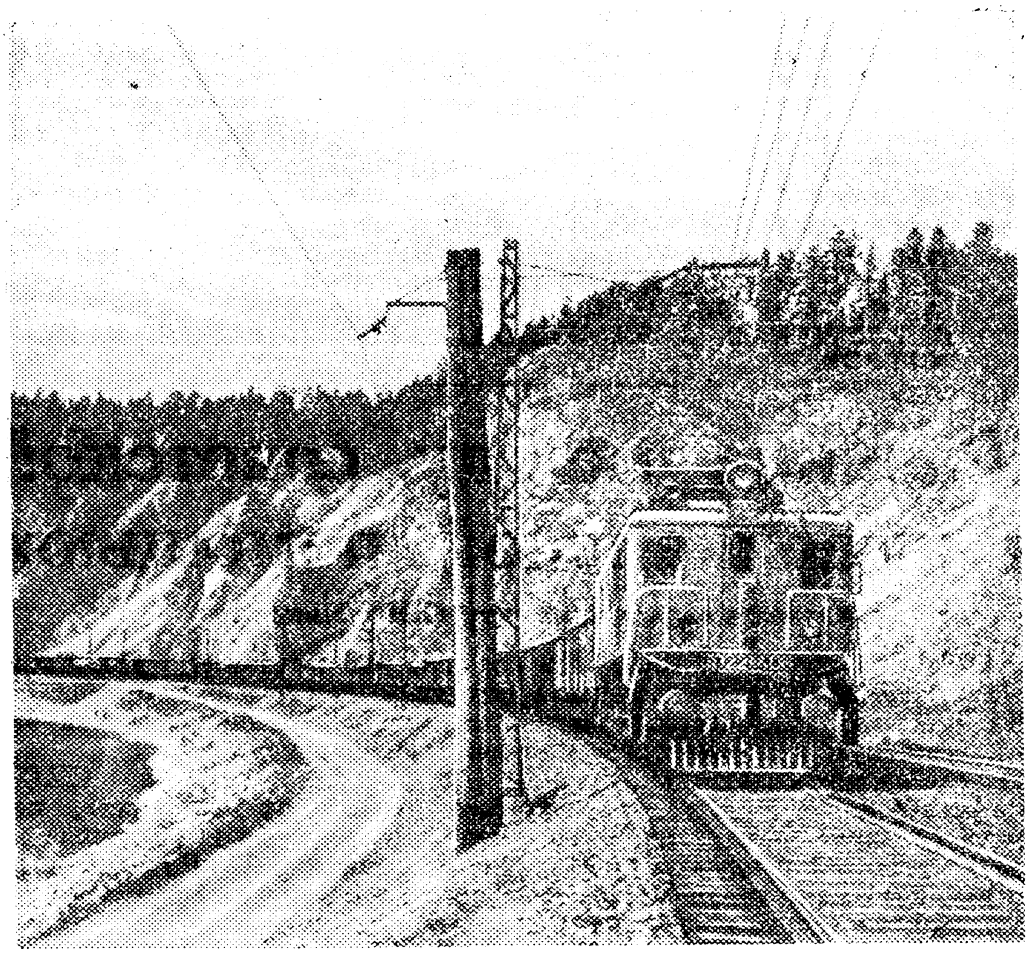

Fig. 24 - An electric locomotive draws a heavy duty train along a section of the Vyazovaya-Kropachevo railway of the South Urals system.

SOURCE: Gudok, 13 July 1956, p. 3.

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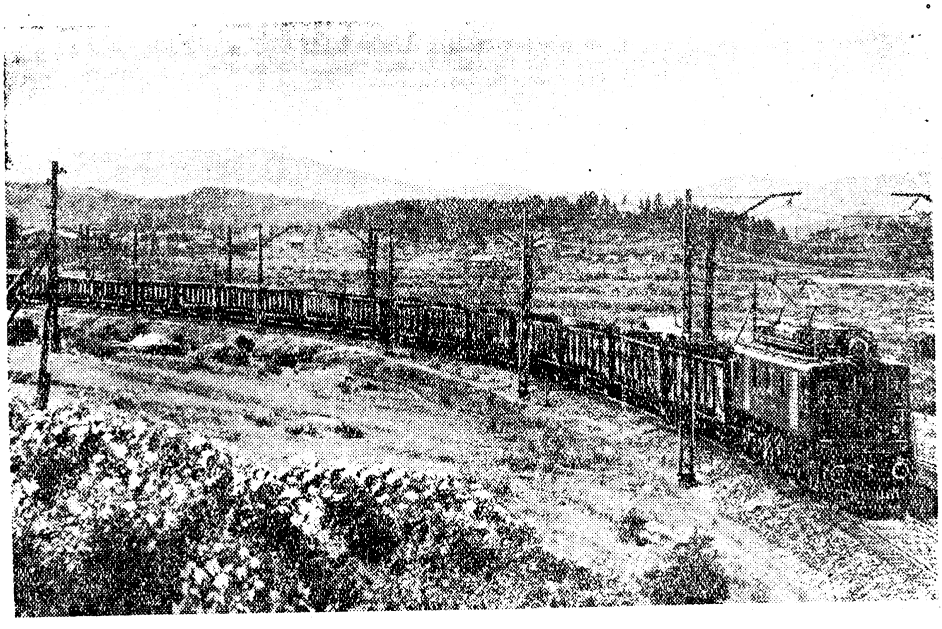

Fig. 25 - A string of railroad cars loaded with coal on an electrified section of the South-Urals Railway.

SOURCE: Gudok, 26 August 1956, p. 1

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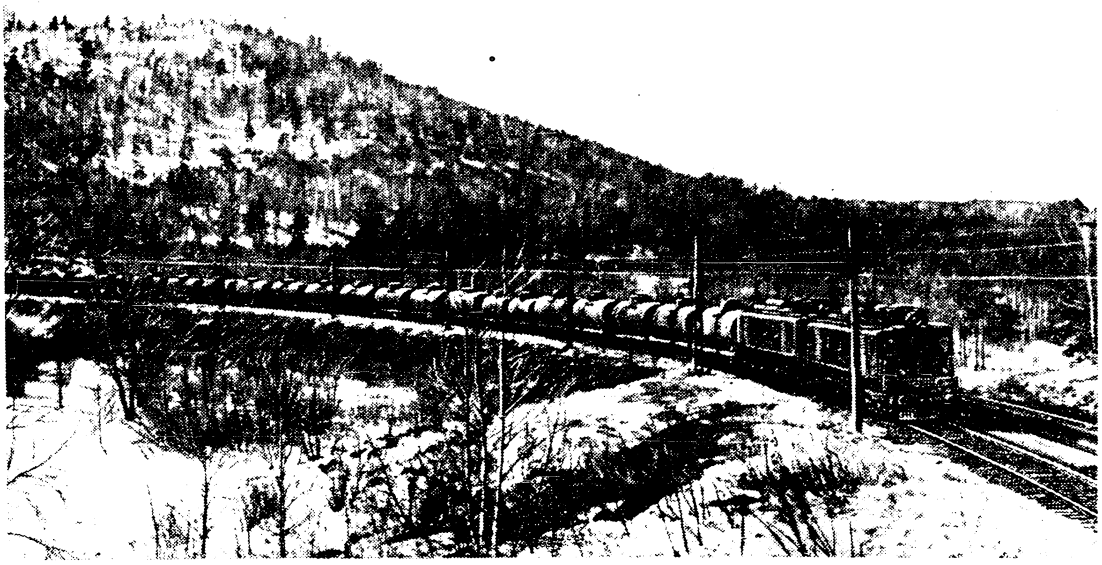

Fig. 26 - A train loaded with 700-800 tons of freight, over the norm hauled by electric locomotive on Zlatoust - Chelyabinsk section of the South Urals system.

SOURCE: Gudok, 9 April 1954, p. 1.

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Fig. 27 - Workmen at Barabinsk electric locomotive enginehouse.

SOURCE: *Gudok*, 2 March 1956, p. 1.

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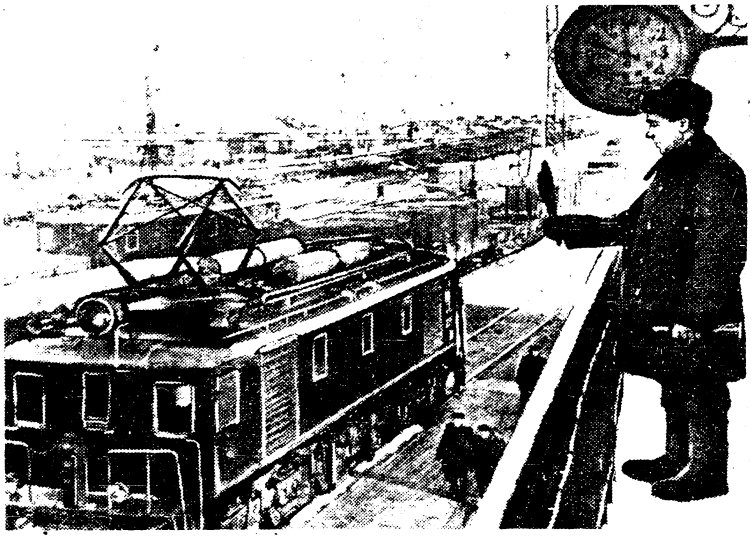

Fig. 28 - Signal - operator at Barabinsk station of the Omsk system.

SOURCE: Gudok, 11 March 1956.

Fig. 29 - This building was formerly used for technical inspection of steam locomotives at Barabinsk, now it has been adjusted for equipping of electric locomotives and has a mechanized system of sanding and lubricating.

Fig. 30 - Near Barabinsk station of the Omsk system.

SOURCE: Gudok, 9 March 1956.

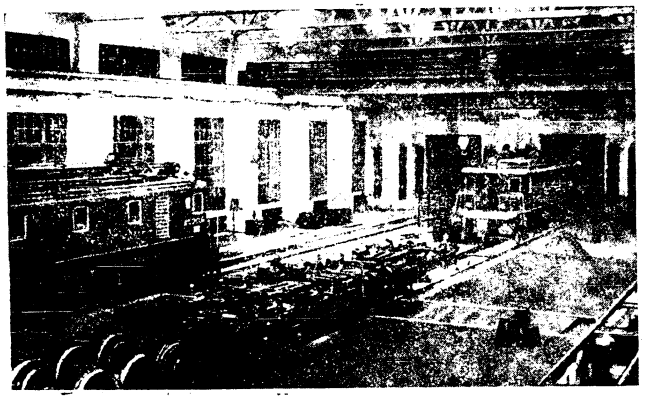

Fig. 31 - An interior view of a reconstructed shop for lifting repair at Barabinsk locomotive enginehouse.

SOURCE: Zheleznod. Transport No. 1, 1956, p. 32.

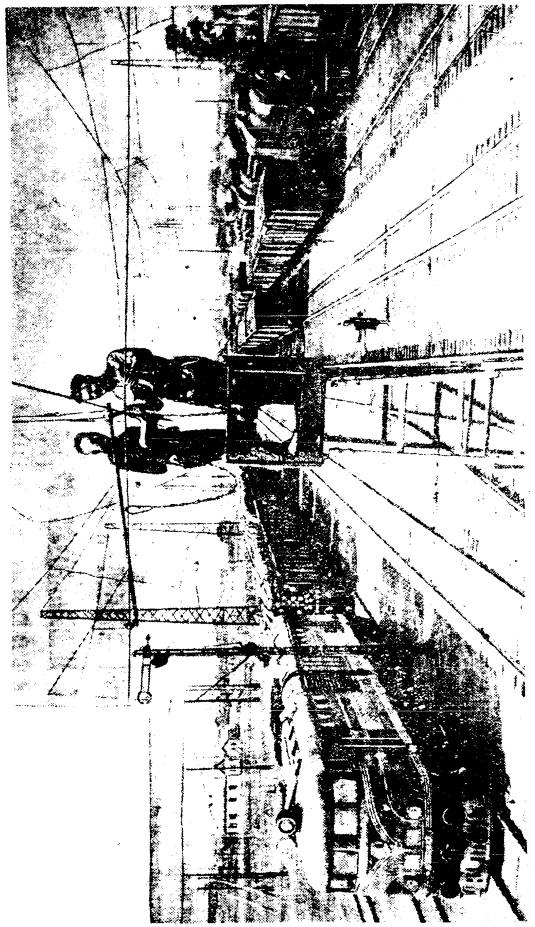

Fig. 32 - Installation of contact network at Nazyvayevskaya station of the Omsk system.

SOURCE: Gudok, 4 July 1956.

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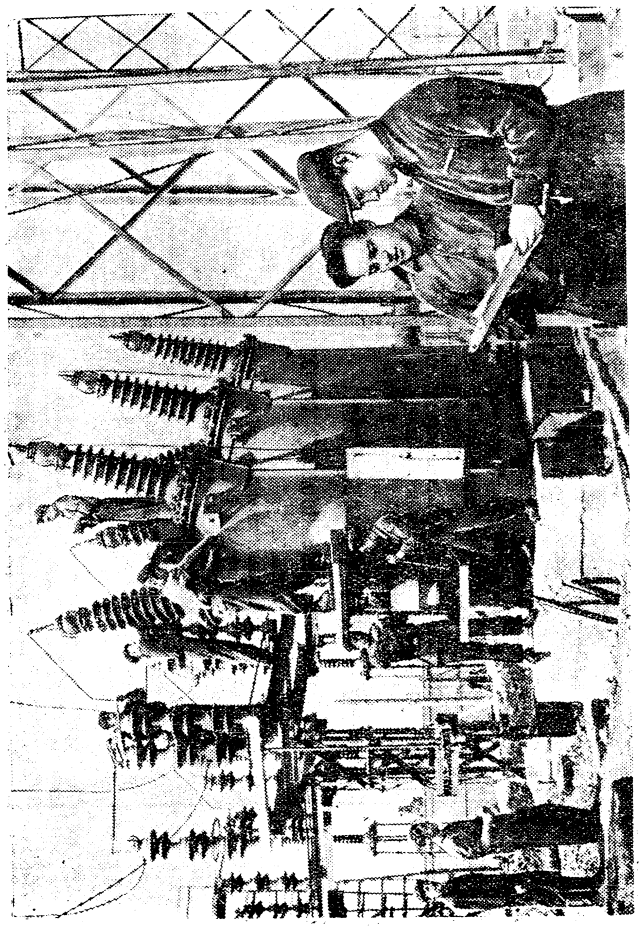

Fig. 33 - The installation of an oil circuit-breaker at the Nazyvayevskaya traction sub-station.

SOURCE: Gudok, 14 July 1956, p. 3.

Fig. 34 - Shunting operations at Nazyvayevskaya Station of the Omsk system.

SOURCE: Gudok, 25 July 1956.

Fig. 35 - View of a contact tower at Nazyvayevskaya station.

SOURCE: Gudok, 21 July 1956.

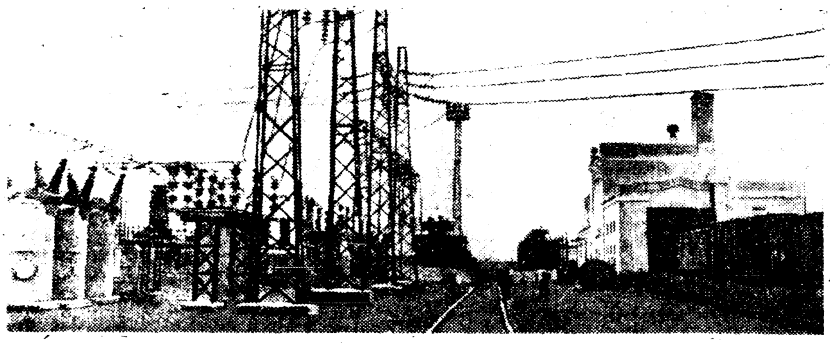

Fig. 36 - View near Petrushanskaya substation on the electrified Omsk - Nazyvzyevskaya section.

SOURCE: Pravda, 14 November 1956.

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Fig. 37 - A part of the electrified Usuaty - Novokuznetsk section of the Tomsk system.

SOURCE: Gudok, 7 June 1955, p. 2.

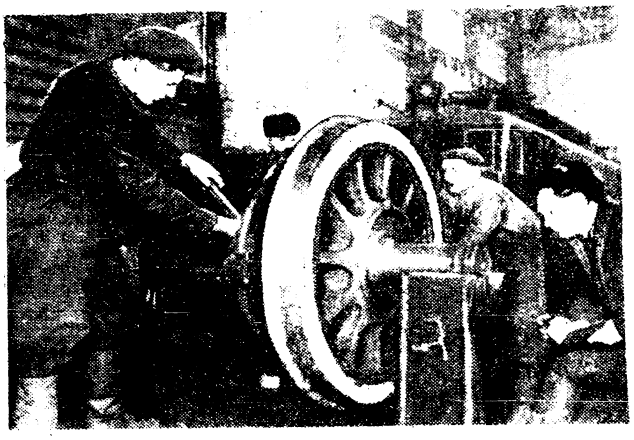

Fig. 38 - Workmen at the lifting and medium repair shop of Inskaya electric locomotive enginehouse of the Tomsk system.

SOURCE: Gudok, 11 March 1956, p. 1.

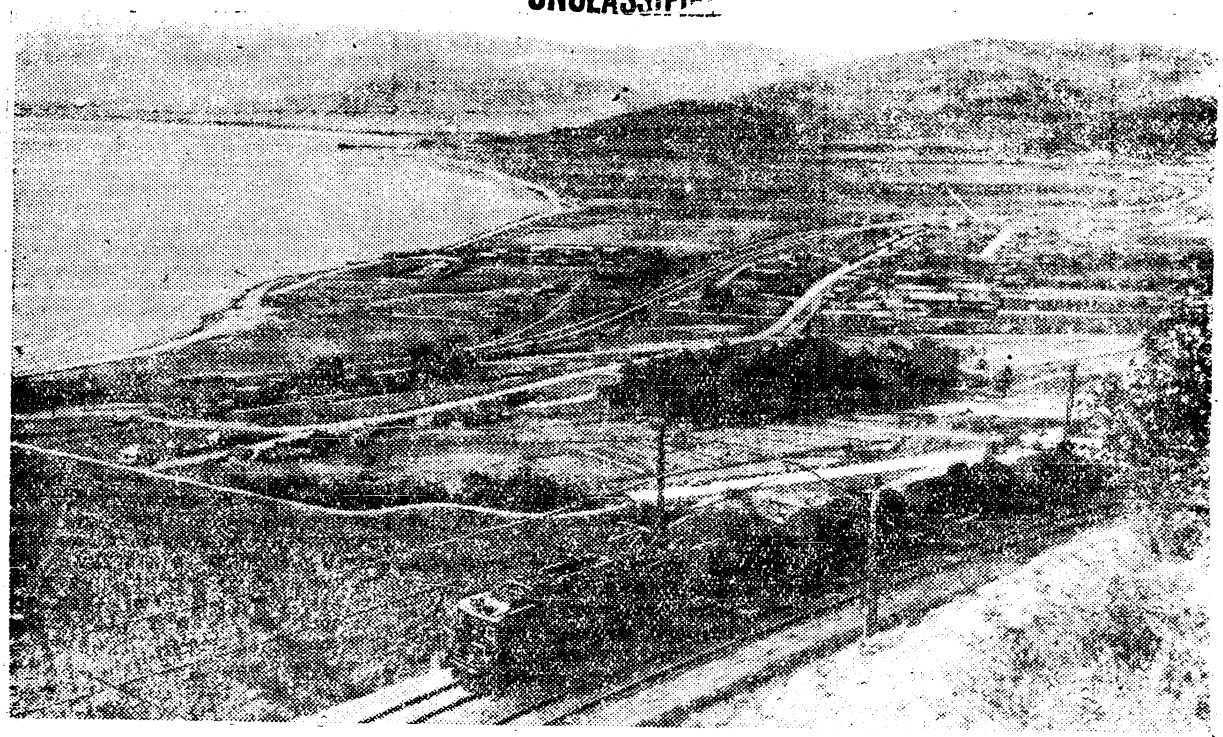

Fig. 39 - An electric locomotive along a section of the Irkutsk Slyudanka line of the East Siberian Railway near the city of Baykal, which lies in the distance.

SOURCE: Gudok, 7 July 1956, p. 3.

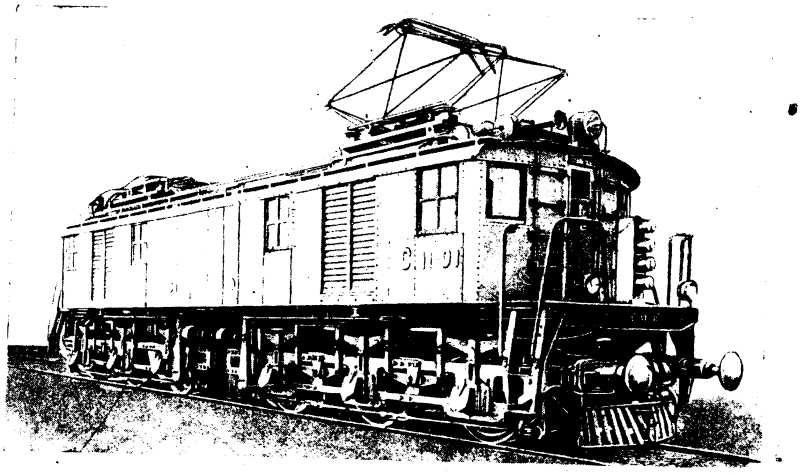

Fig. 40. - [redacted] electric locomotive.

SOURCE: Rakov, 1955, p. 317.

Fig. 41 [redacted] electric locomotive. The inscription on the locomotive states: "First Soviet electric locomotive."

SOURCE: Rakov, 1955, p. 322.

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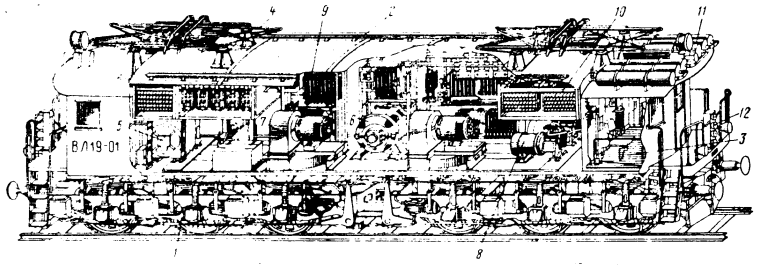

Fig. 42 - Lay-out of equipment on [redacted] electric locomotive.

SOURCE: Rakov, 1955, p. 322

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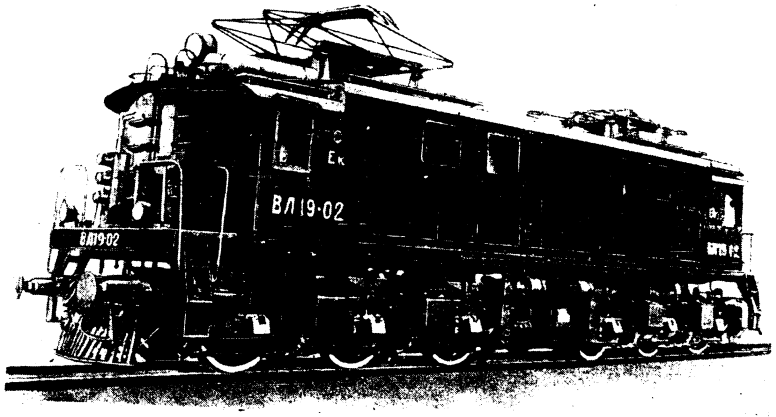

Fig. 43 - [redacted] electric locomotive with rheostatic braking system.

SOURCE: Rakov, 1955, p. 323.

50X1-HUM

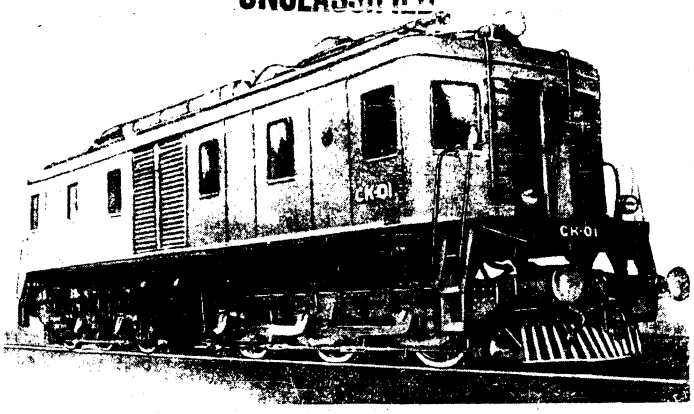

Fig. 44 - [redacted] electric locomotive.
SOURCE: Rakov, 1955, p. 326.

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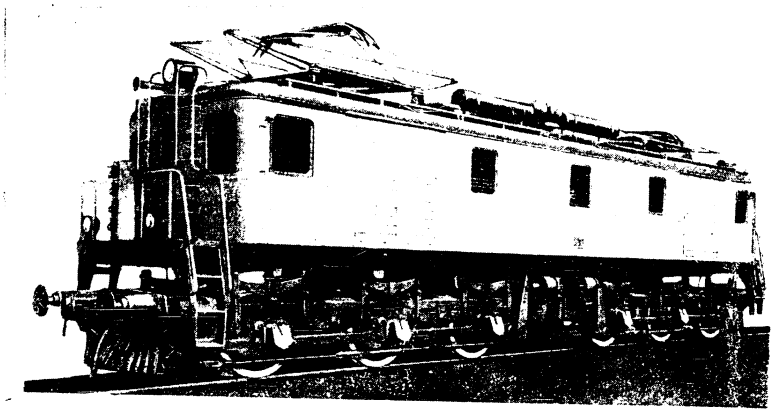

Fig. 45 - [redacted] $0\text{-}3_0 0 + 0\text{-}3_0\text{-}0$ type electric locomotive.
SOURCE: Rakov, 1955, p. 328.

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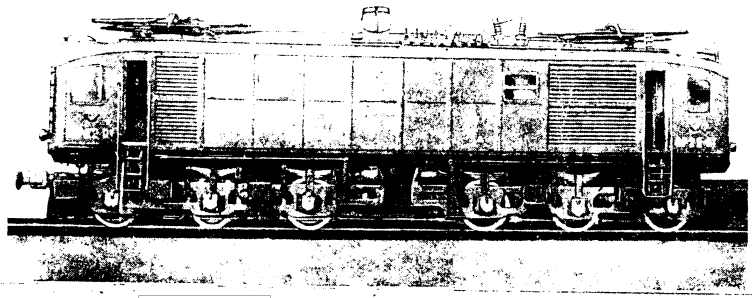

Fig. 46 - [redacted] single-phase electric locomotive.
SOURCE: Rakov, 1955, p. 336.

50X1-HUM

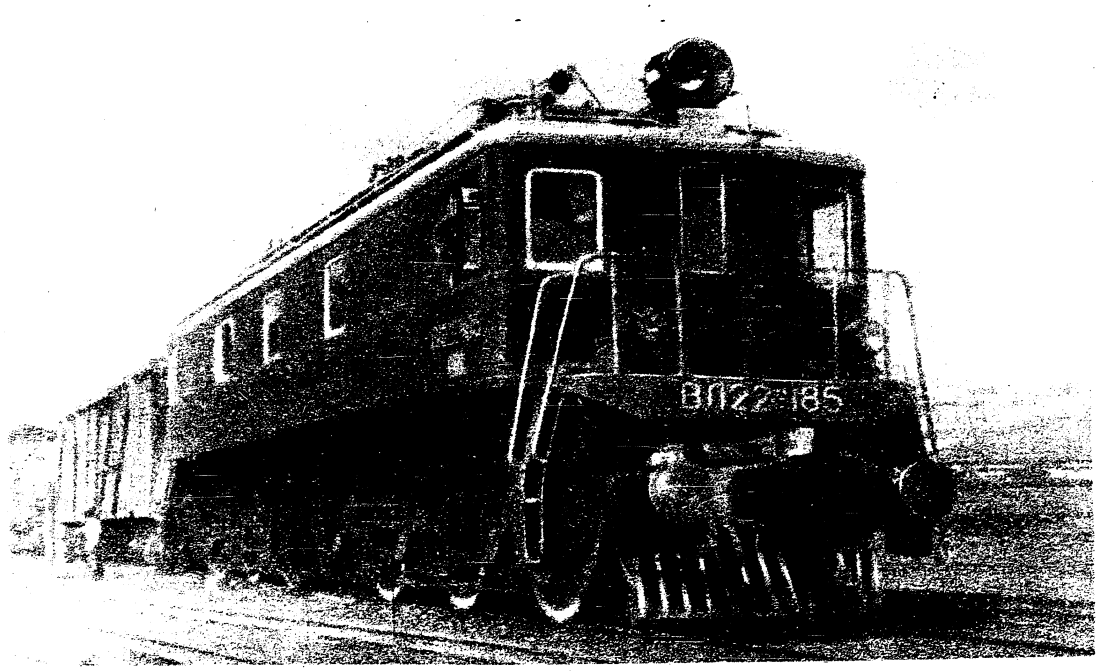

Fig. 47 - The first electric locomotive constructed in Novocherkassk, Rostov o.

SOURCE: Gudok, No. 50, April 23, 1947, p. 1.

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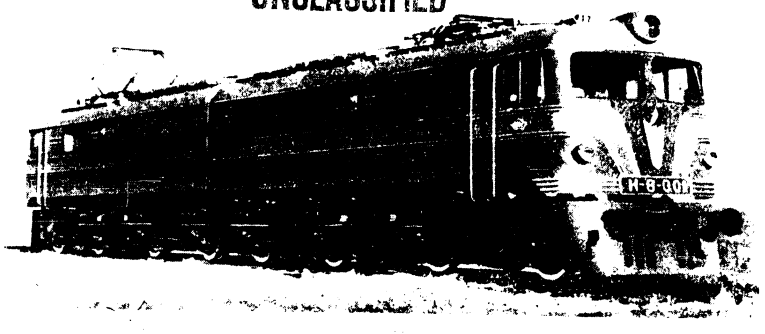

Fig. 48 - [redacted] 8-axle electric locomotive
SOURCE: Rakov, 1955, p. 331

50X1-HUM

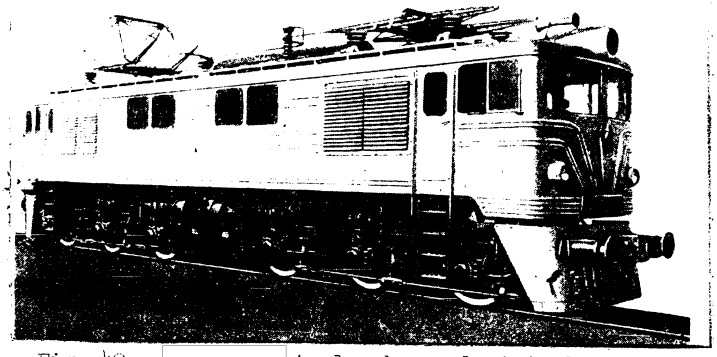

Fig. 49 - [redacted] single-phase electric locomotive
SOURCE: Rakov, 1955, p. 338.

50X1-HUM

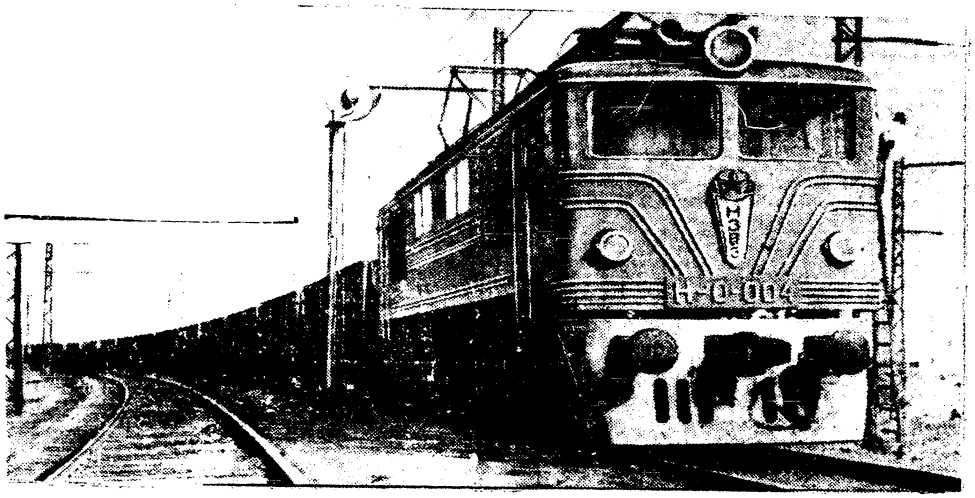

Fig. 50 - [redacted] electric locomotive operating on single-phase industrial frequency current passing testings at the experimental trackage of "Butovskiy" loop of the All-Union Scientific Research Institute of the Rail Transport.

50X1-HUM

SOURCE: Gudok, 25 March 1956, p. 1

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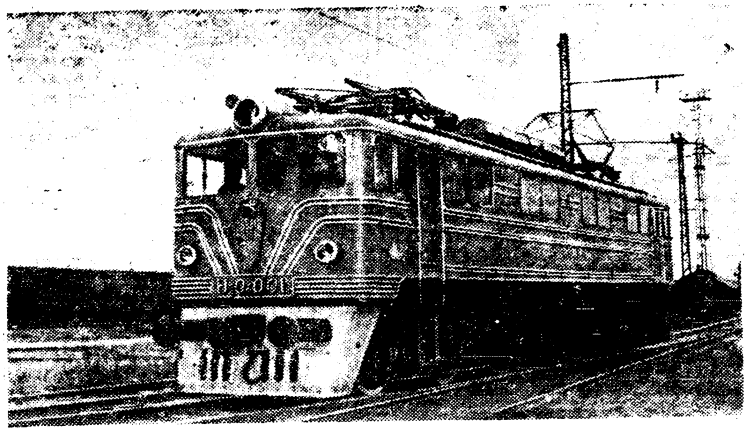

Fig. 51 - New [redacted] electric locomotive built by Novocherkassk Electric Locomotive Building Plant.

SOURCE: Kazakhstanskaya Pravda, 4 January 1955, p. 1

50X1-HUM

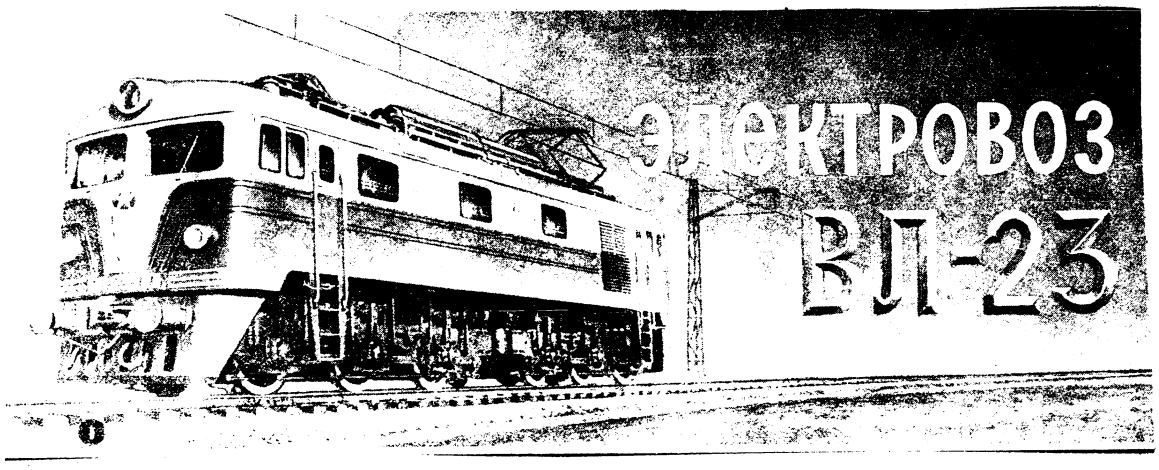

Fig. 52 - [redacted] 4,300 hp electric locomotive and 90 - 100 km/hr design speed built by Novocherkassk Electric Locomotive Building Plant.

SOURCE: Railroad Transport, No. 5, 1956, p. 47.

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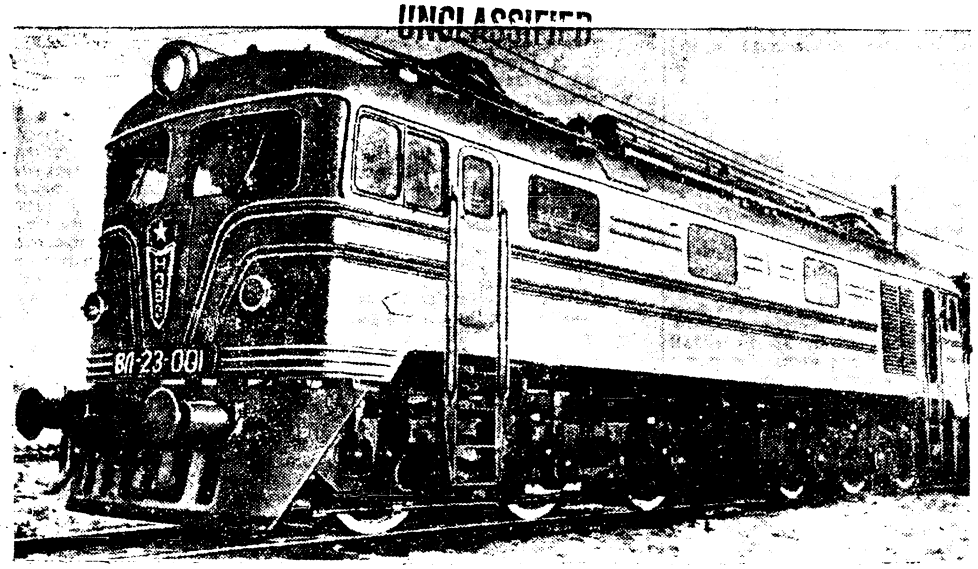

Fig. 53 - The first 6-axle [redacted] electric locomotive produced by Novocherkassk Electric Locomotive Building Plant im. Budennyy.

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SOURCE: Gudok, 11 February 1956.

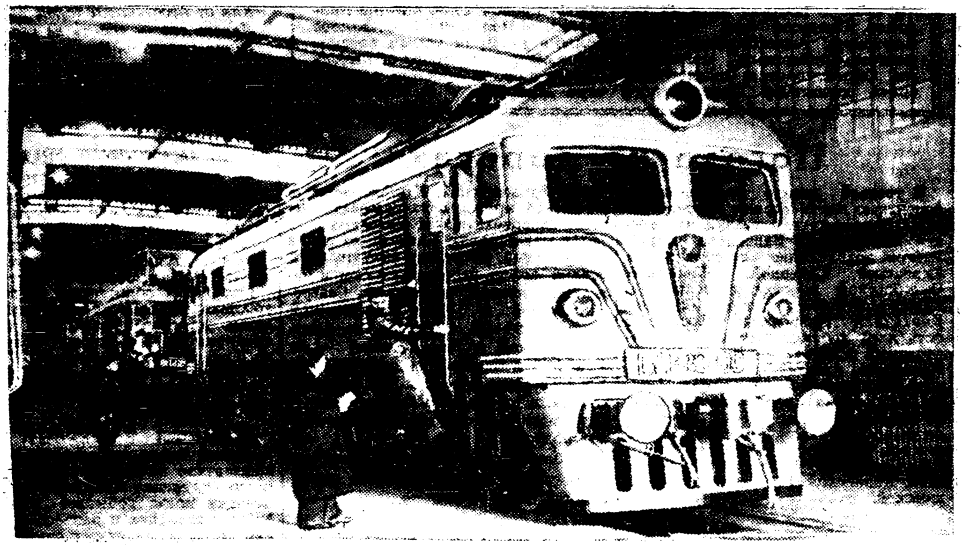

Fig. 54 - The new main line [redacted] electric locomotive produced by Novocherkassk Electric Locomotive Building Plant.

50X1-HUM

SOURCE: Gudok, 1 February 1956.

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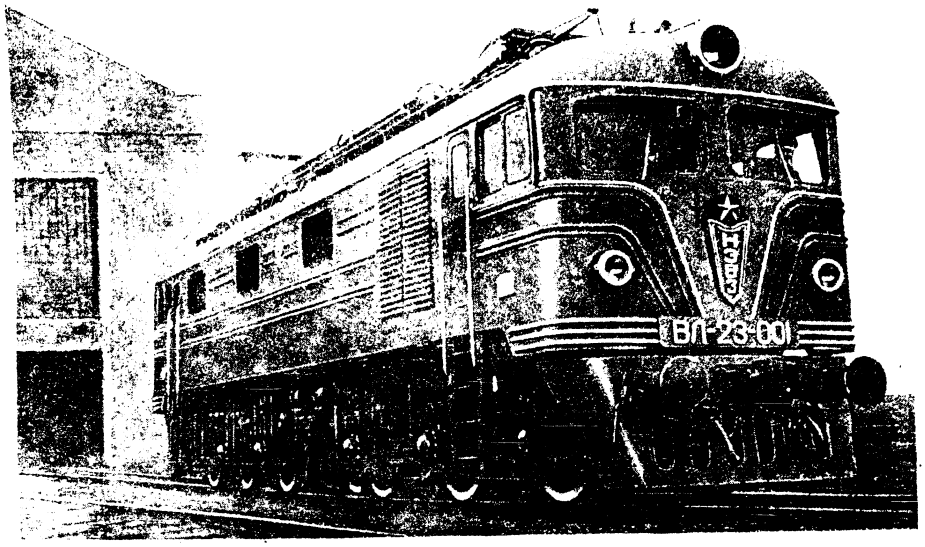

Fig. 55 - New trunk line electric locomotive of [redacted] produced by the Novocherkassk plant.

SOURCE: Railroad Transport, No. 2, 1956, front outside cover

50X1-HUM

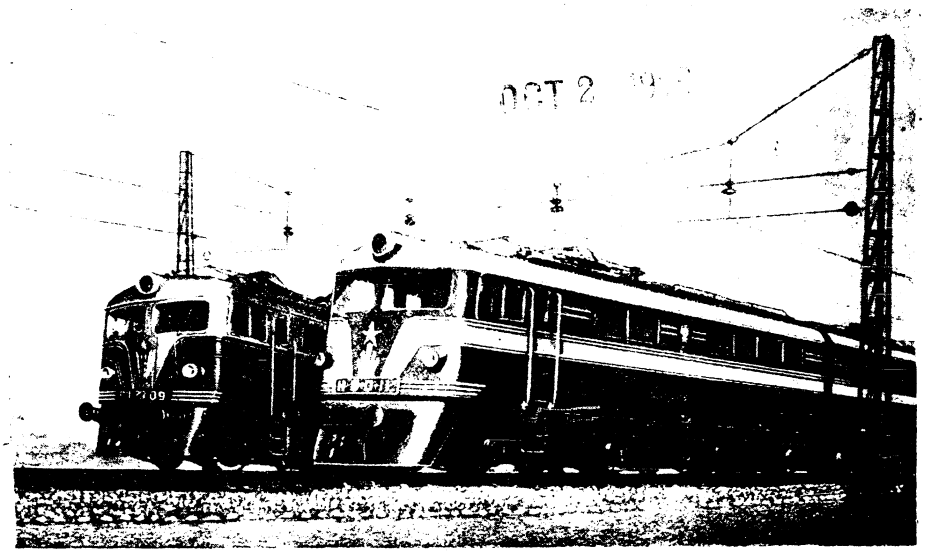

Fig. 56 - High-powered [redacted] electric locomotives on the test tracks of the All-Union Scientific Research Institute.

SOURCE: Railroad Transport, No. 7, 1956, front outside cover.

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Fig. 57 - View of the [redacted] 8 axle, 5,000 hp electric locomotive.

SOURCE: Railroad Transport, No. 2, 1956, p. 47.

50X1-HUM

Fig. 58 - Final preparations at Novocherkassk electric locomotive building plant for the dispatch of 8-axle electric locomotive.

SOURCE: Gudok, 26 January 1956, p. 1

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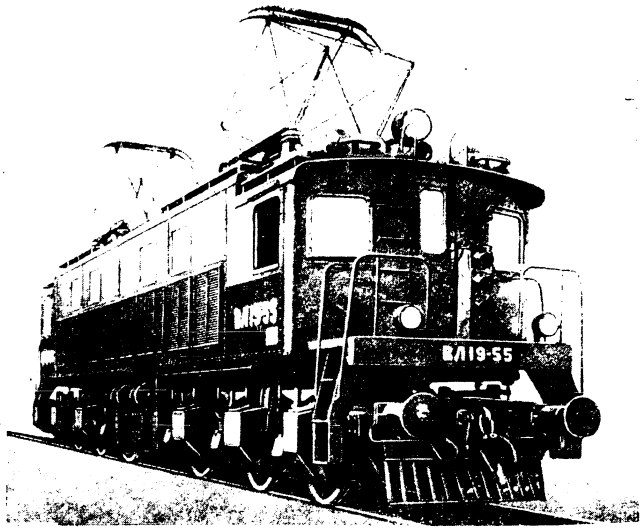

Fig. 59 - [redacted] electric locomotive re-equipped for operations on two voltages.

SOURCE: Rakov, 1955, p. 325.

50X1-HUM

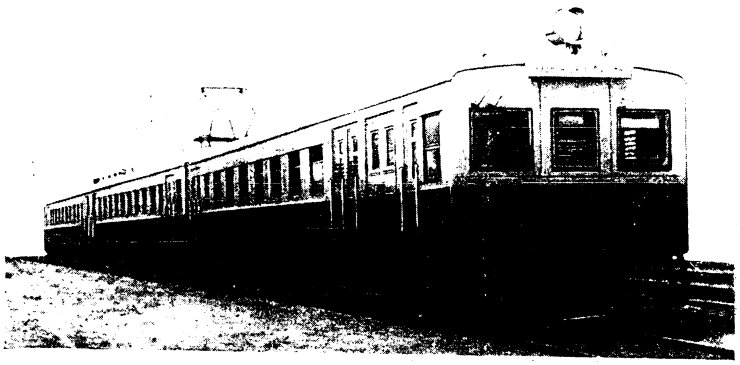

Fig. 60 - Three-car unit with [redacted] motor-car.

SOURCE: Rakov, 1955, p. 353.

50X1-HUM

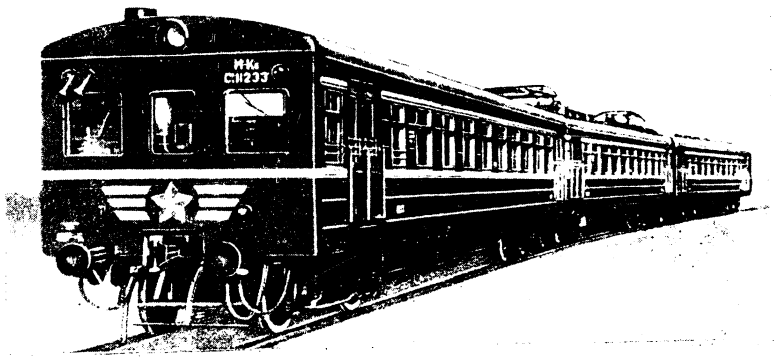

Fig. 61 - Three-car unit with [redacted] motor-car exits to high platforms.

SOURCE: Rakov, 1955, p. 355.

50X1-HUM

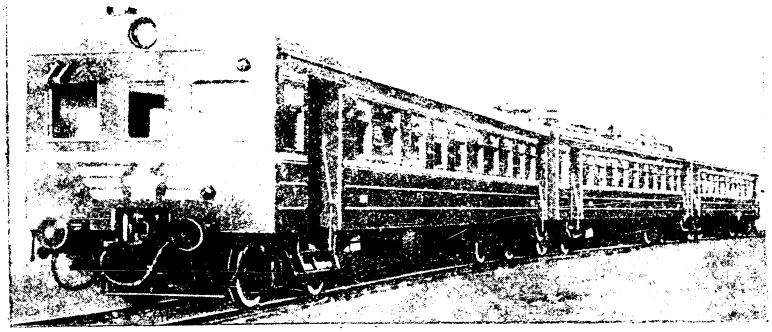

Fig. 62 - Three-car unit [redacted] motor-car with exits to low platforms.

SOURCE: Rakov, 1955, p. 355.

50X1-HUM

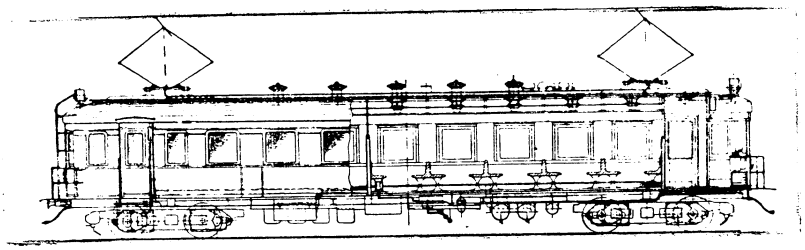

Fig. 63 - Electric motor-car built in 1926 by Mytishchi Railroad Car Building Plant for Baku-Sabunch line.

SOURCE: Rakov, 1955, p. 341.

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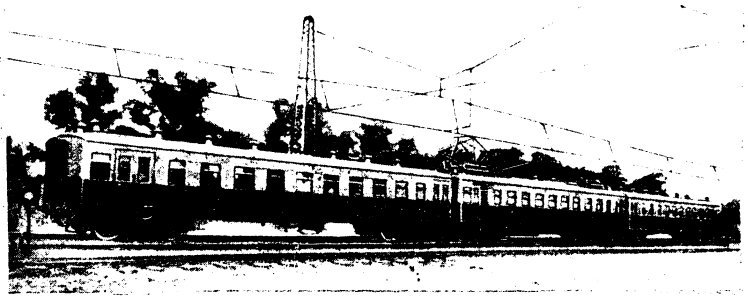

Fig. 64 - Three-car unit with [redacted] electric motor-car.

SOURCE: Rakov, 1955, p. 343.

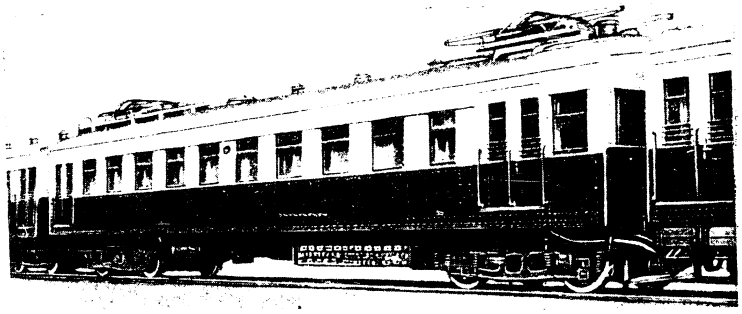

Fig. 65 - [redacted] motor-car.

SOURCE: Rakov, 1955, p. 343.

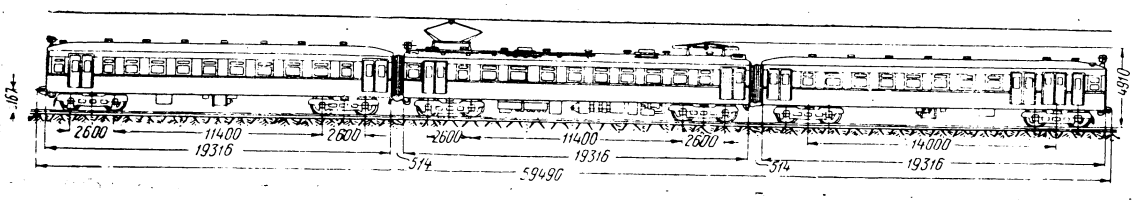

Fig. 66 - Basic dimensions of three-car unit with "Sr" motor-car.

SOURCE: Rakov, 1955, p. 354.

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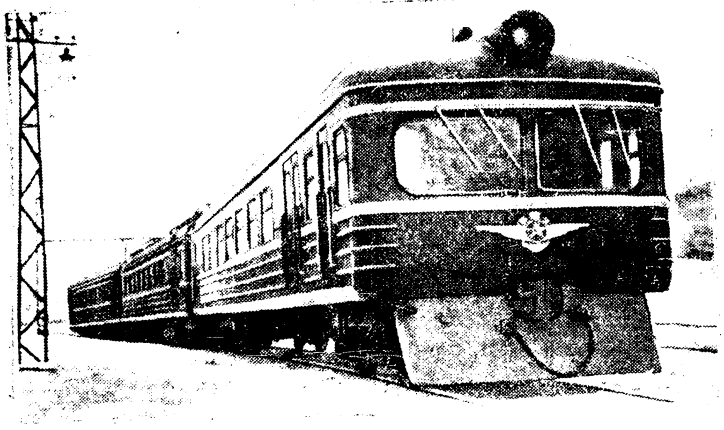

Fig. 67 - Exterior view of the motor-car unit built by the Riga Railroad Car Building Plant.

SOURCE: Gudok, 29 January 1955.

Fig. 68 - Interior view of the motor-car unit built by a Riga Plant.

SOURCE: Gudok, 29 January 1955.

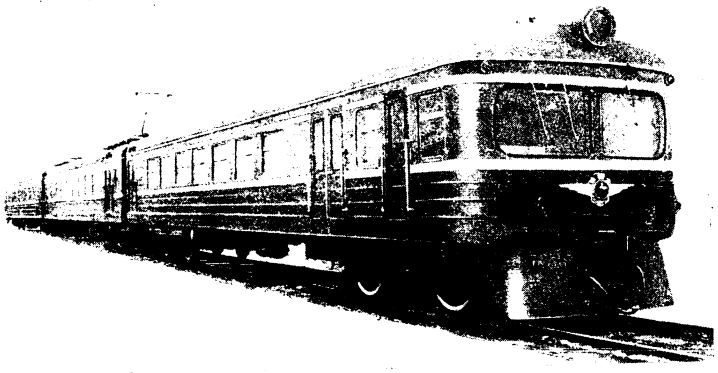

Fig. 69 - New "SN" three-car unit built by Riga Car Building Plant in 1955.

SOURCE: Rakov

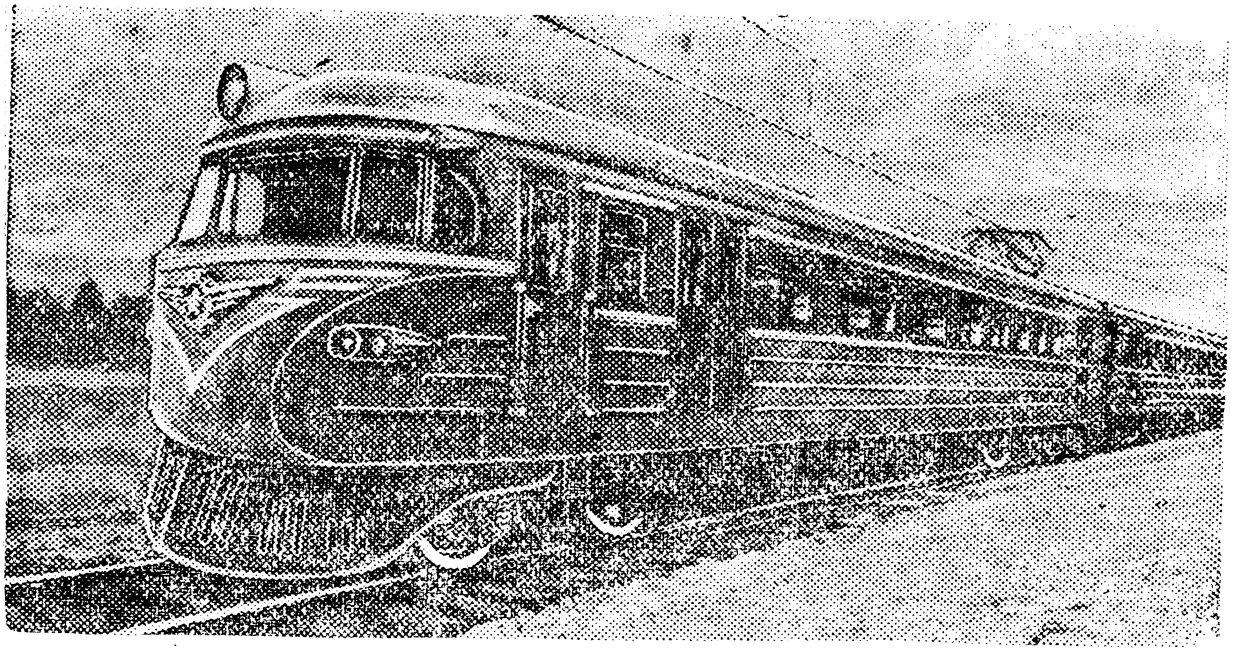

Fig. 70 - Exterior view of the electro-train unit of the "ER-1" produced by the Riga Plant.

SOURCE: Gudok, 21 September 1956, p. 2.

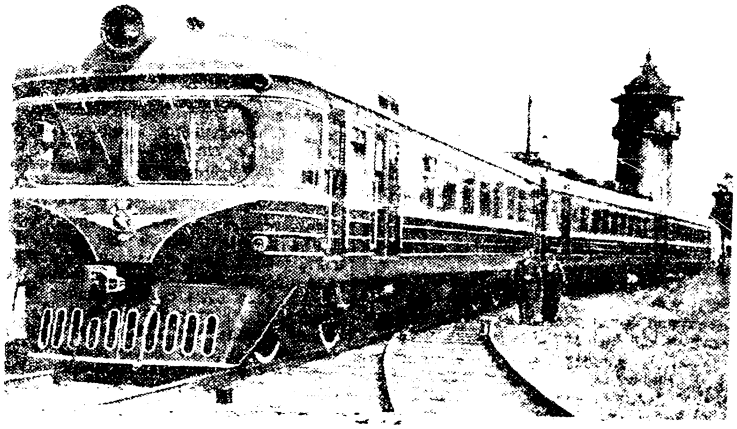

Fig. 71 - New type electric train produced by Riga Railroad Car Building Plant.

SOURCE: Izvestiya, 21 July 1955, p. 2.

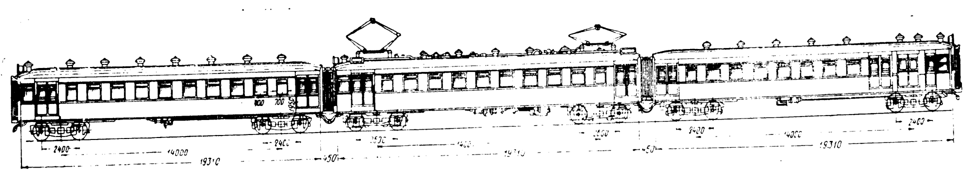

Fig. 72 - Basic dimensions of the three-car unit with "S_d" series motor-car.

SOURCE: Rakov, 1955, p. 346.

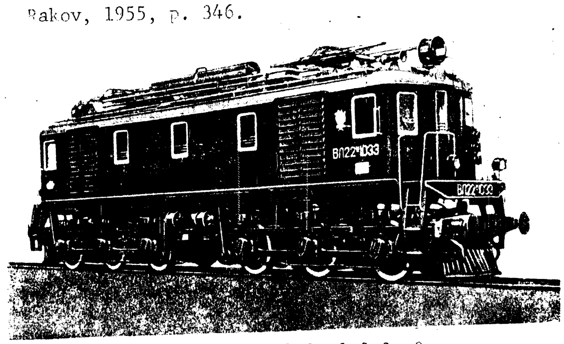

Fig. 73 - "VL22" series $0\text{-}3_0\text{-}0+0\text{-}3_0\text{-}0$ type electric locomotive

SOURCE: Rakov, 1955, p. 330

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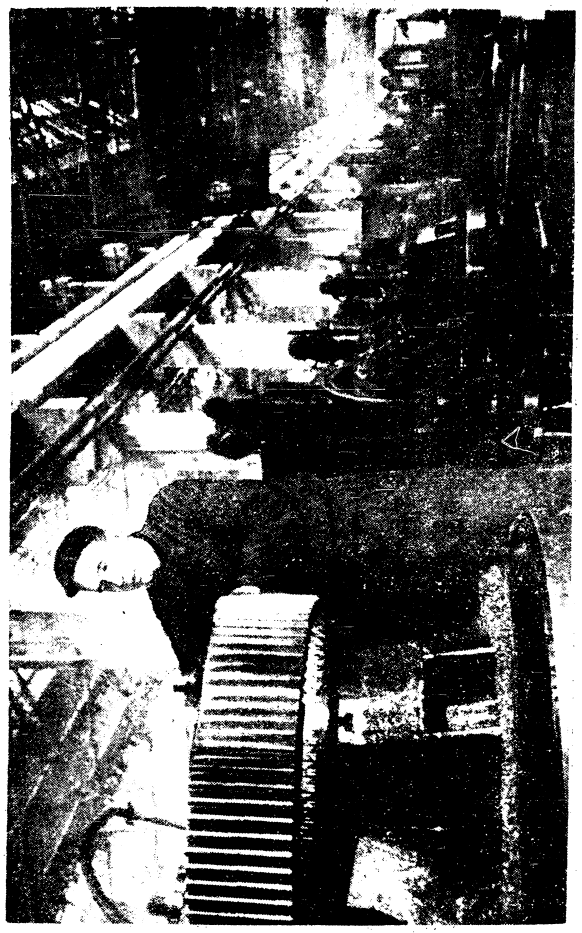

Fig. 74 - At Novocherkassk Electric Locomotive Plant.
SOURCE: Cudok, 22 March 1956, p. 1.

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