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U.S. - U.S.S.R. TRACK AND RAIL METALLURGY INFORMATION EXCHANGE

MARCH 1977

FINAL REPORT

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16. Abstract

The report covers track research and development activities, rail metallurgy and the technology of laying welded rail, assembly and disassembly of track panels and wood tie reclamation. It draws upon the experiences, observations and discussions of a seven-man team of engineers, researchers, and metallurgists who visited the Soviet Union during an 11-day period in 1976. The basic goals were to expand upon the knowledge obtained by previous delegations and to learn as much as possible for application or modification to US research and development activities and track maintenance procedures.

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INTRODUCTION

This report covers the track and metallurgical information exchange of the United States (US) Delegation to the USSR, which took place between June 14 and 25, 1976. The meetings were carried out under the US-USSR Agreement on Cooperation in the Field of Transportation, under the direction of Assistant Secretary for Policy, Plans and International Affairs, Mr. R. H. Binder, of the U. S. Department of Transportation and Mr. G. U. Aleksenko, Deputy Chairman of the Soviet State Committee for Science and Technology. The railroad technology exchange is under the direction of a joint, US-USSR, Railroad Working Group with co-chairmen, Mr. R. E. Parsons, Associate Administrator, Office of Research and Development, Department of Transportation/Federal Railroad Administration, and Mr. N. V. Kolodyazhnyi, Vice Chairman, Council of Science and Technology, USSR Railroad Transport Ministry.

The basic goals were to expand upon the knowledge obtained by previous Delegations and to learn as much as possible for application or modification to US track maintenance practices. The specific goals were to obtain as much information as possible in the following areas:

1. Economic considerations controlling the overall utilization, selection, and use of rail steel and related track components.
2. The design, operation, field and laboratory testing and experience of the Shcherbinka Test Ring and the Track Buckling Facility in relation to the new US Facility for Accelerated Service Testing (FAST) at Pueblo, Colorado.
3. The analysis of data obtained from the test facilities as related to the Soviet's development and modification of track standards and maintenance practices.
4. The metallurgy and strength of rail steel, including its microstructure, chemical composition, heat treatment, service life, reliability prediction, wear, strength, and the initiation, growth, location and type of defects.
5. The manufacture of rail, including production control, hydrogen embrittlement, 25 meter (82 ft.) length rails, heat treating techniques, microstructure, standards, residual stresses and a visit to a rail and axle mill.
6. The technology of laying and surfacing welded rail.

7. The various technologies of joining rails, including the operation of a mobile in-track welding machine with an automatic shear and a reduced welding cycle.
8. The reclamation and reuse of welded and conventional rail, concrete and wood ties and fastenings.

Previous delegations to the Soviet Union dealt with track maintenance procedures, electrification technology and rail flaw defect technology.

Our discussions with the Soviets were characterized by a spirit of cooperation and openness, but were influenced to a considerable degree by the language barrier and time spent in interpretation. The Delegation was highly impressed with the expertise and knowledge of our Soviet counterparts. Although all major goals were covered, we were unable in the time available to cover in detail a few of the very technical areas. We received, however, considerable detailed information covering all aspects of track standards, specifications, maintenance procedures and operations. The more important of these will be translated, which should add a valuable supplement to this report. Most metric measurements obtained in the USSR have been converted into units used in the US.

The Delegation was disappointed that the Ministry of Railroads was unable to arrange a visit to a rail or axle mill where we hoped to learn the techniques of continuous casting, production methods, rail straightening, ingot utilization methods, and axle and wheel production and testing methods. A "first" was achieved, however, in that a meeting was arranged with the Ministry of Ferrous Metallurgy to discuss rail metallurgy and production. We were also disappointed in not seeing the latest version of the mobile in-track welder with an automatic shear and a reduced welding cycle, which many feel holds great promise for use in the US. We learned, however, that a new machine of this type is being shipped to the US for trial.

The author wishes to acknowledge the many contributions of the Delegation members in the preparation of this report. The members of the US Delegation were as follows:

Dr. R. M. McCafferty - Program Manager, Federal Railroad Administration, DOT, Head of Delegation, Washington, D. C.

Mr. R. F. Beck - Chief Engineer, Elgin, Joliet and Eastern Railway Company, Joliet, Illinois

Mr. W. S. Lovelace - Manager-Research and Tests, Southern Railway Company, Alexandria, Virginia

Dr. G. C. Martin - Director of Dynamics Research, Association of American Railroads, Chicago, Illinois

Mr. D. P. McConnell - Project Manager-Railroad Structures, Transportation Systems Center, DOT, Cambridge, Massachusetts

Mr. R. K. Steele - Project Manager-Metallurgy, Transportation Systems Center, DOT, Cambridge, Massachusetts

Dr. D. H. Stone - Manager of Metallurgy, Association of American Railroads, Chicago, Illinois

The members of the Delegation, with the exception of Dr. Martin, are shown in Figure 1.

The members of the USSR Delegation were as follows:

Mr. S. A. Pashinin - Director-Track Directorate, USSR Ministry of Railways

Mr. L. V. Malashko - Deputy Director-International Communications Directorate, USSR Ministry of Railways

Mr. S. J. Finitskyi - Deputy Chairman of Science and Technology, USSR Ministry of Railways

Mr. V. V. Bassilov - Chief Engineer-Track Directorate, USSR Ministry of Railways

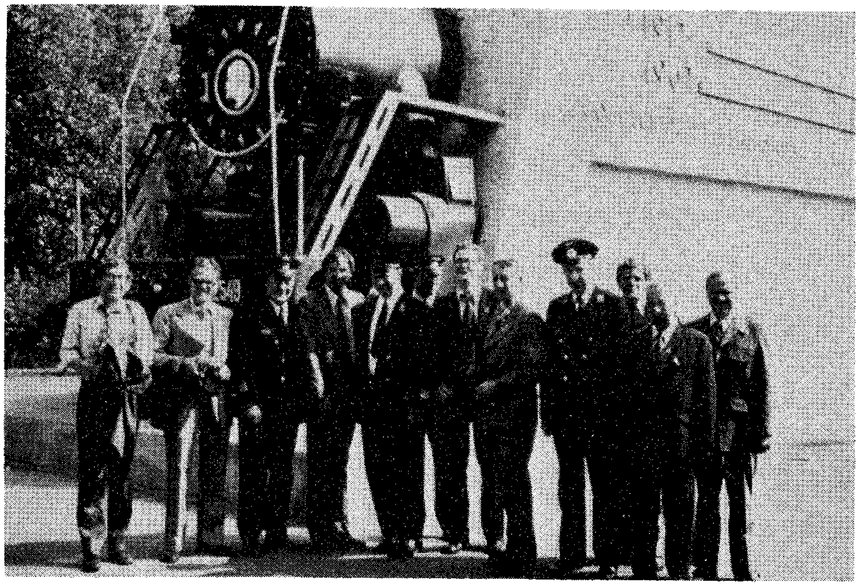
Dr. M. F. Verigo - Deputy Director of the All-Union Railway Research Institute

Mr. K. K. Alexandrov - Deputy Chief Engineer-Track Directorate, USSR Ministry of Railways

Dr. V. G. Albrekht - Head of Track Branch of the All-Union Railway Research Institute

Mr. B. Y. Lukov - Engineer of the International Communications Directorate, USSR Ministry of Railways

US DELEGATION IN BRYANSK WITH OFFICIALS OF MOSCOW RAILROAD



Left to right: Beck, Steele, Tokaryov, McCafferty, Ovsyanik, Kurov, Stone, Alexandrov, Monekehov, McConnell, Millmann and Lovelace

Figure 1

CONDUCT OF THE INFORMATION EXCHANGE

The Delegation visited Moscow, Leningrad, Bryansk and Kiev, traveling on the October, Moscow, and South Western Railroads. We were assigned a pullman car for traveling between these cities. Five consecutive nights were spent in this car. Technical discussions and visits to various facilities in Moscow took place at the USSR Ministry of Railroads, the All Union Railway Research Institute (CNII), the Railway Research Institute of Technical and Economic Information, the Shcherbinka Test Ring and Laboratories, the Lassino Ostrovskaga Track Buckling Facility, and the Research Institute, "GIPROMES", of the USSR Ministry of Ferrous Metallurgy. We also observed operations at Track Panel Pre-Assembly Station No. 99 in Bryansk. These operations included a wood tie reclamation plant, the laying and surfacing of welded rail at the Darnits-Grebyanka main line intersection of the South Western Railway, and the Track Panel Pre-Assembly Facility in Kiev, which included a demonstration of the mobile in-track welding machine PRSM-1. A detailed itinerary is shown in the Appendix A.

BACKGROUND INFORMATION ON USSR RAILROADS

GENERAL DISCUSSION

A report covering only the USSR's research, testing, construction, material components and maintenance procedures, as related to the Delegation's specific objectives, would undoubtedly raise more questions than answers because of the differences between Soviet and American practices. It is therefore incumbent upon the reader to fully understand the Soviet Railway System, the governmental environment within which it operates, traffic density, physical plant, and organization. To do otherwise would surely lead the reader into drawing incorrect conclusions when comparing American and Soviet practices. Although the very basic fundamentals of railroading are similar the world over, research and development, testing, the use of materials, development of standards, and construction and maintenance procedures are dissimilar in many important respects. The following, therefore, briefly concentrates on the basic fundamentals of the Soviet Railway System to give the reader an overview of the system.

OPERATING ENVIRONMENT AND TRAFFIC DENSITY

In the Soviet Union all railway, motor, water and pipeline transportation forms a single transportation system. The growth of each is planned by the government to insure the rational development of the entire system. Thus, competition between major modes of transportation, as we understand it in the United States, is not a factor in the Soviet Union. It was stated, however, that between 1960 and 1974, the productivity of labor nearly doubled thus lowering transportation costs and making the railroads a highly profitable branch of industry.

The USSR covers about 1/6th of the world's surface. A large part of its industries and mineral deposits are located in remote portions of Siberia, the Central Asian Republics and the Urals. These regions are separated from the western portion of the USSR, with its hub in Moscow, by considerable distances. Thus, the 85,250 miles of track, located in diverse geological and climatic zones, presents a series of demanding problems for its three million employees and managers. Two thirds of the country's total tonnage moves by rail. The problem is further aggravated by additional volume which is increasing at a rate of 1.1 mgt. per year. Although the USSR has only 10% of the world's trackage, it moves 50% of the world's freight tonnage. Although the average density is 23.5 million gross tons (mgt) per year, the heavy density lines, such as the October Railroad between Moscow and Leningrad, carry up to 176 mgt. Six minute headway between trains is not uncommon. It was stated that the average turnaround of cars was 5.5 days. One third of the main lines are double tracked and in high density areas, three or four tracks may be used.

Passenger traffic is also increasing rapidly. Three and one half billion passengers were handled last year. We were told that there are upwards of 18,000 passenger trains operating simultaneously.

Thus, it can easily be seen that the railroad system plays a crucial role in the USSR economy. Its integrity, conservative maintenance practices, and the safety of operations is of paramount importance. It further explains the emphasis placed on research and development and the constant testing of the track by track geometry cars and magnetic and ultrasonic flaw detector cars. It is clearly evident that the entire rail transportation system is well financed and not lacking in manpower. An examination of the extensive Moscow subway system with its track, stations, and modern equipment with running speeds of 37 m.p.h. on 45 second to two minute headways, is just one convincing example.

PHYSICAL PLANT

The Soviet rail network consists of four classes or standards of track that are based upon traffic density. The standards were first set in 1964 and have been revised as tonnage has increased. The present system does not meet these standards but the whole system is gradually being brought into compliance. The standards are as follows:

1. <u>Extra Strong Track</u> with tonnage of over 82 mgt. The rail is R75 (152 lb.) with either wood or concrete ties spaced 21.4 in. on centers for

tangent track and 19.7 in. on centers for curved track. A ballast depth of 16 in. is provided for concrete tie track construction and 14 in. for wood ties. A subballast of not less than 8 in. of gravel or stone is used.

2. <u>Heavy Track</u> with tonnage from 28 to 82 mgt. The rail is R65 (132 lb.). The type, number of ties, and the depth of ballast is the same as for the Extra Strong Track. Asbestos ballast is used in some locations.
3. <u>Normal Track</u> with tonnage between 11 and 28 mgt. The rail is R50 (101 lb.) and the ties and ballast sections are also the same as for Heavy Track. This class of track was introduced in 1966 but is now considered obsolete.
4. <u>Light Track</u> with tonnage less than 11 mgt. R43 rail (88 lb.) was used at one time but this track is now constructed of reclaimed rail and reconditioned wood or used concrete ties from main lines. There are still a considerable number of low density passenger lines in this category. Asbestos, sand, and gravel make up typical ballast sections.

It should be noted that at the present time, a great deal of the Extra Strong and Heavy Track sections are constructed of heat treated rail with an extended rail life. The present heat treating facilities do not as yet have the capacity to provide for heat treating all rail. The use of the concrete tie is also rapidly expanding and the Soviets speak enthusiastically about them as do their counterparts in Western Europe.

Electrification, automatic block signals, cab signals, CTC, improved motive power, and a heavier and more reliable track structure have helped alleviate the problems caused by increased tonnage. One third of the trackage is now electrified with either AC or DC power. One half of the tonnage is handled by electric locomotives of 4,200 kw. AC and 6,520 kw. DC. Train lengths vary between 50 and 80 cars as limited by signal blocks. Diesel electric locomotives of 4,000 to 6,000 hp. handle the balance of power requirements, except for about 1% which is steam powered and used primarily in switching operations. Figure 2 shows a diesel locomotive. All freight cars have conventional air brakes and standard couplers with 38% of the fleet fitted with roller bearings. The standard car has 37 in. wheels and a four-axle configuration. The Soviet equipment running on a five foot gauge track is strikingly similar to US equipment as shown in Figure 3, as compared to Western Europe's two-axle cars.

The axle load for diesel locomotives is 26 tons and 28 tons for electric locomotives. The maximum axle load for freight cars

USSR DIESEL LOCOMOTIVE

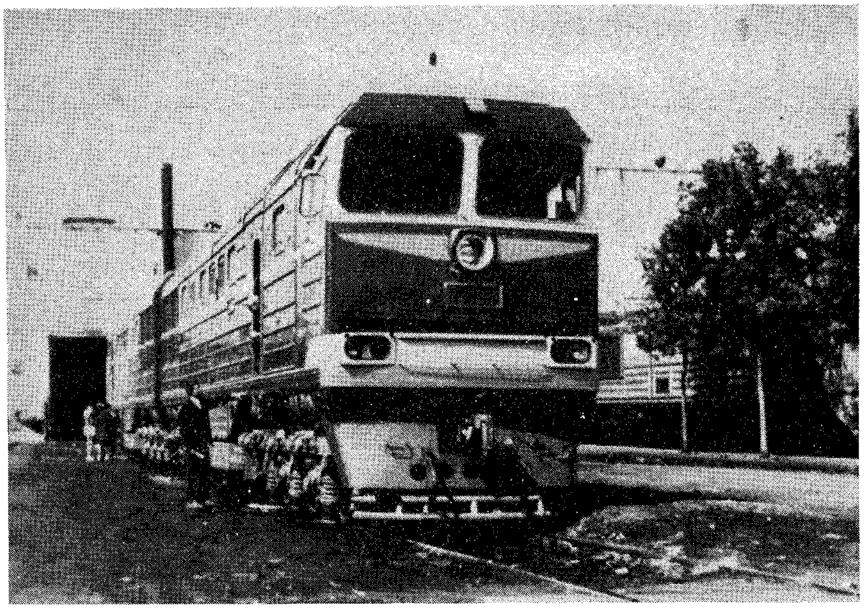


Figure 2.

USSR TRAIN CONSIST ON SOUTH WESTERN RAILROAD

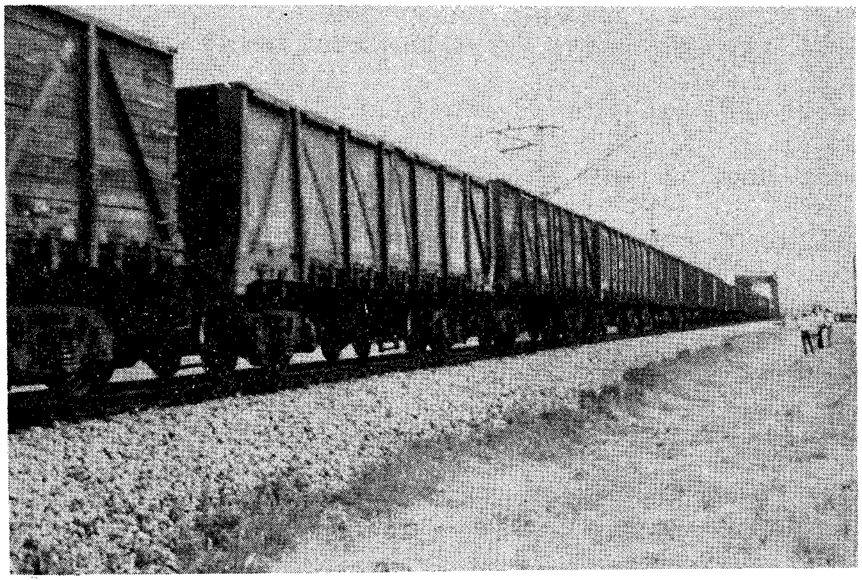


Figure 3

is 24 tons, far below the US standard of 33 tons for cars in general interchange service. Although the Soviets are building cars of 138 ton capacity, four two-axle trucks, mounted on span bolsters, are used. Figure 4 shows a tank car with this configuration.

The top speed of freight trains on main lines is 56 m.p.h. for empty cars and 62 m.p.h. for loaded cars. Passenger trains on main lines operate from 75 to 100 m.p.h. The higher speeds are operated only on the October Railroad between Leningrad and Moscow. This line is being upgraded and next year passenger trains will be operated at top speeds of 124 m.p.h.

ORGANIZATION

The USSR Ministry of Railroads controls and operates the entire Soviet rail network through its 26 separate railroads. These railroads vary in length from 250 to 9,300 mi. Two million of the three million railroad employees are involved in actual railroad operations. The balance are engaged in many other activities which support the overall railroad effort, such as medical, housing, and educational facilities as well as facilities for manufacturing frogs, switches, ties, ballast, and signaling and communication equipment. A collective farm system provides food for railroad employees although it does not fulfill the total requirements. In remote areas, the Ministry provides for water supply, sanitation, shopping facilities, and other required auxiliary services.

TANK CAR WITH FOUR TWO-AXLE TRUCKS

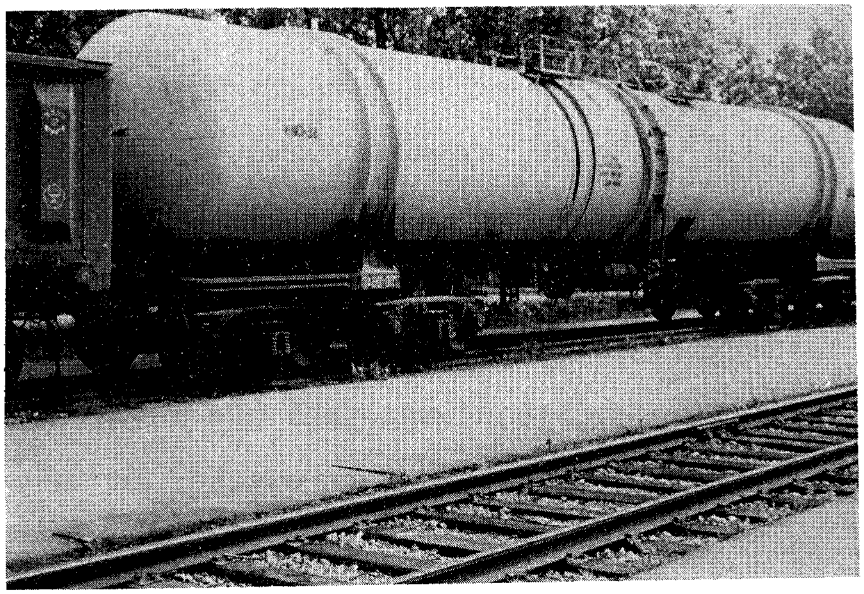


Figure 4

The Ministry maintains two direct lines of control to its 26 different railroads; Operations Control through the head of each individual railroad and Technical Control through its various Directorates located in Moscow. These Directorates include Track, Safety, Finance, Planning, Inspection, Training, Operations, Signal and Communications, Locomotives, Cars, Spare Parts, Specialized Training, Medical, Personnel, Food Supply, etc. A partial organizational chart is shown in Appendix B.

The Track Directorate, headed by Mr. S. A. Pashinin, Director, is responsible for technical control and guidance of the track service departments of each railroad. Standards, specifications and work methods are developed through the All Union Railway Research Institute (CNII) in Moscow for uniform application throughout the entire system. These flow from the Directorate. The Directorate also operates its own geometry and rail flaw detector cars. These cars are periodically operated on each railroad to insure that uniform levels of maintenance throughout the USSR rail network are maintained and for the calibration of individual railroad geometry and detection equipment. The Track Directorate is also responsible for existing line revision. It has no responsibility for new line construction such as that presently being undertaken on the Baikal-Amur (Siberian) line. The construction of new capital facilities is a function of a separate ministry.

The track service department of each individual railroad is directly responsible for the budgeting, timing, planning and support facilities required for track maintenance, working within the parameters set by the Ministry. All standards and work methods formulated and provided by the Directorate to the railroad must be followed. This organizational structure is similar in many respects to the Division Engineer-Chief Engineer relationship on most US railroads, wherein the Division Engineer is responsible for performing the work on a predetermined budget, although the methods, materials, specifications and standards are basically set by the Chief Engineer. Although national governmental standards for every facet of track work may work in the USSR's controlled economy, it is contrary to American philosophy.

Each railroad is broken down into divisions, depending upon the size and operational problems involved. The number of divisions are further broken down into line intersections, which are further subdivided into local section gangs responsible for four to eight miles of track. Details covering heavy maintenance and supporting facilities are covered later in this report.

The Directorate is faced with an ever increasing problem brought about by the annual increase in tonnage. The relatively recent introduction of a more durable and longer lasting track structure, including concrete ties and heat treated rail and more efficient heavy maintenance procedures, will not be enough to keep pace with the increased tonnage. This problem is linked directly to the 165 to 176 mgt. density areas where six minute headway between trains is not uncommon. Major emphasis is now being placed on the following items:

1. Secure a stable and reliable track structure with a maximum service life of all components which will lengthen out the interval between track outages caused by the heavy track maintenance cycle.
2. Reduce the time of heavy track maintenance outages through improved procedures, equipment and methods.
3. Increase the productivity of equipment and manpower engaged in running repairs, especially on high density lines.

Along these lines, it was stated that the number of employees has not been increased in recent years despite the increased tonnages. We also learned that the metallurgists are working on a "super" heat treated rail with a service life goal of 1.3 to 1.7 billion gross tons.

DISSEMINATION OF TECHNICAL INFORMATION

Closely related to the dissemination of technical information is the emphasis placed on education. The technical high schools provide students for the various railway training institutes throughout the country. At these institutes a very high degree of specialization within the railroad industry is provided the student depending upon his individual desires. Thus highly trained technical specialists are provided to the industry rather than personnel with broader based educations. Virtually no professional management training is provided.

The dissemination of technical information to field forces in a country as large as the USSR is a formidable task. This responsibility rests with the Ministry's Railway Research Institute of Technical and Economic Information. It not only includes internal USSR information but the gathering and dissemination of technical railroad information from throughout the world. Over 25,000 pieces of technical literature have been analyzed to enable the Railway Ministry to keep abreast of world developments and to perform technical and economic research in relationship to Soviet railroad problems. Information from 25 different technical railroad fields are processed here. The more significant information is passed on to the field offices of the various railroads.

The most advanced track techniques are studied, presentations organized, and training films produced and distributed to the divisional level of individual railroads. As new equipment and procedures are developed, the entire USSR railroad community learns about it through the Institute, although it may take considerable time before the equipment becomes available in all locations. It is evident that, in general, the Soviet government spends considerable time and money in this endeavor because each Ministry maintains its own institute for this purpose.

The visit to the institute early in our itinerary, provided us an opportunity to see excellent scale models of equipment now being used. More beneficial, however, were several excellent films showing actual heavy track maintenance operations and procedures, which gave us an insight into Soviet Maintenance practices before beginning our technical discussions. Earlier delegations concentrated on track maintenance and inspection procedures. This Delegation placed more emphasis on research and development as it applied to the track and its components.

RESEARCH AND DEVELOPMENT

GENERAL DISCUSSION

Technical discussions were held in Moscow with high level members of the Ministry of Railways and their staffs covering all facets of track orientated research and development activities. This included Mr. S. A. Pashinin, Director Track Directorate, Mr. V. V. Bassilov, Chief Engineer-Track Directorate, Mr. K. K. Alexandrov, Deputy Chief Engineer-Track Directorate, Mr. S. J. Finitskyi, Deputy Chairman of Science and Technology, Dr. M. F. Verigo, Deputy Director of the All Union Railway Research Institute (CNII), and Dr. V. G. Albrekht, Head of the Track Branch of the Institute. This institute plays the most important role in the scientific and technical progress of the Soviet Railroads. Over 5,000 scientists, engineers, and technicians are employed. Their activities cover all areas of railroading.

The highlight of these discussions was in-depth visits to the Track Buckling Test Facility at Lossino-Ostrovskaya Station and the Experimental Test Ring and Laboratories at the Shcherbinka Test Facility. Observations made at these facilities not only provided a basis for the technical exchange of information but also provide considerable information directly related to the new US FAST at Pueblo. Our discussions centered about the track structure as a system and on individual track components.

The Delegation was fortunate to have the opportunity to discuss rail metallurgy and manufacture with the Director, Mr. Guvert, of the research institute "GIPROMES" of the USSR Ministry of Ferrous Metallurgy. Our discussions were not confined to the above principals. Staff members were also made available which contributed a great deal to our knowledge and understanding of Soviet practices.

TRACK BUCKLING FACILITY

The Track Buckling Facility was the first test facility visited. A track buckling test was conducted for us during an all-day downpour. However, it never would have been run under normal conditions. This in itself was indicative of the cooperation received. The rail was covered with canvas to conserve the heat generated in the rail, as can be seen in Figure 5. Experimental work is being performed here on tangent and curved track to determine the characteristics of track buckling and its relationship to temperature, ballast conditions, track irregularities and track loading. Standards for laying continuous welded rail and the permissible horizontal alignment deviations are based on these tests.

The tangent test track was 328 ft. long. It was constructed of R65 (132 lb.) rail, concrete ties, conventional KB fastenings shown in Figure 26 and standard rock ballast. All standards for Heavy Track service are maintained. The track is surfaced by portable electric power tampers. Large blocks of concrete have been constructed at both ends of the tangent track to prevent longitudinal movement. Four different fasteners, various designs of concrete and wood ties, and rock and gravel tamped to varying degrees of compaction have been used in the more than 300 tests conducted. The rail is heated by directly applying 4,000 to 6,000 amps at 24 to 28 volts. Total power consumption is 200 megowatts. When testing curved track the radii has varied from 1,312 to 2,625 ft. and no abutments were used on the ends.

Testing with standard vertical loads has been carried out. No actual track-train dynamic tests are possible at this site. Viabrators, therefore, have been attached to the standard 24 ton axle load rail car to simulate dynamic conditions. Frequencies of from 0 to 13 hz are obtained. This dynamic excitation produced a sinusoidally varying load pulse with a maximum amplitude of ± 5 tons about the static 24 ton preload. The resulting applied load varied from 19 to 29 tons. In these cases, buckling took place immediately adjacent to the point of load application where a vertical rail movement of 0.008 in. was noted. Tests such as this do not duplicate actual operating conditions which lift the rail upward ahead of the wheels, so that a wave form is translated down the track. However, the Soviets believe that this effect has little influence on critical buckling temperatures. They also state that speed has little or no affect on buckling because no dynamic action is perceivable up to 106 m.p.h.

It is their belief that the overall condition of the track structure and the type and quantity of ballast used are the principal factors in preventing track buckling. It was also stated that the additional forces created by traction, braking, and train handling on vertical curves may add up to 20,000 lbs. to the longitudinal forces induced by constrained thermal expansion. The conclusions reached were that no buckling will take place if fastenings are kept tight on concrete ties and anchorage is sufficient on wooden tie trackage. This assumes that welded rail laying procedures and temperature standards are followed and that ample ballast shoulders are provided.

Changes in gauge on wood ties, before buckling takes place, have been observed when the spikes are not tight. The greatest lateral stability has been achieved with a concrete tie which has a 1 in. recess for the tie plate and an elastic pad. The recess of a standard tie is 0.80 in. This behavior is an indication of the influence of fastener design on track stability.

In the test conducted for us, the track was lined to a centerline reference wire to the nearest 0.04 in. and a deviation in alignment of some 0.79 in. peak amplitude over a 32.1 ft. span was introduced. During normal testing procedures, horizontal deviations are introduced into the track in accordance with allowable deviations under the track standards, and to insure a controlled test verifying the standards. The rail was heated as previously described and horizontal measurements were manually recorded from displacement dial gauges attached to the base of the rail by a steel wire. This is shown in Figure 6. With all of the rainfall experienced, Doctors Verigo and Albrekht were not sure that the rail could be heated sufficiently. However, when the dial gauges started to rotate rapidly, they stated buckling was imminent. With a loud bang and a swishing noise, the track buckled in the form of a S curve. The post test buckled shape of the track is shown in Figure 7 and is plotted in the center graph of Figure 8.

Current Soviet theories of the buckling of track are based exclusively on empirical data derived from over 305 buckling tests which have been conducted. Earlier attempts by the CNII to provide an analytical theory for the buckling of track were abandoned when the analytical predictions showed poor agreement with the data from early tests. Furthermore, since the Soviet test procedure is not based on an appreciation of the post-buckling track response, the empirical theory which has evolved centers on measures of track deflection up to the critical temperature increase which marks the onset of buckling. This is also shown on the graph in Figure 8. Contemporary US theories of track buckling would indicate that this approach is most valid for the larger alignment deviations. Both theories agree that the critical temperature increase should be taken as the lowest temperature increase for which buckling can occur, although the ability of the Soviet technique to determine this point consistently was not demonstrated.

The principal use of the data derived from the track buckling test series has been to define for each configuration of track

TRACK BUCKLING TEST MADE DURING A DOWNPOUR

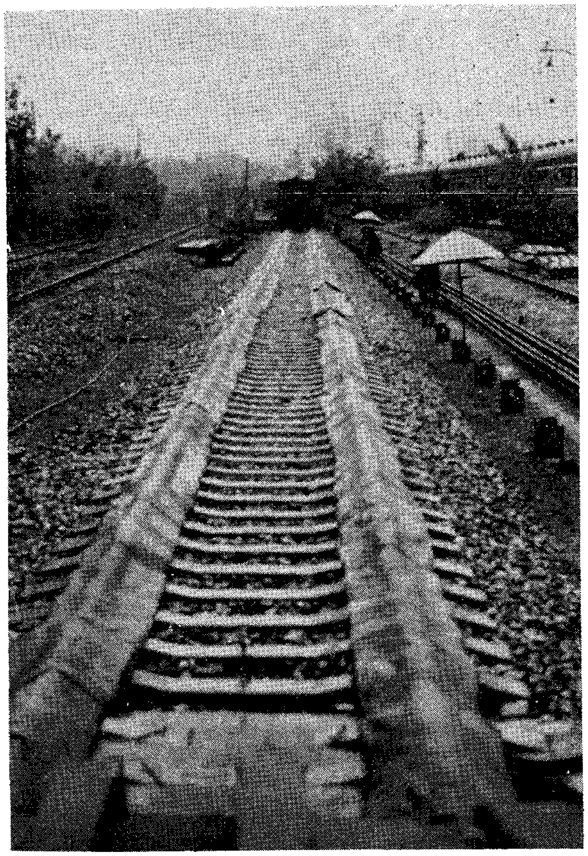


Figure 5

DISPLACEMENT DIAL GAUGES USED IN TEST

Figure 6

TRACK BUCKLE OBSERVED

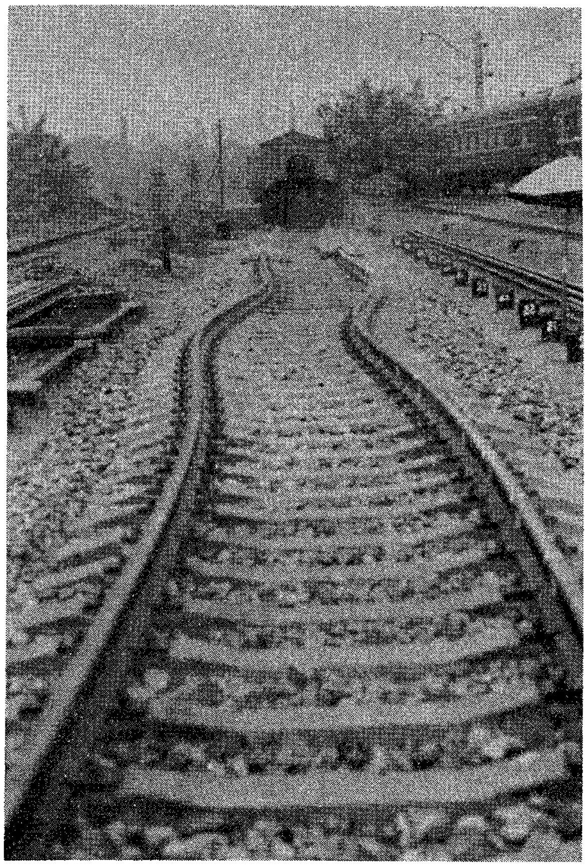
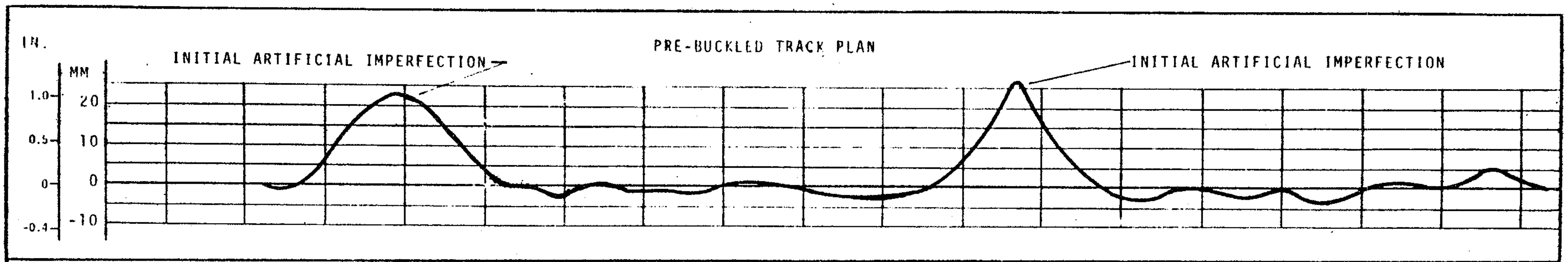
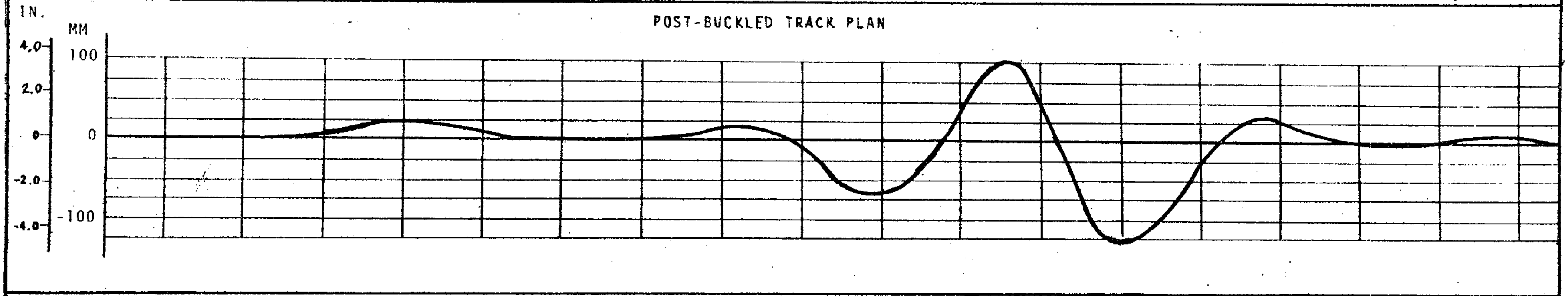


Figure 7

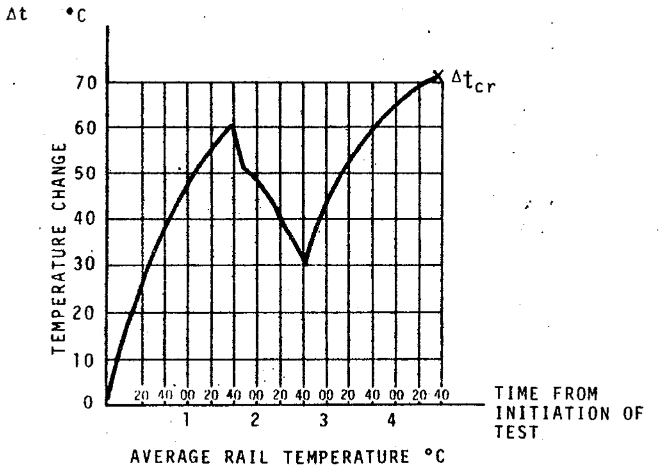
SOVIET TRACK BUCKLING TEST DATA

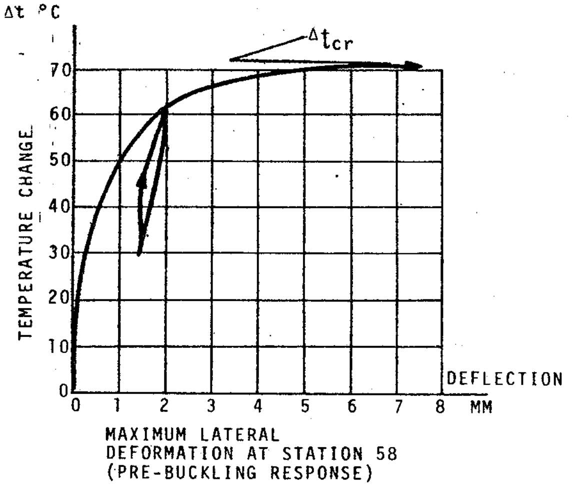


STATION NO.	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90
POST-BUCKLED TRACK GAGE mm (in)	1522 (59.92)	1525 (60.04)	1517 (59.72)	1520 (59.84)	1517 (59.72)	1521 (59.88)	1522 (69.92)	1522 (99.92)	1522 (59.92)	1522 (59.92)	1523 (59.96)	1522	1524 (60.00)	1522 (99.92)	1525 (60.04)	1522 (59.92)	1521 (59.88)	1525 (60.04)



POST-BUCKLED TRACK GAGE mm (in)	1522 (59.92)	1525 (60.04)	1518 (59.76)	1521 (59.88)	1520 (59.84)	1521 (59.88)	1522 (59.92)	1522 (59.92)	1522 (59.92)	1523 (59.96)	1522 (59.92)	1521 (59.88)	1527 (60.12)	1522 (59.92)	1517 (59.12)	1523 (59.96)	1521 (59.88)	1525 (60.04)





TEST NO. 305
JUNE 16, 1976

TRACK CONFIGURATION

RAIL: R65 (132 LB/YD)
TIE TYPE: KB70 CONCRETE
FASTENER: GBR CLIP TYPE
BALLAST: CRUSHED STONE
TIE SPACING: 54 cm (21-1/4 IN.)
TEST STAND: 100m (328 FT.)

TEST METHOD

RAIL HEATING: DIRECT RESISTANCE ELECTRIC
POWER: 28 VOLTS (DIRECT TO RAIL) 6000 AMPS
INDUCED TEMP. CHANGE: 70°C

Figure 8

construct a maximum allowable temperature increase above the neutral rail anchoring temperature for which buckling can be anticipated. This data provides one of the factors upon which the Soviet standards for rail laying and anchoring are based.

Current Soviet standards require that for any given location on the railway network where continuously welded rail is to be installed, the maximum and minimum anticipated annual rail temperature be determined. This is accomplished by monitoring rail temperature for a period of at least three years. This determines the T_{max} and T_{min} shown in Figure 9. To set the lower limit on the allowable rail anchoring temperature (T_{ℓ}), ΔT_{cr}, the temperature increase necessary to buckle the track, is subtracted from the maximum anticipated rail temperature. Similarly, the upper limit on the range of rail anchoring temperatures is set by adding the temperature change needed to pull apart rail welds (ΔT_r) to the minimum anticipated rail temperature. As Figure 9 shows, this determines a range of rail temperatures within which continuously welded rail may be laid and anchored with a low probability of pull apart of the rail in winter or buckling of the track in summer. For most Soviet track constructions, in all but the most severe climatic conditions, this procedure defines a range of over 30°C (54°F) in which continuously welded rail may be anchored.

The Soviets follow this practice in all but the most extreme climates, such as in Siberia. In these regions the temperature extremes are so great that there is no rail temperature for anchoring which is suitable for both winter and summer. In these locations, the rail is restressed every spring and fall, using a temperature range based on the maximum and minimum rail temperatures anticipated for the fall-winter or spring-summer seasons.

RANGE OF RAIL TEMPERATURES WITHIN WHICH CONTINUOUSLY WELDED RAIL MAY BE LAID AND WELDED

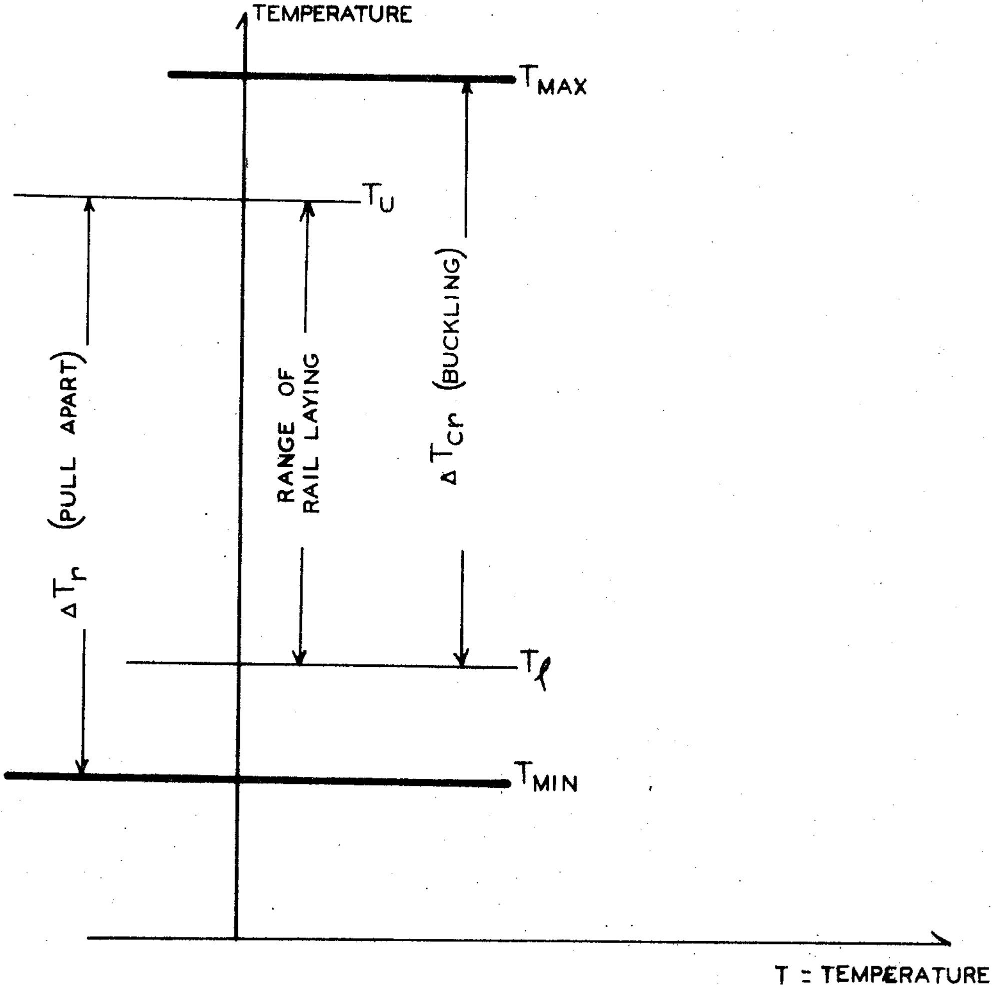


Figure 9

SHCHERBINKA EXPERIMENTAL TEST RING AND LABORATORIES

GENERAL DISCUSSION

The Shcherbinka Facility has enabled the USSR to investigate and test all track structure, cars, and locomotives as a system, as well as their component parts. No equipment or component of any kind can be used on the Soviet rail network until it has been approved by the Shcherbinka laboratory and through ring testing and field testing followed by the establishment of standards. The facility is the focal point for track related data from which all specifications, standards, maintenance procedures and service life calculations are ultimately based. This Shcherbinka Facility is now in the process of upgrading for the "Second International Railway Transport '77" which will be held July 13 to 27, 1977. The completion of the new FAST at Pueblo will provide an opportunity to obtain the data required to help improve overall US rail operations.

FACILITIES

Railway research and development activities have had a long history in the USSR, having started as early as 1882 with steam locomotives in Kiev. As early as 1901 a test loop was proposed. The first of the three test loops, with a radius of 3,136 ft. and a length of 3.7 mi., was placed into operation at Shcherbinka in 1932 for the testing of steam locomotives. The track was placed on a level grade, was built to provide uniform tractive resistance, electrified and upgraded to heavier R65 rail in 1935. This permitted top operating speeds of 87 m.p.h. Both electric and diesel locomotives are tested on the outside ring in addition to cars and their components.

In 1950, two additional tracks were built inside the original track with radii of 2,625 and 1,969 ft. respectively. The inner rings are not completely circular. A 5,000 ft. long, tangent track was also built in addition to auxiliary tracks. Track construction on these tracks is the same as previously described except for new test materials such as rails, ties, fasteners, ballast and many types of panel track construction. Figure 8 shows a typical portion of the three rings for testing track and rolling stock. If the USSR were to construct a new facility from scratch, it would be built in the form of a figure 8 to introduce reverse curvature.

Adjacent to the tracks are 30 different laboratories, power substations, auxiliary facilities and housing for the personnel who work here. Some of the more important laboratories are electrical labs for catenaries, pantographs and current collection devices; diesel and electric locomotive laboratories; fuel and lubricating oil analysis; static testing of cars; testing of disc brakes and brake shoes; and the dynamic and static testing of track components. The latter is similar to various track testing facilities in the US, except for the absence of computers and more sophisticated instrumentation. No computers were observed in any of the facilities visited.

SHCHERBINKA TEST RINGS

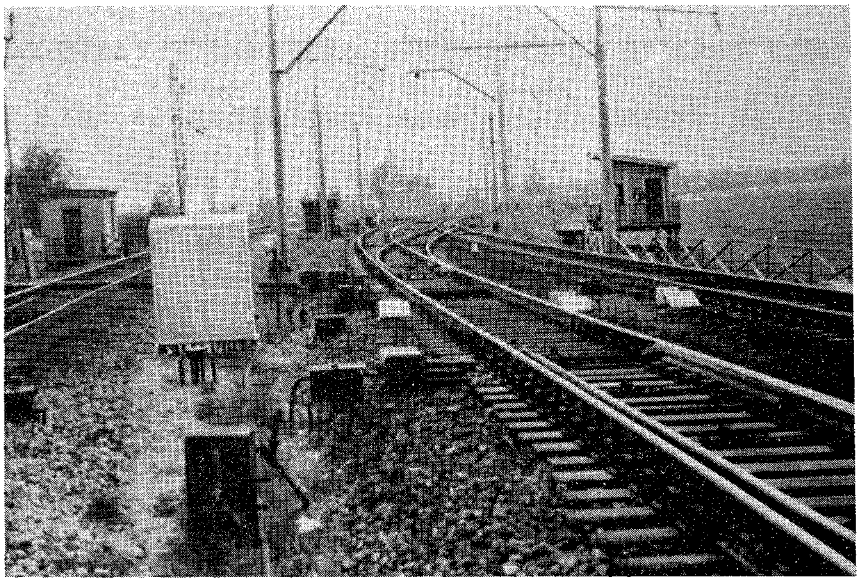


Figure 10

STATIC LOAD TEST

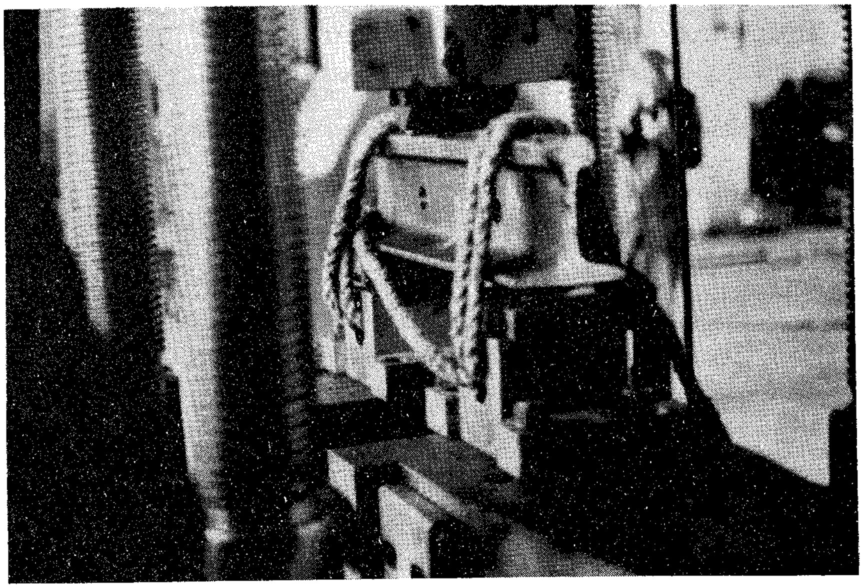


Figure 11

Figures 11 and 12 show typical rail testing taking place and Figures 13 and 14 show the testing of car components.

A portable, battery operated, ultrasonic device, which maps flaws in the rail head area, was of great interest to the Delegation. It is shown in Figure 15. This instrument is used to determine the rate of flaw growth. A diagram of the flaw is recorded on paper. We were told that the instrument will also be used as a calibrating device for ultrasonic flaw detector cars and hand pushed ultrasonic flaw detector carts. An instrument of this type would be a valuable addition to flaw detection and the study of growth characteristics of defects in the US.

A new track, 790 ft. long, is under construction on the inside of the inner ring for the testing of new open and ballast deck bridge designs. Older designs are also being built to serve as control. Precast, pretensioned concrete components and concrete ties will be tested. New standards for bridges and approval of concrete bridge ties will be based on these tests. Figure 16 shows a bridge abutment under construction.

TRAIN OPERATION

The track testing loops are referred to as a "Time Machine". Each night approximately 1.3 million tons are moved over the track. This equates to about 444 mgt. per year. Testing takes place seven days a week, 10 hours per day, except when major modifications are made for tests. Maintenance and safety considerations govern the

RAIL ROLLING LOAD TEST

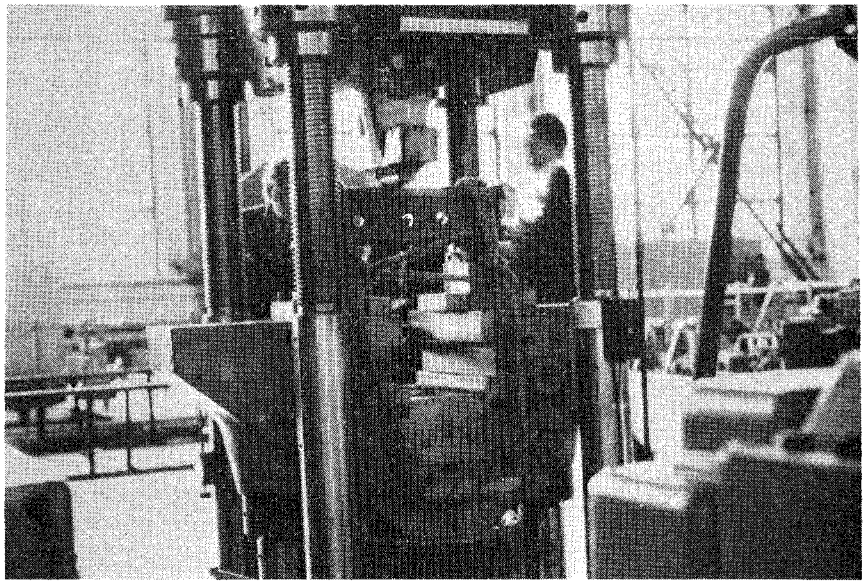


Figure 12

STATIC TESTING OF CAR WHEEL

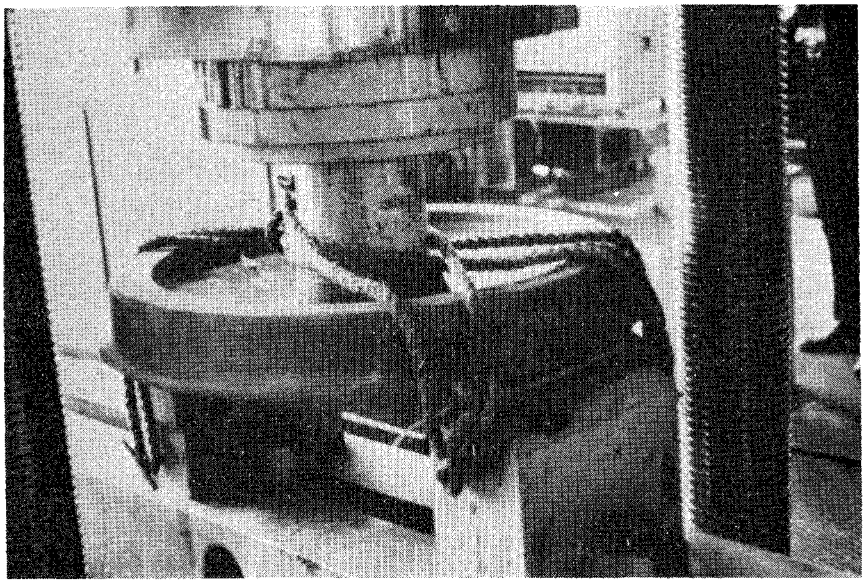


Figure 13

STATIC BOLSTER TEST SHOWING FAILURE

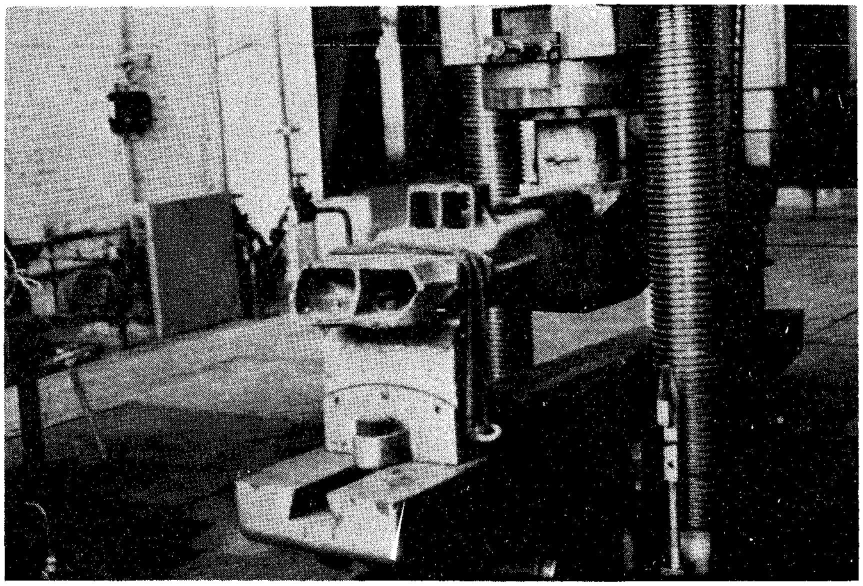


Figure 14

ULTRASONIC RAIL FLAW PROFILING DEVICE

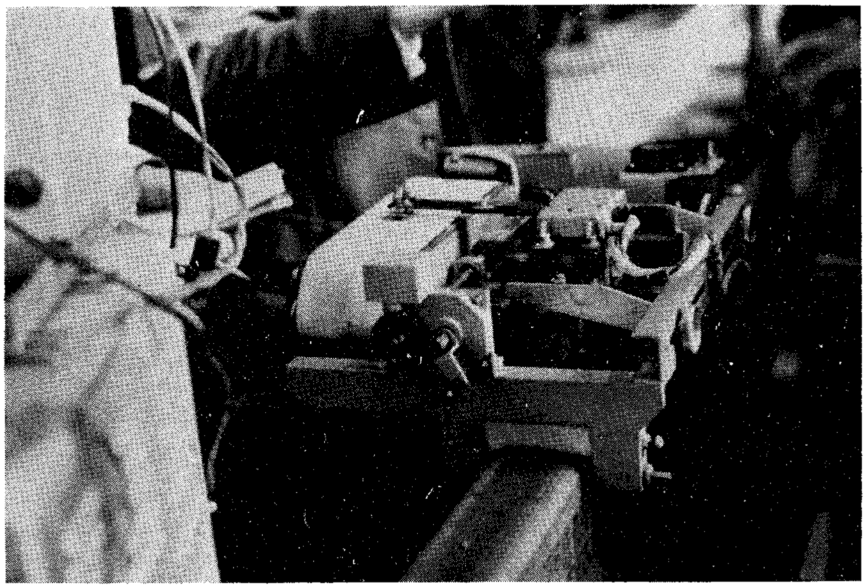


Figure 15

BRIDGE OF NEW DESIGN UNDER CONSTRUCTION

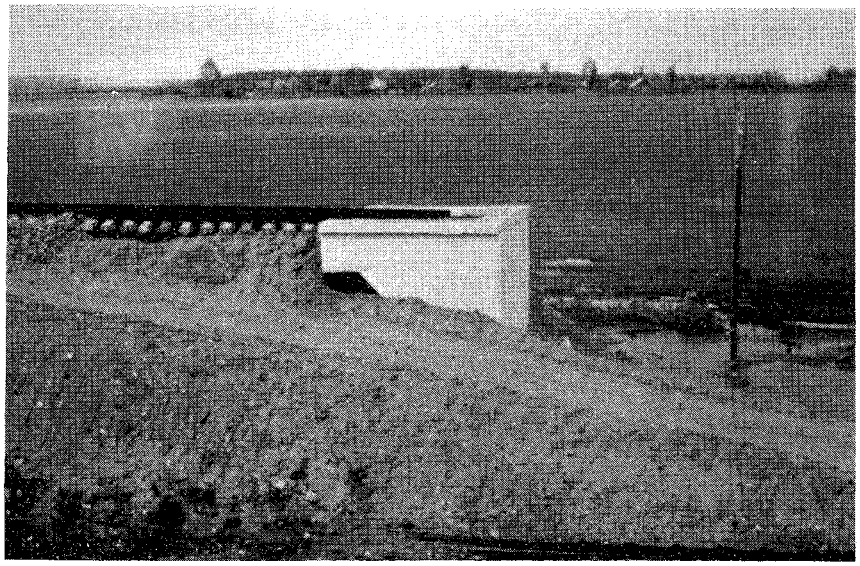


Figure 16

10 hour day. The train runs continuously at a uniform speed of 37 to 44 m.p.h. for two 5-hour periods, separated by a rest break period for the engineer. This schedule is not rigid but may vary with a break after four hours. During these periods the cars are checked visually. The engineer sounds his whistle at each pass of the control tower and the operator acknowledges to demonstrate crew alertness.

Diesel locomotives are used at this time, although the tracks are being electrified. The train consist varies between 9,400 and 9,900 tons. Conventional, loaded four axle roller bearing cars are used and a standby locomotive is provided. No cars are moved forward in the consist unless maintenance is required on one or more of the cars. The braking cycle used varies greatly, depending upon the type of test being run. Hot box detectors are located on the ring. One roller bearing failure per six months, on the average, has been experienced.

TRACK MAINTENANCE PROCEDURES

The track is maintained to USSR track standards for Heavy Track, except for tests where deviations may be introduced. The rail is lubricated. Two track gangs are used during daylight hours when trains are not running. A heavy gang of 45 to 50 men lays and removes track and components for various tests. Minor maintenance, spot surfacing, etc., is carried out by a smaller gang based upon information generated by a track geometry car.

LABORATORY AND FIELD TESTING

a. General

Track components are statically and dynamically tested in the laboratory before they are placed in the ring. If a component fails here, the testing is terminated. If the testing is successful, the components are placed in the ring. If the ring tests are successful, the component is placed into main line track for continued observation. Although testing at Shcherbinka is said to be more severe than normal service conditions there is no sure guarantee of ultimate acceptance, because some components have failed under actual field operating conditions.

b. Instrumentation

No advanced instrumentation is located on the test rings. Strain gauges of various types are used for all measurements. No permanent installations have been set up to record the dynamic load response of the track structure or any of its components. In this respect, the instrumentation, collection, and the storage and retrieval of data by computer for FAST at Pueblo will far exceed the Soviet's present capability at Shcherbinka.

A track geometry car covers the rings weekly and a daily inspection of the rail is made by a hand pushed, ultrasonic detector cart. Instrumented wheel sets with sensors applied to wheels, side frames, bolsters, etc., including accelerometers, are used twice a year to record dynamic forces. It was stated that the data is read from a magnetic tape but none was available for examination. They agreed to give us the results of their research work in some areas if we would supply them with some of our own data. In this context we were discussing the mean, standard deviation, power spectral density, etc. All test data is analyzed daily. Much of the data is not formalized but is used for comparative purposes with data obtained from other tests. Most high speed tests, including track train dynamics testing of truck hunting are carried out on a 16 mi. section of main line track located at Bellerinchin-Mycoff in the Caucasus.

c. Laboratory Testing of Rail

The usual laboratory static and dynamic testing of rail, as previously pointed out, takes place at Shcherbinka. In addition, non-destructive testing for internal rail defects is carried out. The rail is first subjected to approximately 1 mgt. in the test ring trackage. It is then removed, cleaned, defects located and logged. The rail is then placed back into the track and growth of the defect is observed daily. From these tests it was concluded that inclusions greater than 0.08 in. length were unacceptable because of the possibility of accelerated fatigue failure. Similar segregation requirements on the basis of inclusion content exist in Germany and France where ultrasonic inspection of all finished rail is mandatory for the DB and SCNF railroads. Laboratory testing has also determined that a deviation of 30 BHN cannot be exceeded in production rails.

Laboratory testing of residual stresses in rails has been carried out. Strain gauges are positioned at 29 characteristic points on the rail perimeter and the results recorded. A 1.6 in. section, not less than 37 in. in length, is then cut out of the rail section by cold cutting saws. Strain gauges are again read after cutting to obtain the residual stresses. The weakness of this method is that information is only obtained on surface stresses. This test is impractical for application to the mill production of rails.

A different type of test is conducted at the rail mills. This consists of cutting a slot 0.8 in. wide on the web of a 24 in. long section of rail. The slot is 16 in. long and is cut along the central axis. The magnitude of the residual stresses is determined from the opening or closing of the groove. It has been concluded that, if the separation does not exceed 0.15 in., the residual stresses involved can be tolerated.

d. Field Testing of Rail

Consignments of experimental rails passing the laboratory test phase are placed into the ring. They are compared to standard production rails used as a control. Over 60 different types of rail have been tested with up to 12 tests taking place at one time. Thirty to 40 rails, 41 ft. in length, comprise a typical test section. The rails are inspected daily for defects, tonnages are noted and growth characteristics of defects measured. If a failure occurs or a defect becomes critical, the rail is removed and replaced with another experimental rail from the same consignment. The test is concluded when 20% of the components have failed.

The total service life of the rail in millions of tons of freight is calculated. This includes both main line and secondary usage. As will be pointed out in more detail later, service life in the USSR is actually determined by the number of defects per unit length rather than by head wear. The data received from the testing is processed by statistical methods. Final calculations include rail service life in mgt., mean tonnage cycles between failures, mean square deviation, coefficient of variation, quantile of distribution with assured probability of 90% and absolute and relative limiting errors. If all of the testing is successful, the experimental rail is placed in a main line test section which is never less than 1,650 ft. long.

e. Laboratory and Field Testing of Concrete Ties

Consignments of experimental concrete ties are tested in the laboratory to help estimate service life. The ties are tested statically on elastic and fixed supports, and dynamically on a fixed support. Strain gauges, vertical displacement dial gauges, loading equipment and visual observation are used in these tests. The loads applied, location and types of cracks observed, deformation, loading cycles, and the moments and stresses computed, are used in creating a fatigue graph. This graph can then be compared to the graph of an approved tie in main line service.

From this it is possible to make a relative estimate of service life. The ties are then placed into the ring in minimum track lengths of 650 ft. If these tests are successful, a field test of at least a quarter of a mile is inaugurated.

f. Laboratory and Field Testing of Rail Fasteners

Little was learned in this area except that it is difficult to duplicate actual conditions in the laboratory. Many types of fastenings have been tested and discarded. One of the problems with the concrete tie and its fasteners is the harshness of the ride and lack of track structure elasticity. Figures 17 through 19 show some of the fastenings which have been tested.

g. Track-Train Dynamic Testing and Track Loadings

This testing is not carried out at Shcherbinka but on a main line section in the Caucasus. It is important, however, to cover this now.

Data on stress in the shoulder of the rail base is obtained through the use of strain gauges to estimate the long term fatigue strength. Vertical and horizontal wheel loads are measured to determine contact stresses, estimate the stability of the wheel against flange slippage and determine the transverse shifting of ties in the ballast section. The data is generated by instrumented wheel sets.

It has been determined that the ratio of the total axle lateral force acting on the rail head to the mean vertical axle load must not exceed 0.40. The Soviets were unfamiliar with the l/v ratio

TRACK FASTENING BL65

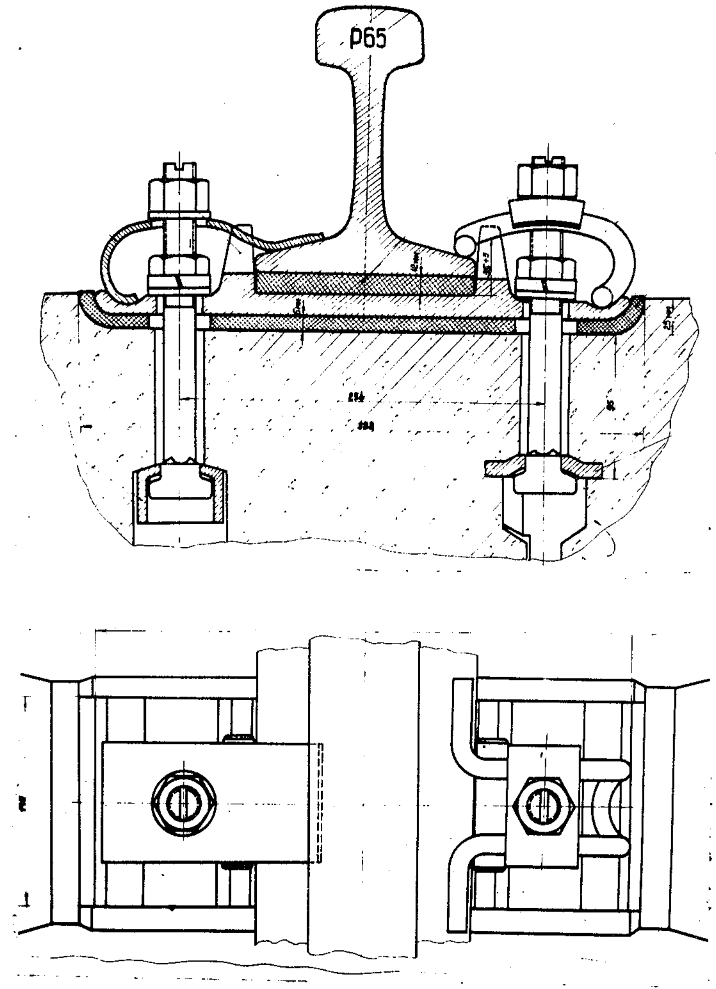


Figure 17

TRACK FASTENING K2S

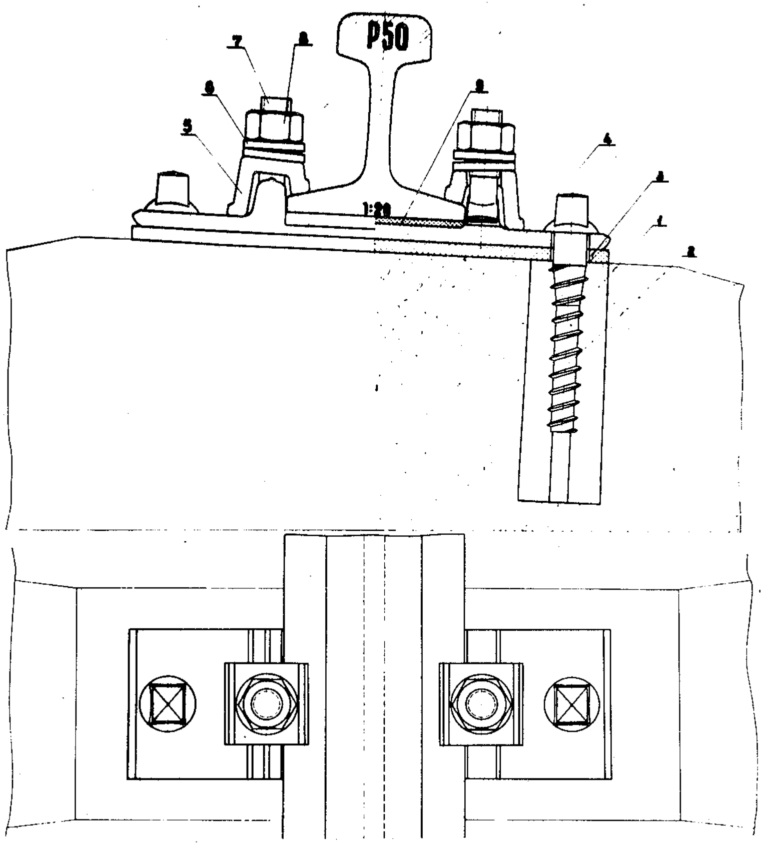


Figure 18

TRACK FASTENING BS3

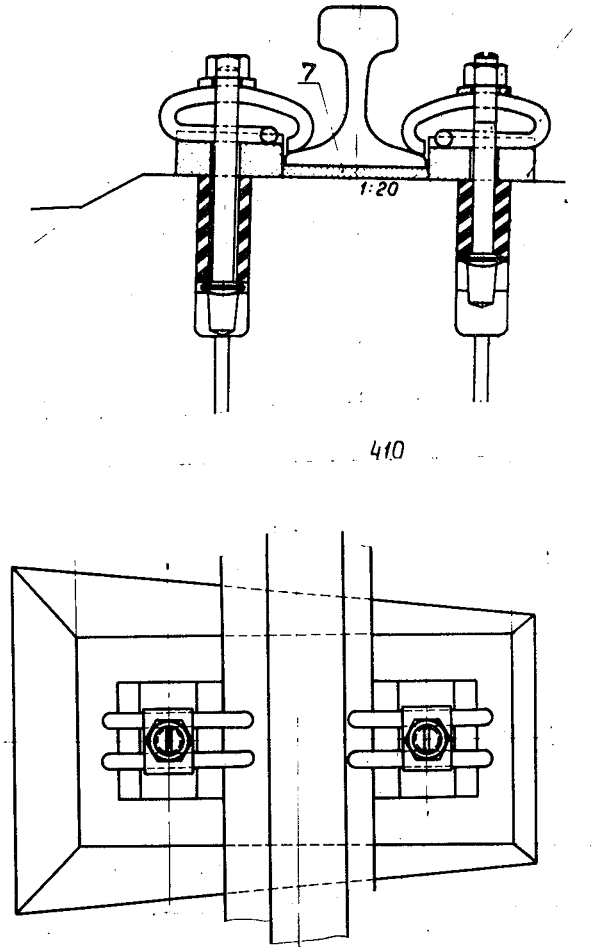


Figure 19

nomenclature as normally used in the US. Based upon US equipment and track geometry, wheel lift can take place at an l/v of 0.82 to 1.0 depending upon the wheel rail interface limit. Rail rollover, however, can occur at far lesser values in the US, depending upon many factors.

The vertical and horizontal tie loadings are also measured to estimate tie strength, the capacity of the hold down fastenings and the strength of the tie base to resist transverse shifts in the ballast section. The measuring devices are designed by CNII.

Elasticity is said to be computed from data generated by instrumentation. Residual, vertical deformations of the track structure are determined by precision leveling. Residual, horizontal deformation is measured with displacement dial gauges located at appropriate reference points. Ballast and subgrade stresses are measured by standard hydraulic dynamometers used in basic soil research.

The recording of dynamic response is said to be accomplished with appropriate instrumentation such as oscillographs. Measuring points are located where maximum vertical and horizontal accelerations and forces occur. Preliminary runs of the instrumented wheel sets located these points. Both statistical and automatic processing are used to average mean values and probabilities. Averaging of experimental data on rail stresses is accomplished with Gauss, Gramme-Charlie or Pearson curves.

We tried several times to learn the relationship between field test data and design considerations but were unsuccessful. It was stated that designs generally perform better in the field than would be anticipated based upon experimental ring testing.

A significant factor which emerged was a standard for the load per meter of track. The Soviets are convinced that to increase the present track loading, the number of axles per car must be increased. This is in direct contradiction to past US practice, which has increased axle loadings to a maximum of 263,000 lbs. for cars with four axles in general interchange service. Present maximum axle loads in the US are approximately 37% higher than the maximum permitted in the USSR. The much higher axle loadings in the US are related, to some degree, to the increased rail and track problems, including plastic deformation, rail corrugations, fatigue failures and muddy track, we are experiencing. The USSR's ratio for load per meter of track is 6.5 for the standard 24-ton axle loading and 8.6 for the eight wheel, 138-ton capacity car. The USSR 100-ton capacity car is being built with six axles. The trend, however, is toward the heavier eight axle car. Up to this time the Soviets have not been willing to take chances with higher wheel loads because of their almost complete dependence upon the railroads.

RAIL METALLURGY, PRODUCTION AND PROPERTIES

In past years, the USSR has placed emphasis on the development of new rail sections of increased carrying capacity and a corresponding reduction of rail failures. The R65 (132 lb.) and R75 (152 lb.)

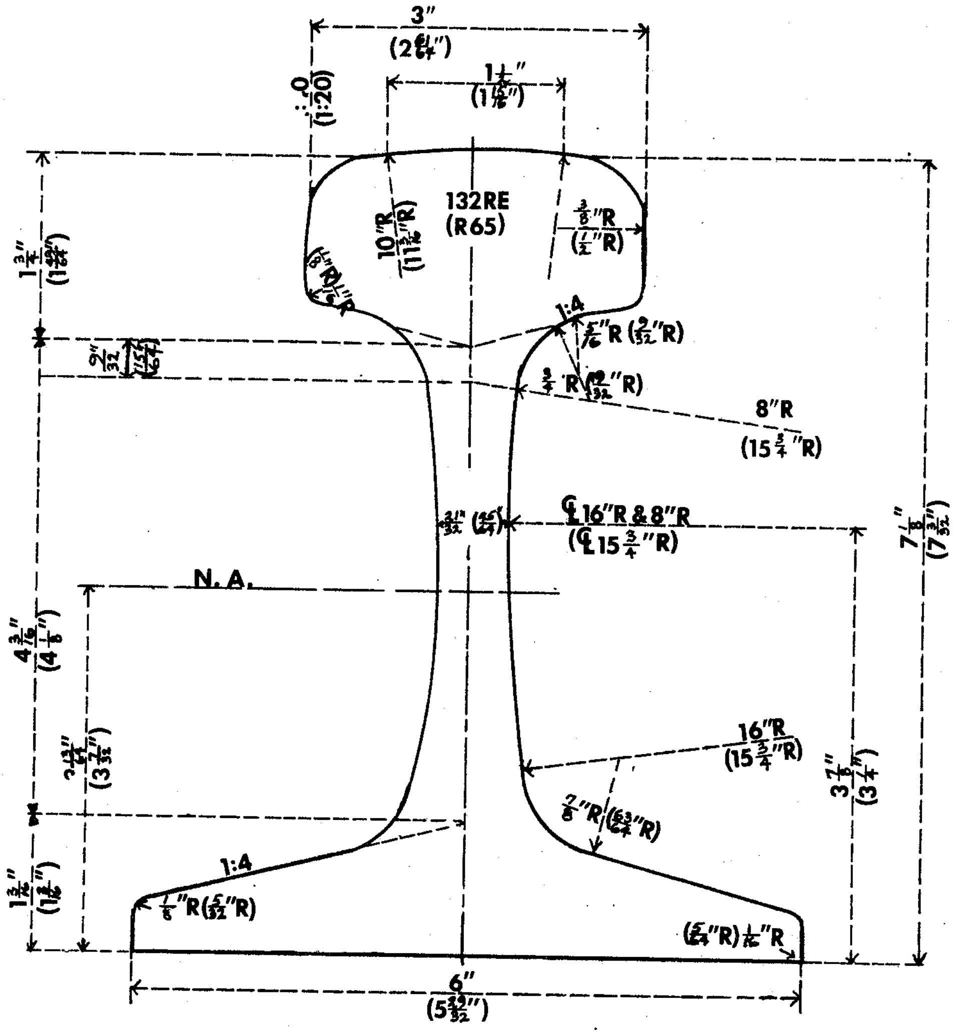
sections, as previously mentioned, are used in main lines. The R65 section accounts for most of the rail production and is very similar to the US 132 lb. RE Section. The major differences appear in the head, as can be seen in Figure 20.

The development of new rails is based upon the rail's relationship to the track structure, the metallurgical and manufacturing processes, and the extreme climatic conditions within the USSR. Special emphasis is placed on reducing the likelihood of fatigue crack initiation rather than wear resistance, as is the case in the US. From the track standpoint, axle loads, speeds, traffic density, track structure stability, rigidity of concrete tie trackage, geometry, and the equalization of the life of all track components is considered. The traffic densities bear repeating here, 23.5 mgt. on the average, reaching 176 mgt. on very high density lines.

Various combinations of manganese, chromium, silicon and nickel were tried several years ago, but the results were disappointing and alloy steel rails were not adopted for use. This is interesting, because work has been intensified in other countries to develop alloy steel rails in recent years with some success. The Soviets concluded that the carbon content plays a very important role in hardness. Research was instituted on what they term "thermo hardening" or heat treating. Fully heat-treated rail has been in widespread use since 1966.

It was stated that hydrogen embrittlement was eliminated by 1935 in the USSR. Work continued on reducing manufacturing induced

RE 132 LB. RAIL SECTION WITH US AND USSR DIMENSIONS



NOTE: USSR UNITS IN PARENTHESIS

Figure 20

residual stresses and on increasing the cleanliness of rail steel. The earlier metallurgical programs were also aimed at increasing contact fatigue and wear resistance. Inclusions resulting from Al_2O_3 were reduced by new deoxidation processes. Control cooling of billets and vacuum degassing has also been tried. Vacuum degassing accounts for about 220,000 tons of the average yearly 2.5 million tons produced. Many difficulties are involved with this process.

The heat treating processes worked on included through hardening of the complete rail section using an oil quench, hardening hot rolled Bessemer steel by utilizing the residual heat with an automatic water mixture quench, and surface hardening to a depth of 0.4 in. using induction heating with a water and air cooling process. The latter method has not proven successful because of nonuniformity of hardening, but experimentation continues.

Currently, 90% of the rail is produced by the basic open hearth process and is used for heat treated rails. The remaining 10% is produced by the Bessemer process and is used for the R50 (101 lb.) rail section. This section is only used on lines where the minimum temperature does not drop below -40^{o}C.

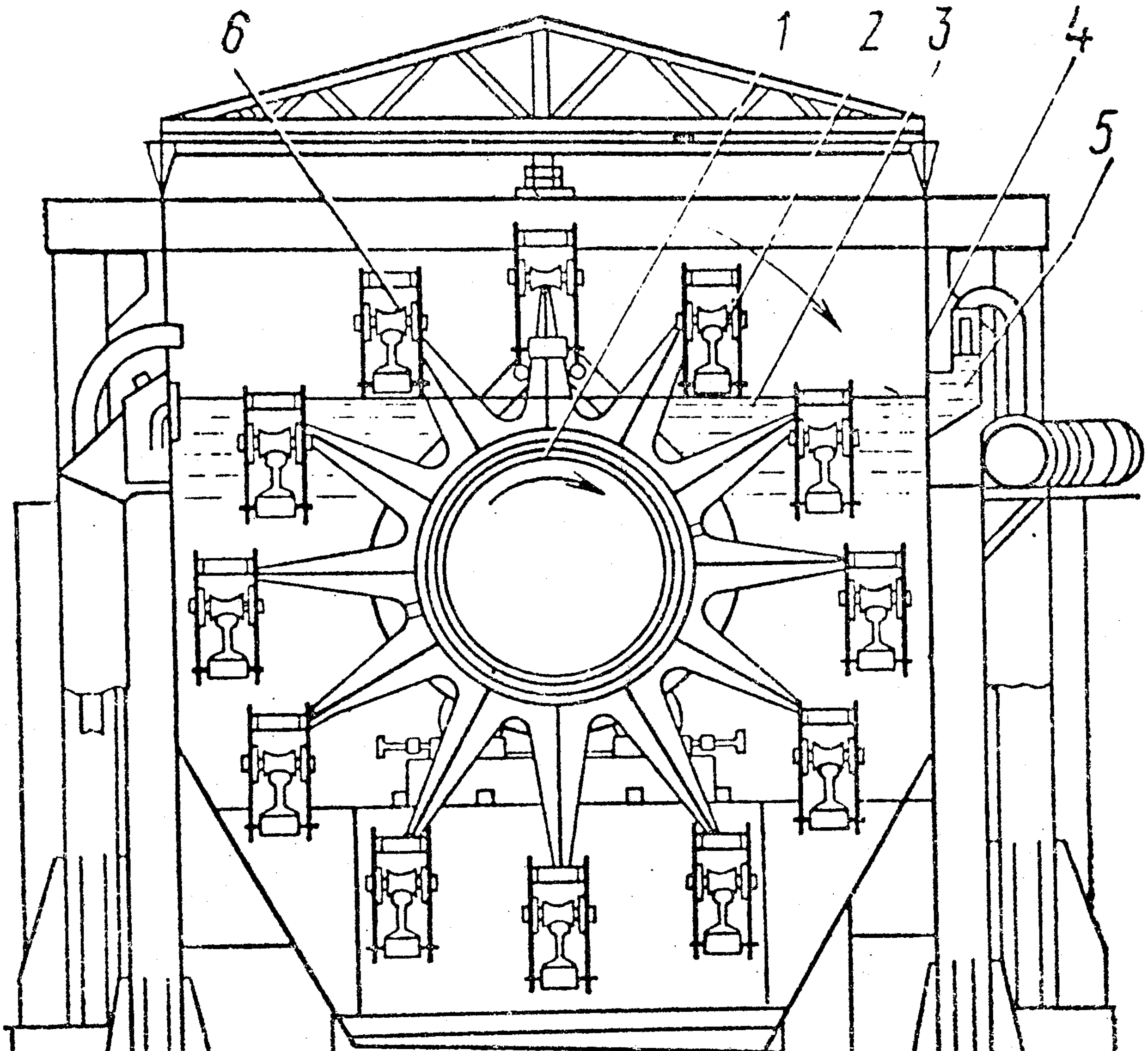
The method now used results in completely through heat-treated rails. Rail steel is placed in an isothermal annealing furnace for two hours at 1,100^{o}F (600^{o}C) to reduce the hydrogen content of the steel, thus eliminating the control cooling process. The heat preserved in the rail encourages heat treating after annealing.

The rails, in packs of 12 to 13, are reheated to 1,560°F (850°C) in a neutral nitrogen atmosphere and then introduced into a quenching drum. This drum receives a new rail on a series of ferris-wheel supports which carry the rail down into the lower two thirds of the drum. The drum is filled with quenching oil. This equipment is shown in Figure 21. After the rail continues upward through the oil bath to the surface, it is removed from the opposite end of the drum and introduced into a tempering furnace. The rails are tempered at 840°F (450°C) and straightened in a six roll, vertical and horizontal straightener. If necessary, the rail ends are press straightened in order to meet the 0.55 mm/m (0.018 in./yd.) Soviet rail specification.

The resulting rails have an essentially pearlitic microstructure. Presently, 45% of all current rail production is fully heat treated in this manner, with 25% of the system laid with heat treated rails. Heat treated rails account for 80% of the R75 rails produced and 77% of the R65 rails. The new Baikal Amur line now under construction in Siberia is being built of R65 heat treated rail.

All mills, except one older one, have been converted to producing 82 ft. rails rather than the older 41 ft. length. A new, combination rail and structural mill has been built in Nizhni Tagil and is reported to have a capacity of 845,000 tons per year. The Director of the Metallurgical Research Institute, Mr. Guvert, stated that the new facility, using the latest technology, was more economical to construct and operate than conventional mills employing

OIL QUENCHING EQUIPMENT FOR HEAT-TREATED RAILS



1-the rotating mechanism; 2-rail entering bath; 3-the quenching oil; 4-tank; 5-oil inlet; 6-quenched rail in process of being removed from bath.

Figure 21

the control cooling process. He also stated that the heat treating process increases rail manufacturing costs by 8.3%. We had heard earlier that heat treated rail was 20% more costly than conventional rail. He also stated that six years ago the BHN was 321, is now in the 331 range, and is pressing toward the 351 range with the present metallurgy. A BHN beyond 388 is considered dangerous with the present metallurgy.

The Soviets are not satisfied that the present heat treated rails are sufficient for their future needs. Even though service life has been extended 1.5 times, the tonnage has increased 1.6 times since 1966. Thus, the track engineer is back where he started. Conventional rail must therefore be replaced in about three years on very heavy density track and in less than five years with heat treated rail. This is not a simple procedure because, unlike the replacement of rail in the US, Soviet practice is to completely replace the entire track structure and clean the ballast. This is a time-consuming operation, even with their newly developed heavy equipment. This operation must, of necessity, disrupt transportation operations and reduce track capacity considerably. The Soviets, therefore, are working on what they call a super rail, with tensile properties of 228 to 242 ksi, a BHN of 450, and a service life of 1.3 to 1.7 billion gross tons. It is anticipated that these properties can be achieved by suitable alloying combined with oil quenching and tempering. The most likely elements will be Cr, Si, and Mn, while maintaining carbon at a relatively high level.

The possibility of boron additions has been considered. In order to achieve the high strength levels needed, the microstructure will be bainitic. By way of comment at this point, it is not clear how a rail of such high strength will be straightened or what precautions must be taken to weld it satisfactorily.

Research and development is continuing in narrowing the hardness bond for heat treated rails, improving the microcleanliness of rail steels, improving the surface properties of rail steel ingots, improving rail design, relieving residual rail stresses and improving the operational reliability of rail.

The mechanical and chemical properties of US and USSR untreated rail, as well as the mechanical properties for heat treated rails, are shown in Table 1.

RAIL SERVICE LIFE, DEFECTS AND WEAR

The service life of conventional and heat treated rail in main line track is based upon two criteria, the number of defects and the amount of wear. Although heat treated rails have extended the average rail life, curvature with radii of 2,133 to 2,628 feet has reduced rail life about 30%. Standards have been set which call for replacement of untreated R65 rail after 550 mgt. and 825 mgt. for heat treated rail. The term service life is relative, however, as the rail may be required to take considerable more tonnage depending upon replacement availability. Some conventional rail has been subjected to 700 mgt. before removal. Experience has

PROPERTIES AND COMPOSITION OF US AND USSR RAILS

MECHANICAL PROPERTIES OF SOVIET AND AMERICAN HEAT-TREATED RAILS

	U.S.A.	U.S.S.R.
Yield Strength	118-126 ksi	114-142 ksi
Tensile Strength	170-180 ksi	170-190 ksi
Surface Brinell Hardness	352-375	321-351

CHEMICAL AND MECHANICAL PROPERTIES OF A.R.E.A. AND UNTREATED SOVIET RAIL STEELS

Typical Mechanical Properties

	A.R.E.A.	U.S.S.R.
Yield Strength	69 ksi	68 ksi
Tensile Strength	135 ksi	136 ksi
Brinell Hardness	277-293	280-290

Chemical Composition, Weight Percent

	A.R.E.A.	U.S.S.R.
Carbon	0.69 - 0.82	0.69 - 0.82
Manganese	0.70 - 1.00	0.75 - 1.50
Phosphorus	Less than 0.040	Less than 0.035
Sulfur	Less than 0.050	Less than 0.045
Silicon	0.10 - 0.25	0.13 - 0.22

Table 1

shown that three defects per km (4.8 defects/mi.) can be expected at 550 mgt. for conventional rail and at 825 mgt. for fully heat treated rail. Manufacturing defects are not included in this statistic. One of the major differences between US and Soviet practice is that Soviet rail life is usually determined by defect formation rather than by wear as in the US. This practice, while expensive to implement, will very likely preserve the high structural reliability of the rail. It is also in line with the Soviet's philosophy that outages cannot be tolerated.

Considerable study in the field and laboratory have been given to this subject. As would be expected, a few manufacturing defects appear at random during the incubation period for conventional rail, which is around 300 mgt., but no fatigue failures are experienced. This period is called the reliability life. The failures increase with traffic density, speed, track conditions, etc., with the third defect appearing at about 550 mgt. This is depicted in Figure 22. The graph shows that heat treated rail is displaced to the right by approximately 275 mgt. Unfortunately, time limitations did not permit detailed discussions of how the shape and position of these curves, especially heat treated rail, would be altered by curvature and gradient. It is interesting to note that the joint AREA-AISI-AAR Rail Research Committee has been gathering data at test sites on the Santa Fe and Union Pacific. On these sites, the first defects occur between 50 and 150 mgt. and the third defect per kilometer at 500 to 600 mgt. However, one of the other test sites has a considerably

FATIGUE DEFECTS AND TONNAGE

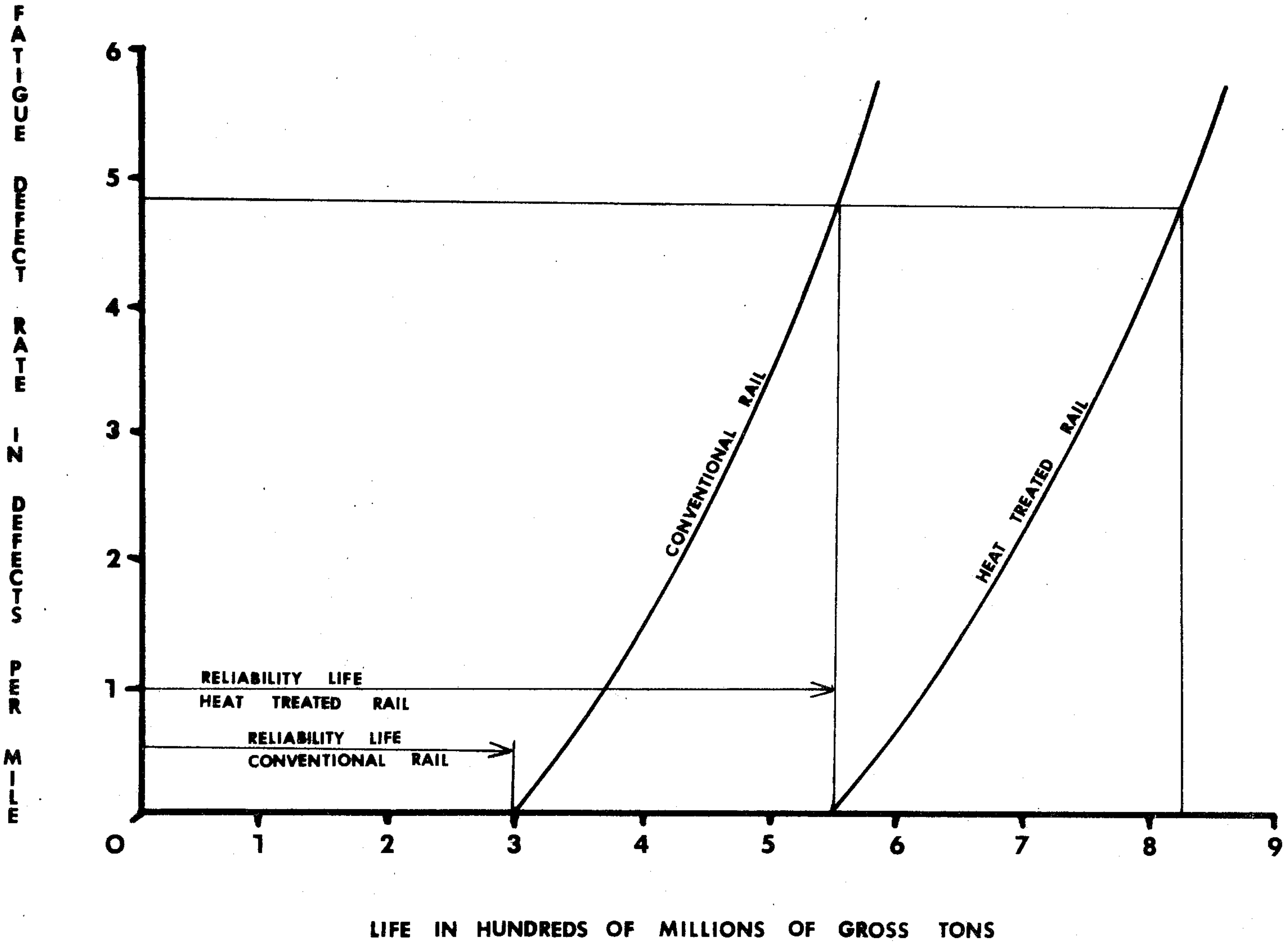


Figure 22

lower defect/km rate after accumulating 600 mgt. The Soviets have noted that higher rates of wear reduce fatigue defects, and corrugations increase the tendency for defect occurrence.

As has previously been reported by other delegations, flaw detection plays a very important role in track related operations. Soviet methods of dealing with defects are given in the pamphlet "Classification of Defective and Damaged Rail" which classifies and catalogues defects. It is similar in some respects to the Sperry Rail Defect Manual. The classification of defects is a semantic problem, even here in the United States. Thus, it is even more difficult to relate directly to Soviet nomenclature on the nature of defects. The accumulation of rail defect data was dropped several years ago by the A.R.E.A., thus we have nothing concrete on which to compare data.

Table 2 shows the types and percentages of 1974 rail defects for both conventional and heat treated R65 rail. As an example, it can be seen that metal strength is related to 48.2% of the defects in fully heat treated rail whereas the conventional rail percentage is 56.7%. Similarly, transverse cracks and breaks in the head are 34.4% for fully heat treated rail and 47.1% for conventional rail. This is the latest Soviet data available, is based on averages and may vary considerably by location. Shelling related defects, including transverse fissures, are in predominance with almost three fourths of the total defects in the head area. The greater ability of the heat treated rail to reduce head failures is clearly reflected in

USSR RAIL DEFECT STATISTICS FOR CONVENTIONAL AND HEAT-TREATED RAIL

Location	Types of Defects	CAUSE OF DEFECTS IN %										
		Manuf.	Metal Strength	Rail Section and Fastngs. Deficiency	Maint. of Track Deficiency	Rolling Stock	Impact or Mech. Damage	Welding Tech-nology	Heat Treat Tech.	Weld Build-up and Fastening	Other	Total %
Head	Lamination and Shelling on Surface	4.2 3.7	8.7 9.6			3.4 1.9			6.6 3.6	0.8 2.1		23.7 20.9
	Transverse Cracks and Breaks	4.5 3.3	28.9 42.6					1.0 1.2				34.4 47.1
	Longitudinal Cracks	13.1 9.2	1.1 0.6							0.8 1.2		15.0 11.1
	Flow and Uneven Wear	1.3 1.5	9.5 3.9					0 0.2	1.8 1.5		0.7 0.8	13.3 7.9
Web	Defects and Damage to Web			1.8 2.8	5.0 6.9			0.5 0.7				7.3 10.4
Base	Defects and Damage to Base								0.3 0.3			0.3 0.3
Other	Other										6.0 2.4	6.0 2.4
	Total %	23.10 17.70	48.20 56.70	1.8 2.8	5.0 6.9	3.4 1.9		1.5 2.1	8.7 5.4	1.6 3.3	6.7 3.2	100.0 100.0

Note: Top Number Denotes Heat Treated Rail Percentages
Bottom Number Denotes Conventional Rail Percentages

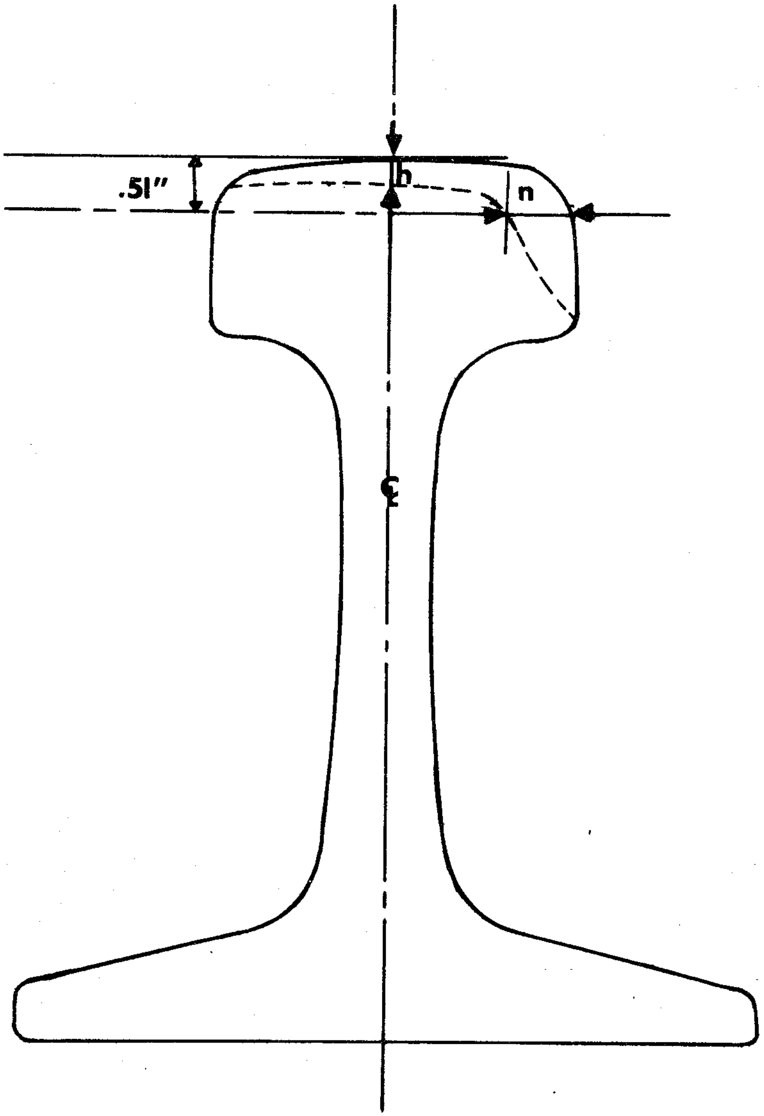
Table 2. 1974 R-65 RAIL DEFECT STATISTICS

the "percent of cause" for shelling and transverse cracks. The greater percentage of heat treated rail in the flaw and uneven category may reflect that heat treated rail is used predominantly in the most severe service locations. The number of bolt hole cracks is exceedingly small in comparison to the last reported 1971 A.R.E.A. bolt hole failures, even though the Soviet main line track is inspected at least once weekly by ultrasonic, manual push cars which have equipment specifically designed to detect bolt hole defects. The first theory that comes to mind is the heavy US axle loading in comparison to Soviet practice, but flat wheels and low joints for which we have no data could also be important contributing factors. The Soviets claim that main line joints are disassembled, inspected, and lubricated each year.

The second criteria for rail removal is wear. The standard for removal is a combination of head and gauge side wear which, when combined, cannot exceed 0.51 in. for R65 rail and 0.35 in. for R50 rail. The total wear allowed is given by the formula $H = h + \frac{1}{2} n$. Vertical wear at the centerline of the rail head is denoted by h and the horizontal factor on the gauge side of the head is n. Figure 23 shows the application of the formula to the rail head. It was noted from field observation of conventional R65 welded rail, supposedly removed from track after 550 mgt., that the rail surface was very smooth with no spalling or degradation. Plastic deformation was negligible.

One of our goals was to determine economic conditions controlling overall utilization, selection, and use of rail steel and related

WEAR CRITERIA FOR RAIL REMOVAL



H = total wear allowable

$H = h + \frac{1}{2} n$

Figure 23

components. There are few, if any, economics which are in control, at least in the way we understand economics in the United States.

The factors which govern, however, are the non-competitive environment of the railroad industry, the extremely heavy and rapidly increasing traffic densities, and the almost complete reliance upon the railroads to haul the country's goods and passengers. All of these factors dictate that the railroads be operated efficiently and safely with minimum disruption to service. It is therefore incumbent on the USSR to use the strongest, longest lasting, maintenance free track structure that its engineers and scientists can devise. Much has already been accomplished. They are now working towards increasing the service life of the complete track structure, decreasing the cycle of heavy track maintenance and track outages, and improving the productivity of manpower and equipment. Economics as we understand it, therefore, cannot play a leading role, because the overall successful operation of the railroads with minimum outages for whatever reason must, of necessity, be the paramount factor.

TIES, FASTENINGS AND CONCRETE PANELS

The Soviet Railway network is still predominantly a wood tie railroad. The use of the concrete tie has gradually evolved. It is estimated that, at the present time, 25% of all main line ties are of concrete. The Soviets appear to be enthusiastic about them, even though track elasticity is not what they would like it to be.

The very widespread use of concrete in all types of construction indicates it is in plentiful supply, whereas the consumption of high quality lumber is a national economic problem. The concrete tie meets one of their primary objectives, increased service life. It is estimated they will last 40 years or more. This is yet to be proven.

Current standards do not permit the use of welded rail on wood ties. Prompted by US experience, however, a field test of welded rail, 6,562 ft., in length is now underway. Cut spikes are being used and every tie is box anchored with four rail anchors. If the testing proves successful, welded rail on wood ties may be used on secondary lines.

The Soviets have experimented with reinforced cork pads placed beneath the tie plate on wood ties. Their experience with the pad was not satisfactory and different types of pads are now under test. The use of rubber pads was observed in the assembly of track panels for main line use.

Twenty-four separate concrete tie and slab tests have been carried out on the rings. The concrete tie, as originally designed, has changed very little since 1966. Some modifications have been made based upon field experience. The central portion of the tie has been lightened to reduce the amount of concrete. It now weighs 551 lbs. Various prestressing designs are used. The ties we observed in the field contained double 24 strands of prestressed, high carbon steel wire with a diameter of 0.12 in. If more than two strands fail, the tie is rejected. The same tie is used for R50, R65, and R75 rail.

Many types of fastenings for concrete ties have also been tested. Three types are shown in Figures 24, 25, and 26. Originally a wood plug was used in the tie which proved to be unsuccessful. This was followed by a German plug design which was also discarded. Various kinds of fastenings, including the Pandrol and German type K, were also tested and discarded. The testing indicated that the fastenings must provide a hold down pressure of one ton on both sides of the rail to prevent longitudinal movement.

The present KB fastening system shown in Figure 27 incorporates an elaborate tie plate, which is secured on both sides of the rail with a T head bolt and a two coil washer assembly. This bolt extends into a metal section which is precast into the tie. An 0.80 in. flared recess in the rail seat area provides space for the pad and tie plate. It also helps to absorb lateral load. The original pads proved to be too stiff and did not provide enough elasticity for the track structure. Polyethylene and rubber pads, 0.24 in. thick, are now used between the tie and tie plate. The same thickness pad is used between the tie plate and the rail base. The elasticity of the concrete track structure still leaves something to be desired. Work continues on testing of hold down fastenings and pads.

Wood ties comprise most of the ties in track. They are still being placed on main line trackage. The ties are mostly of pine, creosote treated and have an average life of 16 years. A cross

TYPE OF FASTENINGS TESTED

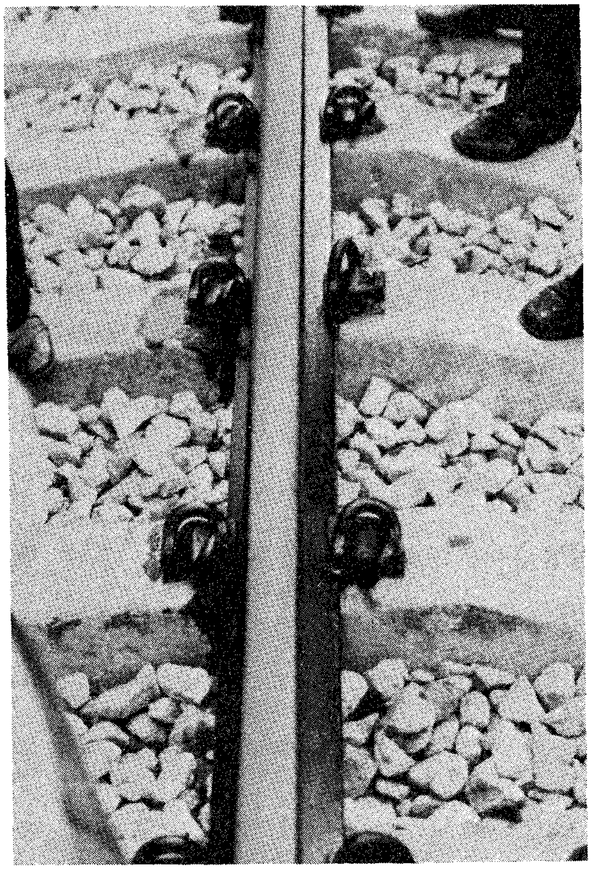


Figure 24

TYPE OF FASTENINGS TESTED

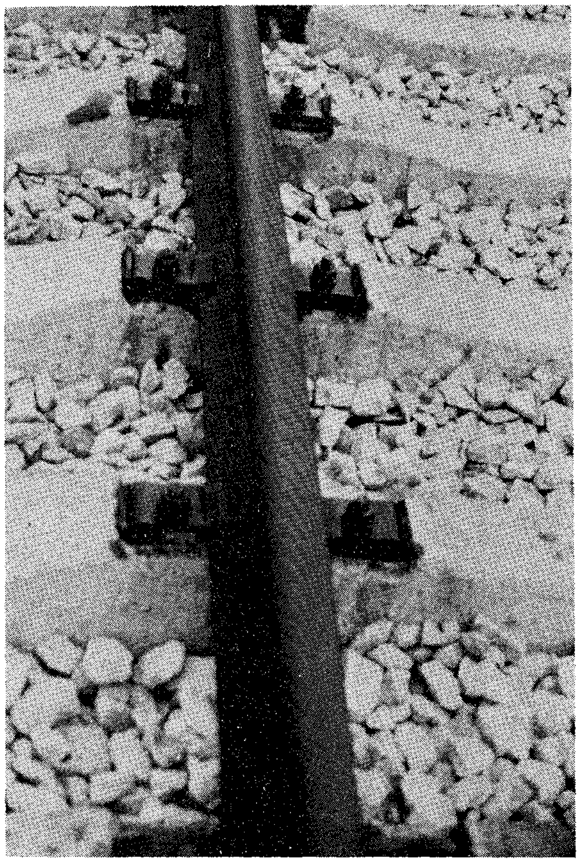


Figure 25

TYPE OF FASTENINGS TESTED

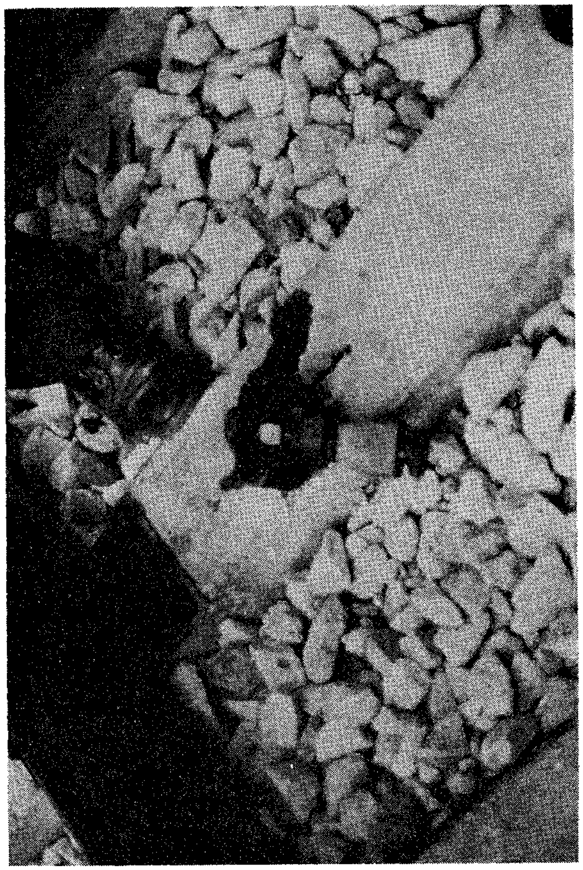
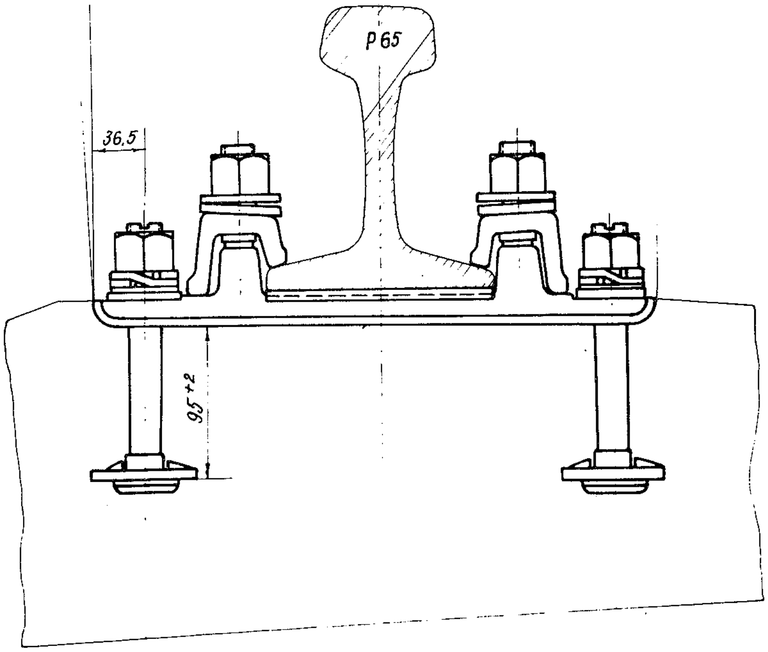


Figure 26

PRESENT STANDARD CONCRETE TIE AND KB FASTENING



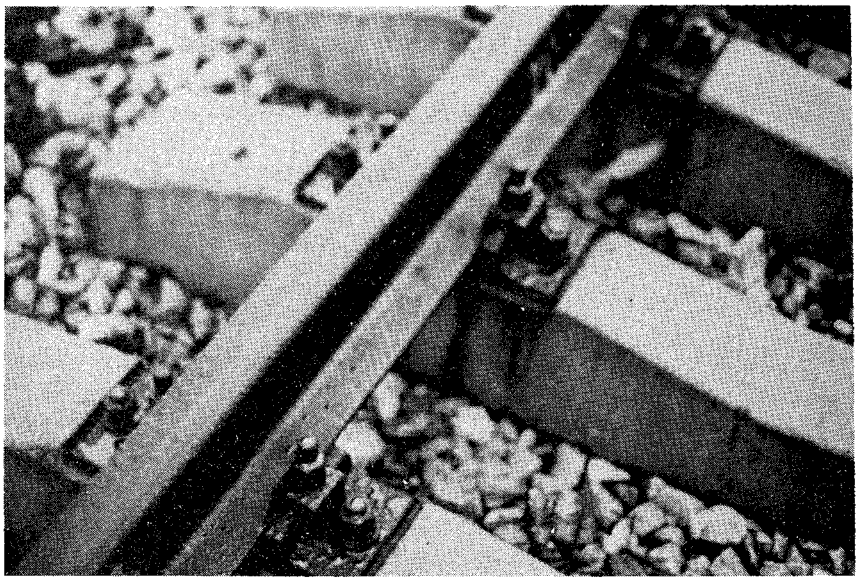


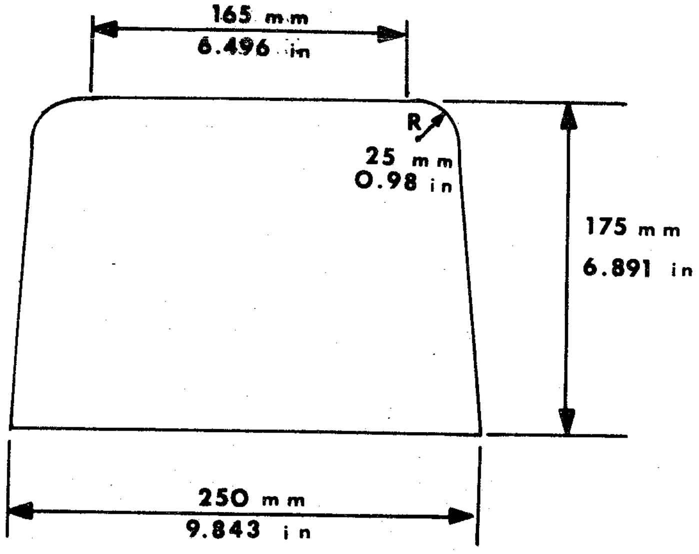
Figure 27

section of the Soviet main line tie and its US counterpart is shown in Figure 28. The Soviet tie is basically a 7" x 10" tie with sloping sides, as differentiated from typical US main line ties of 7" x 9". Five cut spikes are used on sharper curves and four on tangent track. Forty-two rail anchors per 82 ft. of rail length are used on tangent track and increased to 50 anchors on sharp curves. The 21.4 in. tie spacing is the same for both wood and concrete ties. The tie plates have a different configuration than those used in the US. The length is approximately the same but the width is only about 6-3/4" compared to 7-3/4" in the US even though the tie width is greater. Considerable tie plate cutting was observed.

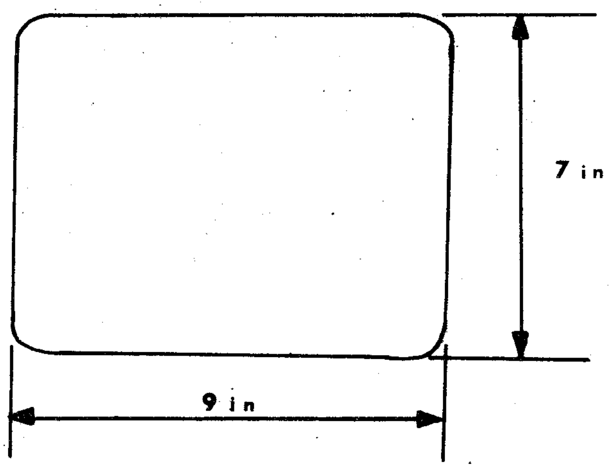
Wood ties are used for turnouts, but concrete slabs and beams have passed the tests at Shcherbinka. About 120 slab and beam installations are now being tested in the field to gain experience. The results are not conclusive.

Concrete panel track of various designs has been tested as shown in Figure 29. These tests took place between 1964 and 1968. Concrete slab sections three to six miles long are now being tested in the field under operating conditions. Little or no enthusiasm was shown for this method of construction. This may be misleading because we did not have the time to discuss it in any great detail.

CROSS SECTION OF SOVIET AND US MAIN LINE TIE



Soviet Main Line Wooden Tie



Typical U.S. Main Line Wooden Tie

Figure 28

VARIOUS TYPES OF CONCRETE SLAB TRACKAGE

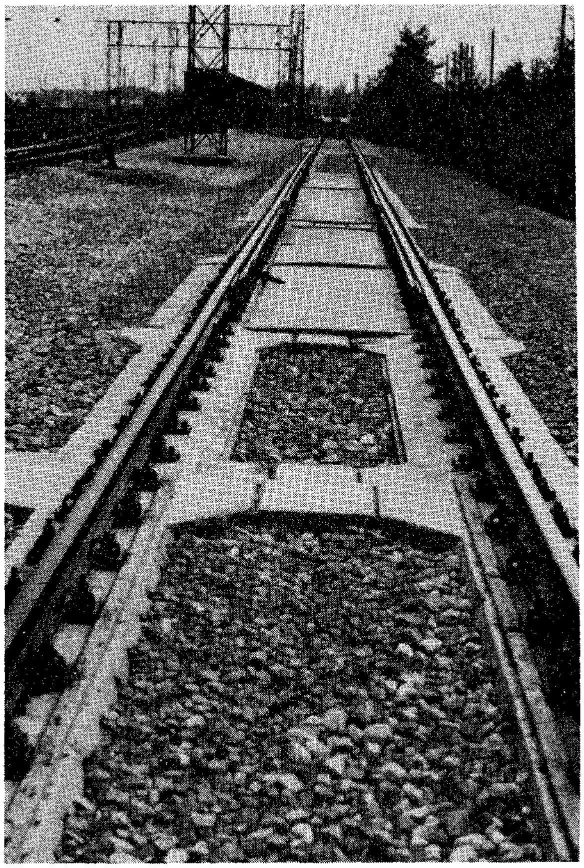


Figure 29

LAYING OF WELDED RAIL

A welded rail laying operation was observed 37 mi. from Kiev on the double track, Darnits-Grebyonka, main line intersection of the South Western Railway. The rail being replaced was from a new track constructed in 1971. The track was constructed of 82 ft., square joint, prefabricated panels of R65 rail with six hole bars and concrete ties. The standard, heavy duty panel laying crane and power ballaster were initially used in this construction. Ordinarily, the bolted rail from the panels is removed and replaced with welded rail after about 350,000 tons of traffic. In this case, however, the tonnage over the track had been about 1.1 mgt.

The schedule for the day called for replacing 1.5 mi. of bolted track with welded rail and surfacing the track. This had to be completed within a two hour period, or "window", as it is called in the USSR. Twelve 2,625 ft. standard length welded rail strings were brought in by the welded rail train. The strings were pulled from the welded rail train by three coupled, self-propelled, remote controlled, flat cars and placed in the center of the track.

A newly designed, on-track, self-propelled machine with a long extended boom removed the bolted rail. This can be seen in Figures 30 and 31. This rail was stockpiled mechanically on flat cars ahead of the machine. Prior to this, all rail hold down

WELDED RAIL LAYING CRANE

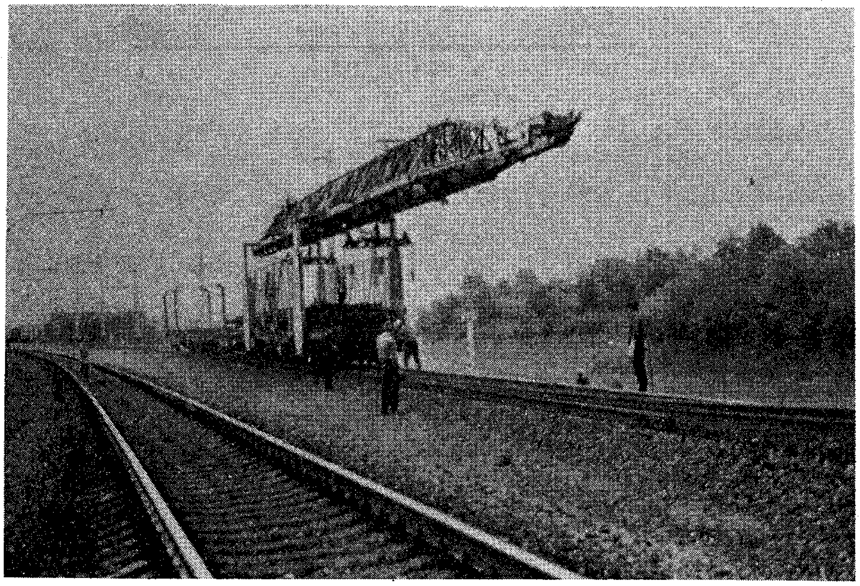


Figure 30

WELDED RAIL LAYING CRANE

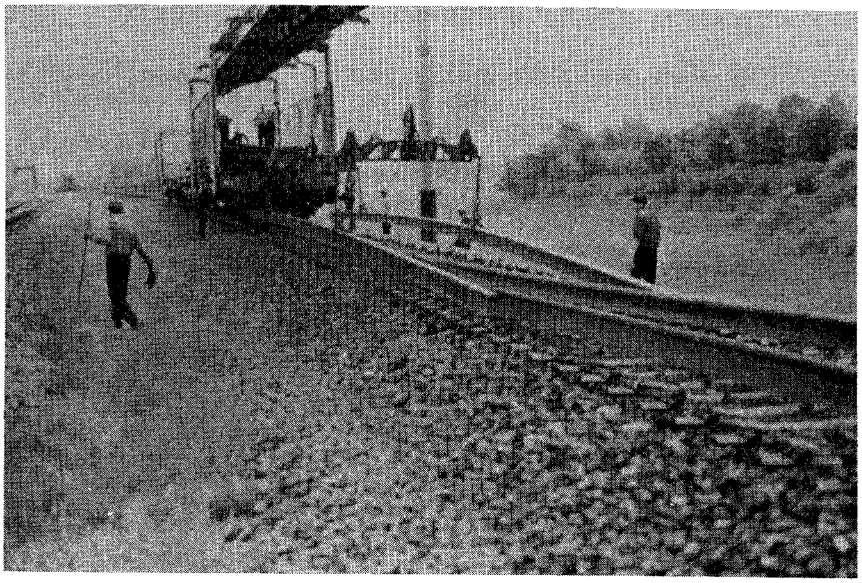


Figure 31

fastenings had been removed and the rails held together by one bolt per joint. Before lifting and stockpiling the bolted rail, however, it had to be turned so that it would not catch on the high projection of the tie plate and pull the tie out of its bed. Even with this precaution, some ties were displaced.

As the rail retrieval crane moved ahead, it pulled a rail threader sled which rides in the rail seat area of the tie plates vacated by the rail just removed. The welded rail is automatically placed in the proper position at proper gauge. This is shown in Figures 32 and 33. The three coupled cars, previously mentioned, follow and seat the rail firmly in place. Any ties that have been raised from their tie bed by the rail removal operation are also seated.

The rail tie down fasteners are then applied and tightened with electrically driven torque wrenches, as can be seen in Figure 34. It was noted that not all hold down fastenings were tightened. This will have to be done at a later date by the local section crew.

The rail temperature is recorded but the rail is neither heated, cooled, or stretched. It is laid in accordance with the standard specifications for that particular area, as previously described in the report.

The track was tamped by a continuous vibrating VPO-3000 tamper which moves down the track at about 2 m.p.h., as shown in Figure 35. The vibrating bar extends 0.4 in. under the tie end

WELDED RAIL THREADER SLED

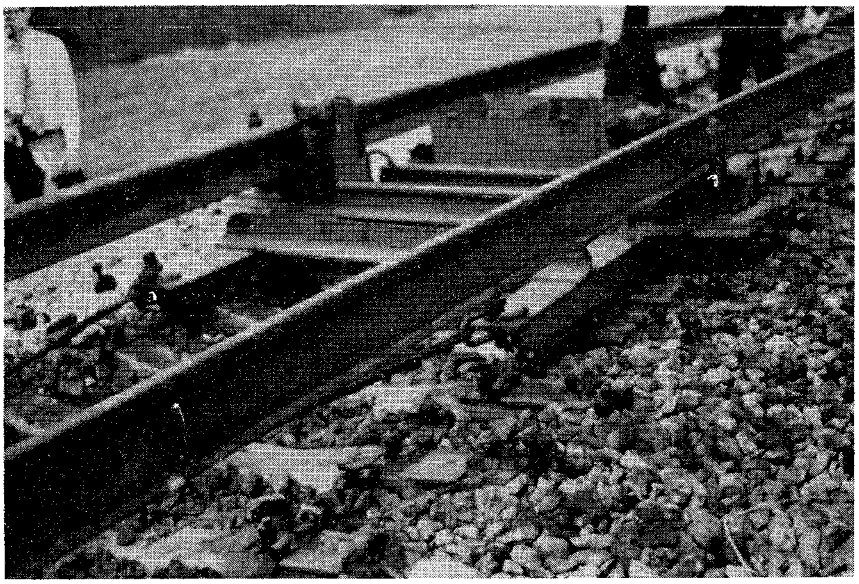


Figure 32

REMOTE, SELF-PROPELLED CARS

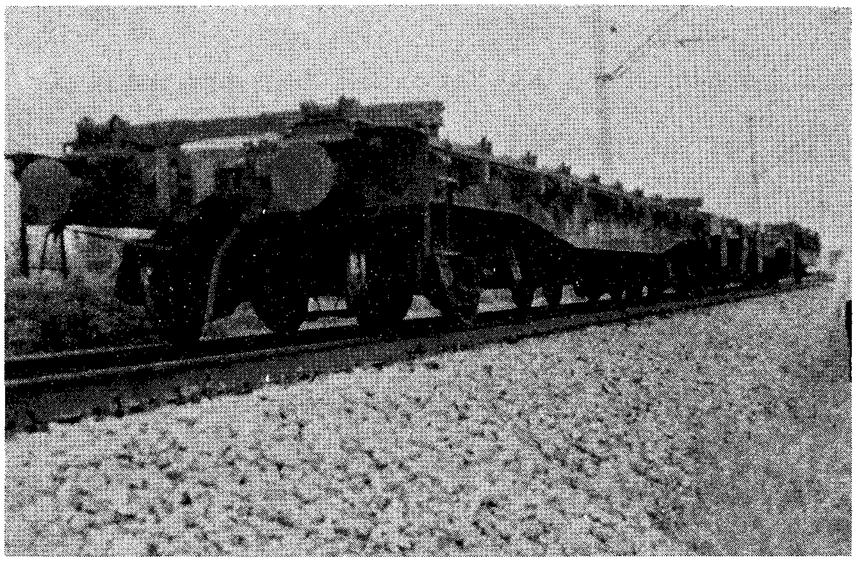


Figure 33

TIGHTENING RAIL FASTENINGS

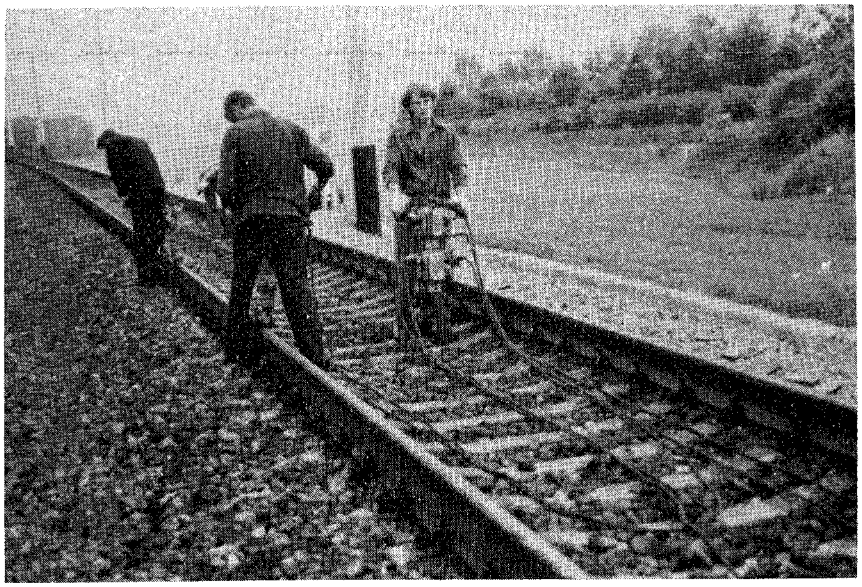


Figure 34

CONTINUOUS VIBRATING POWER TAMPER

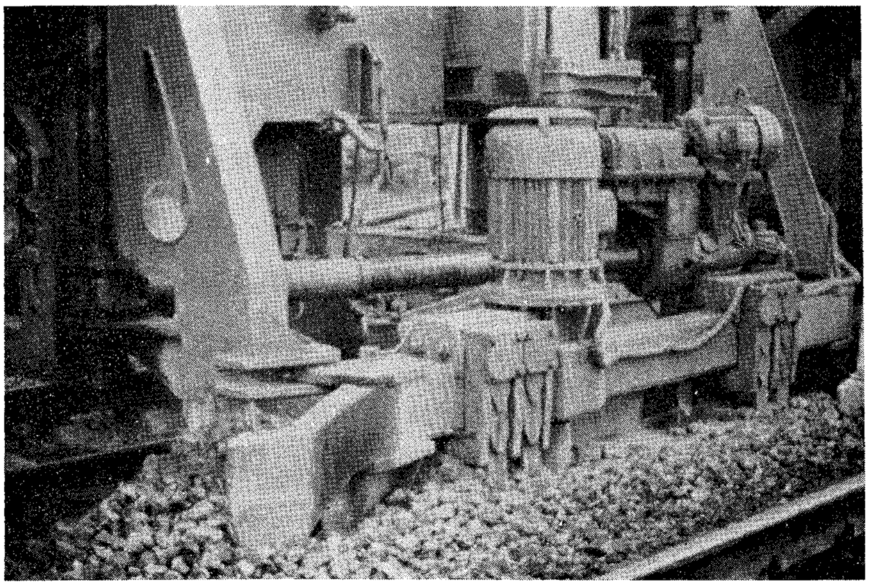


Figure 35

and 5.6 in. below the bottom of the tie. The ballast is vibrated toward the middle of the track from the ends of the ties without center binding. Note that a portion of the material being vibrated under the track is part of the subgrade. The ballast train did not distribute ballast ahead of the tamper, but followed it. This is an unusual operation. Ordinarily, tamping does not follow welded rail laying operations. The track worked on, however, was of relatively new construction and some settlement had taken place.

The tamper did not include track lining equipment. The minimum raise set was 0.12 in. A survey crew had previously written the amount of raise proposed, on the adjacent track, after running profiles. The operator added this to the fixed setting of the tamper. This is not a very sophisticated operation. The track looked reasonably good behind the tamper. It was not up to standard in the US, because of our more sophisticated lining and leveling equipment which follow tamping operations.

It was interesting to observe the use of an epoxy bonded, insulated joint within a string of welded rail. A rail plug containing the insulated joint was welded into the welded rail string at the center welding plant. It was located at exactly the right location for a signal, as can be seen in Figure 36. An explosive method is used for the application of bond wires.

A 20 car ballast train was used in this operation and followed the surfacing operation. Each car is equipped with

EPOXY BONDED INSULATED JOINT IN WELDED RAIL STRING

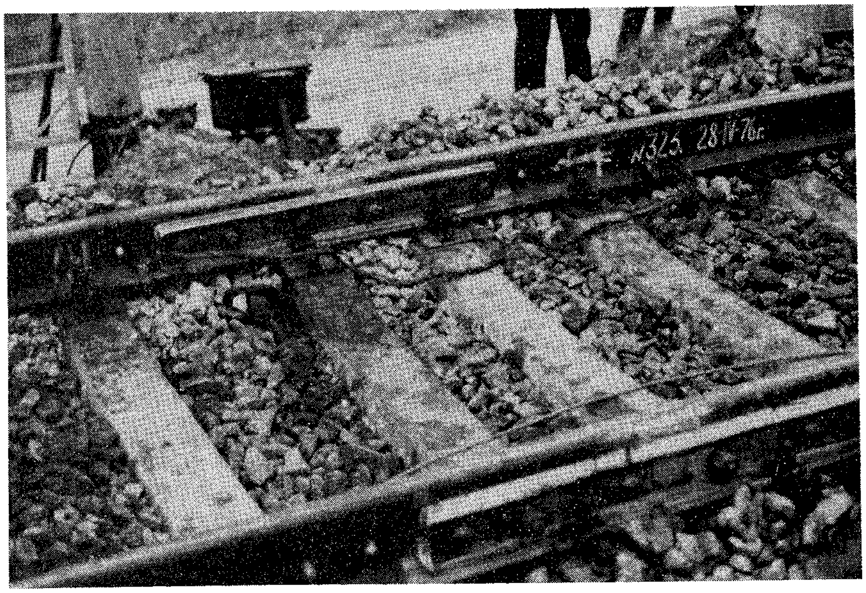


Figure 36

air operated controls and ballast doors which permit the placement of the desired amount of ballast at whatever location is desired.

Forty-six workers, men and women, were used in this operation. This included eight operators. Excellent flagging protection on the adjacent track was provided. Radio communication was used by the supervisors, foremen, and equipment operators.

The Delegation learned of a very interesting, new, welded rail development from Mr. K. K. Alexandrov, Deputy Chief Engineer-Track Directorate, who accompanied the group on the tour to the Bryansk and Kiev areas. A second look has been taken at the use of maximum 2,625 ft. welded rail strings separated by the three standard, square joint, 41 ft. rails. This is a very conservative practice, and experiments are now taking place with longer lengths of welded rail. The lengths were first extended to 3,280 ft. and one test section is even 7,874 ft. long. It appears the Soviets may have been influenced by recent visits to the US, although this work is being carried out strictly on an experimental basis. The longest length string compares with their maximum signal block length. The standard length block has been 2,625 ft. but blocks of 3,937 ft., 5,249 ft., and 7,874 ft. are in use. If the tests prove successful, the welded rail strings may end up more closely related to longer signal blocks. The standard 2,625 ft. welded rail string is used to make up these test sections. The in-track mobile welder welds the additional length required in the field. No buckling difficulty should be experienced with the longer strings, based upon their welded rail standards. Unless the fasteners are kept tightened, which appears to be a serious maintenance problem, difficulties will probably ensue.

The welded rail operation was efficient and exceeds production rates in the US. It should be pointed out, however, that an operation of this type is not feasible on wood tie construction in the US because there is insufficient tie plate anchor spiking to the tie and many ties have very poor retentive properties because of their age. As a result, there is no way to permanently seat the tie plate to the wood tie, as is the case with the concrete tie and the tie plates would become dislodged and skewed making the operation impractical.

SUPPORT FACILITIES

GENERAL DISCUSSION

Track Panel Preassembly Station No. 99 of the Moscow Railroad in Bryansk and Station No. 121 in Kiev on the South Western Railroad were visited. Facilities of this nature are in reality two of the many staging areas for the replacement of main line trackage for the Soviet rail network. The station's responsibilities include the construction, placement and removal of track panels, and the reconditioning of ties and rails. They also surface track, lay welded rail, distribute and clean ballast and maintain the equipment. Not all stations, however, perform all of the above operations. The entire operation is very closely coordinated with transportation operations to provide for the "windows" required to perform the actual main line work.

The facilities we saw were well laid out, mechanized, and appeared to be productive. There appears to be little use for main line panel track construction facilities in the US, at least at this time. On the other hand, a mechanized wood tie restoration facility may hold considerable promise for ties that may be removed because of abandonment or upgrading of US trackage.

DISASSEMBLY OF WOOD TIE TRACK PANELS

As track panels are removed from main line track, they are loaded on flat cars and sent to a disassembly station as shown in Figure 37. The old panels are moved by a mechanical system through a rail mounted disassembly station. The ties are knocked off the panel by vertical hydraulic equipment and fall onto a conveyor. The spikes and tie plates also are dislodged at this time and are channeled into a box at the side of the system. This operation can be seen in Figure 38. The conveyor moves the ties to the end of the car, where they are graded by an operator. He pushes a button to mechanically reject unusable ties. The usable ties continue on the conveyor and are ultimately placed in storage for eventual reconditioning. See Figure 39. The dismantling rate, with six employees, was given as 328 to 492 track ft. per hour.

About 50% of the ties are rejected, primarily because of splitting and cracking. They will be reused in some other industrial application. The ties observed were primarily of birch.

TIE RECLAMATION

The ties to be reconditioned are moved into a double line, mechanized, reconditioning plant. Figure 40 shows a flow diagram of the reconditioning process. A partial overhead view can be seen in Figure 41. The tie is moved, via conveyor, to a machine which plugs the old spike hole, adzes and drills the tie for the spiking pattern required by the tie plate. This is a one person operation and is shown in Figure 42. The tie then moves to the

TRACK PANELS TO BE DISASSEMBLED

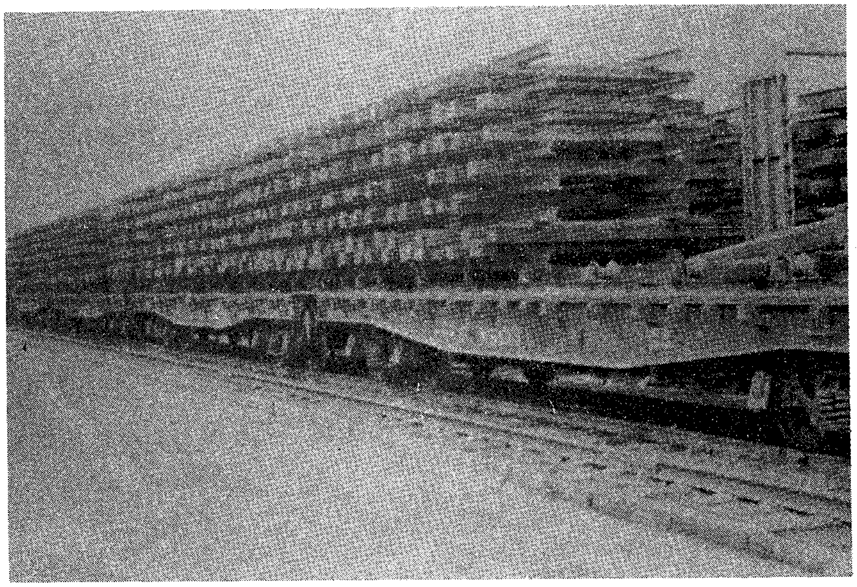


Figure 37

TIES BEING REMOVED BY HYDRAULIC EQUIPMENT

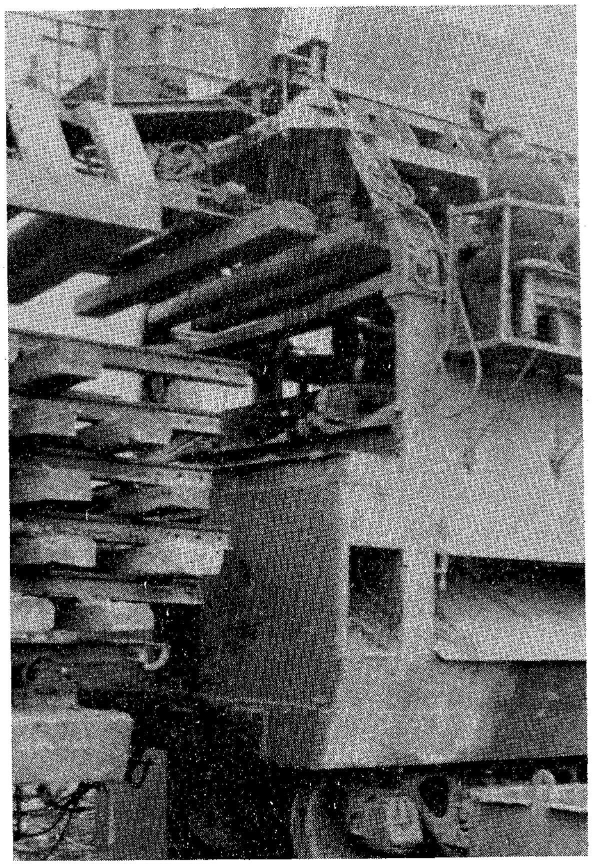


Figure 38

USABLE TIES LEAVING DISMANTLING STATION

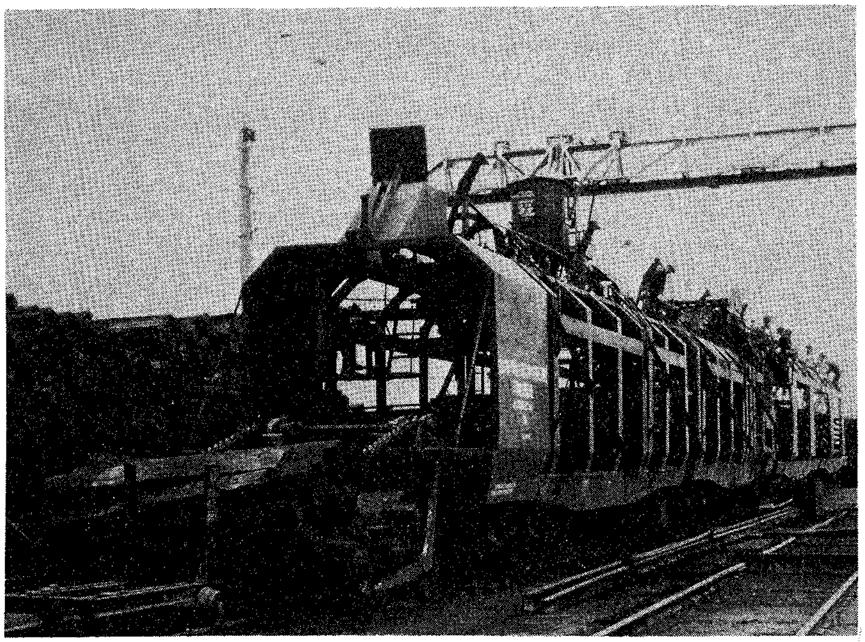
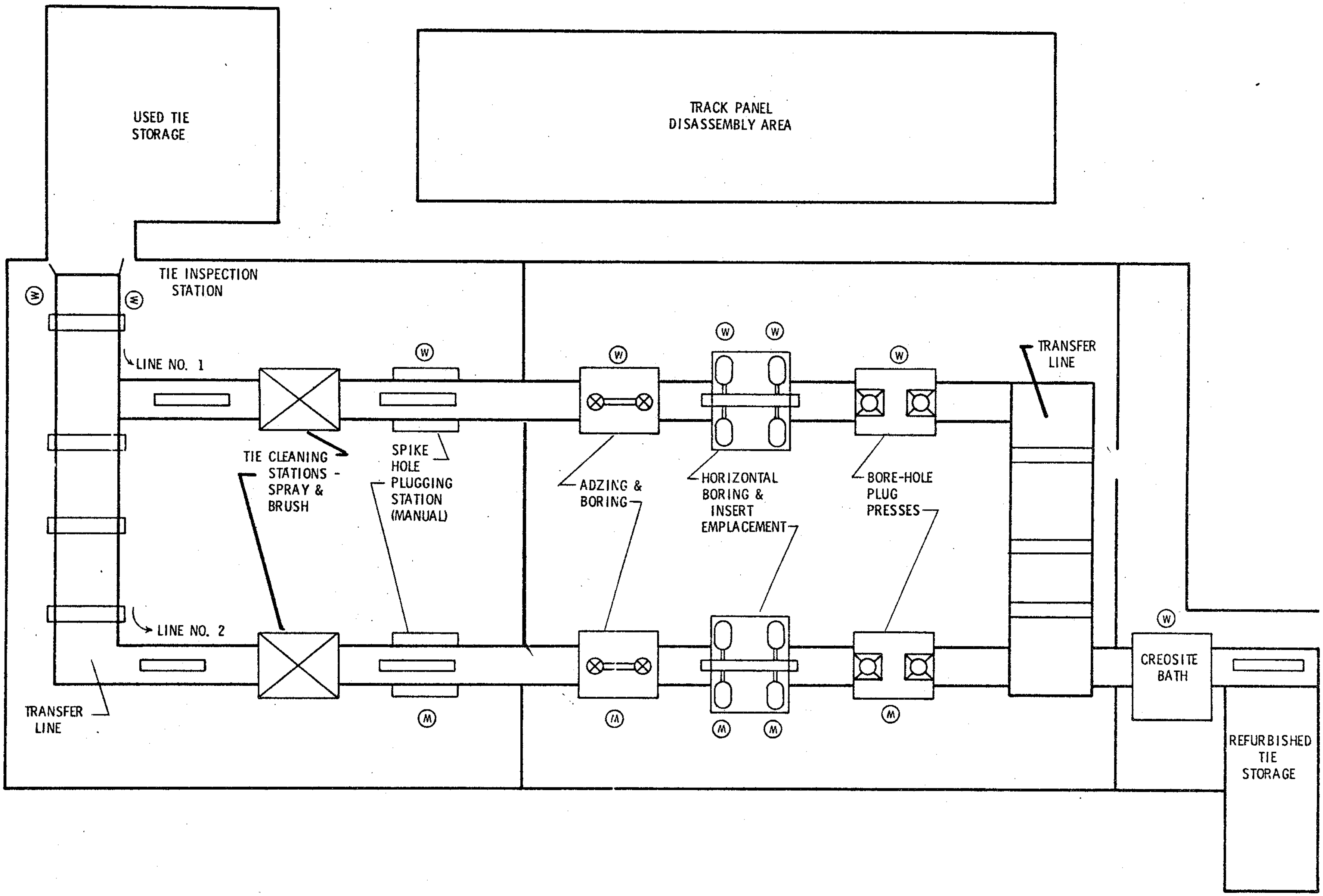


Figure 39



PROCESS FLOW AND PLANT LAYOUT

Figure 40

PRODUCTION LINE IN TIE RECONDITIONING PLANT

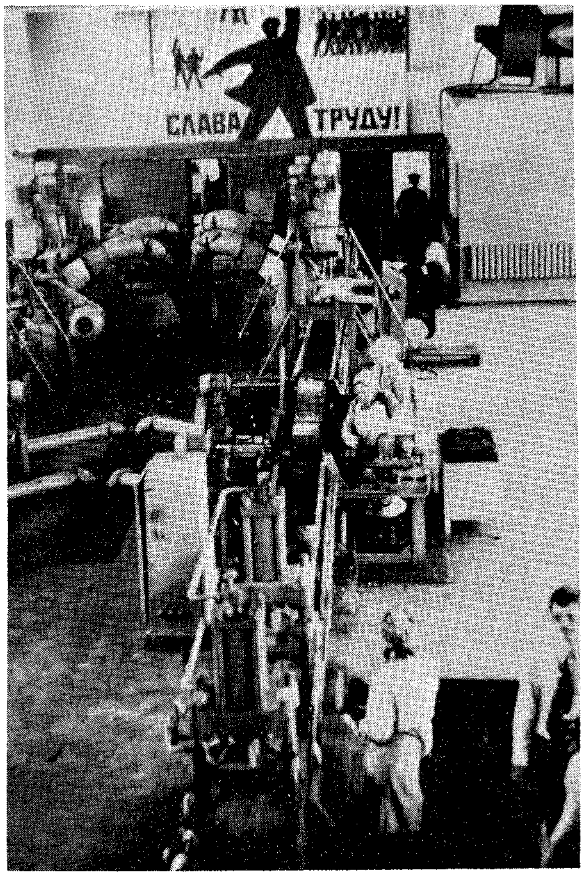


Figure 41

DRILLING TIE FOR NEW SPIKING PATTERN

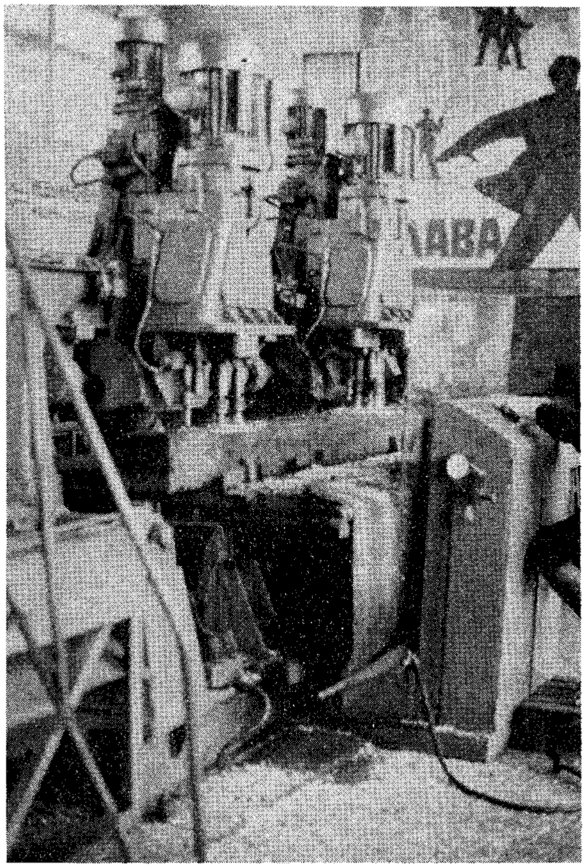


Figure 42

doweling station, manned by two operators who first drill both sides of the tie simultaneously. The drill bit is removed and is replaced with a wood dowel, which is then drilled into the tie. Figures 43 and 44 show this operation and the dowels used. The tie moves into a chamber for dip creosoting, as shown in Figure 45, from which it is moved into a storage area. The ties we observed will be used in building prefabricated track panels of R50 rail for us in secondary track.

The production rate is said to be 700 ties per eight hour shift. The two lines employ 16 workers, including the foreman and fork lift operator. Some of the ties were going through the reconditioning process for the second time, but this is the first time that has happened. The facility was very impressive, well designed, and productivity appeared to be good.

ASSEMBLY OF TRACK PANELS

Track panels 82 ft. long, using both concrete and wood ties, were observed under construction. Both operations were highly mechanized, although different in application. The assembly stations are all rail mounted, which provides for considerable flexibility.

Wood tie panel construction requires the use of all new components. Concrete tie panel construction, however, may reuse concrete ties. In this case, new fastenings and pads are required.

When building a panel with wood ties, the ties move via conveyor through a hydraulically controlled machine which automatically gauges the tie plates, spikes the tie plate to the tie and

PLACEMENT OF NEW WOOD DOWELS AFTER ADZING

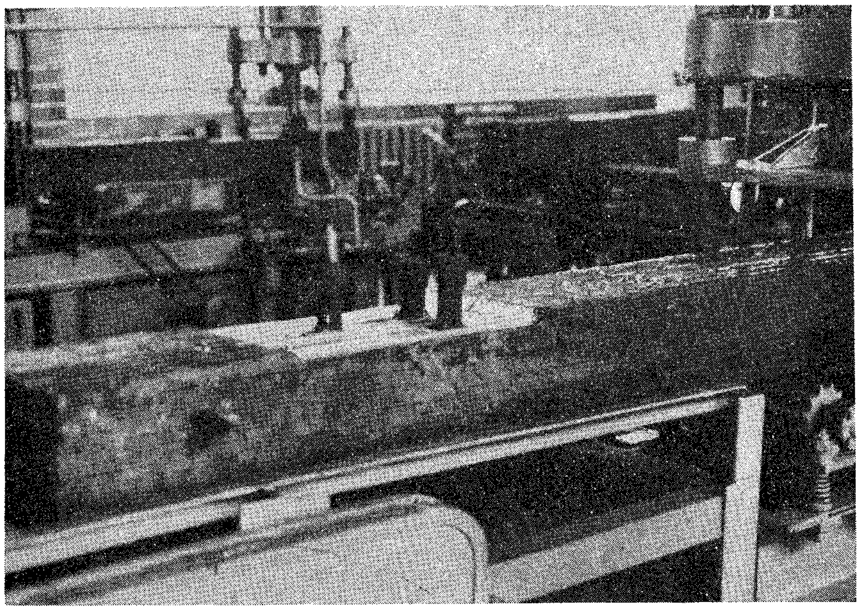


Figure 43

WOOD DOWELS USED AT BOTH ENDS OF TIE

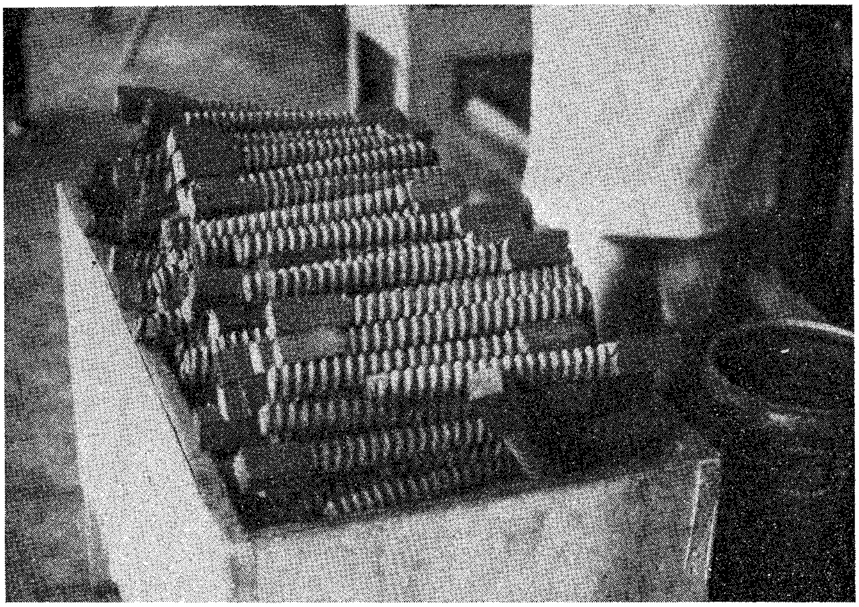


Figure 44

TIE CREOSOTING STATION

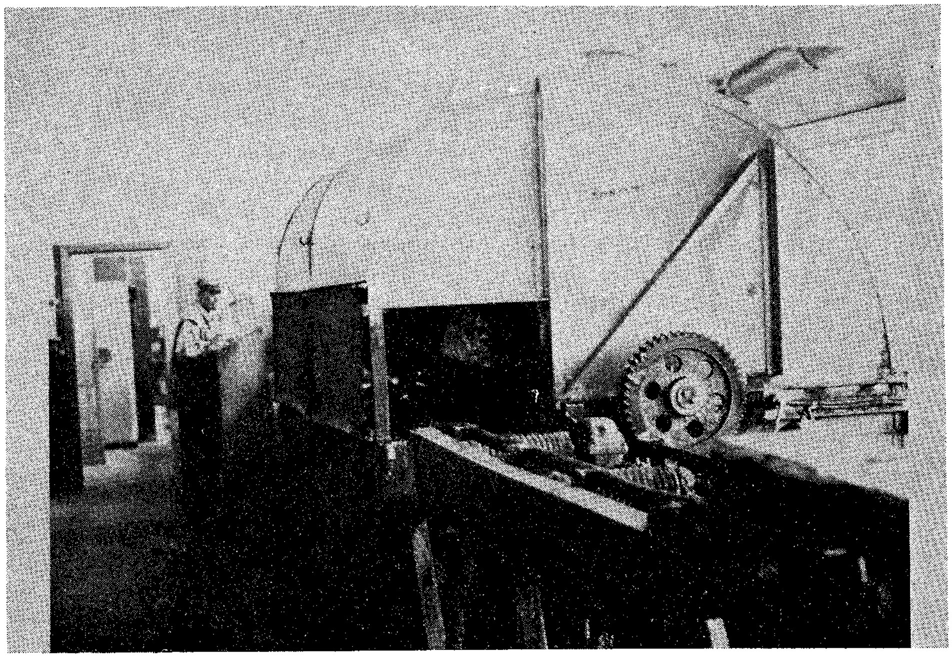


Figure 45

spaces the tie to the designated dimension. The rail hold down spikes are set manually as the ties move on a hydraulically operated carriage. These operations can be seen in Figures 46 and 47. The rails are then placed on steel supports over the tie carriage by an overhead gantry crane. The ties on the carriage are raised to meet the rail and the entire carriage mechanically moved to an automatic hydraulic spiker. This machine drives the rail hold down spikes. The sequence is shown in Figures 48, 49 and 50. The completed panel then moves down the track on rail mounted dollies, where it is picked up by overhead gantry crane and placed into the storage area. This is shown in Figure 51.

The panel under construction was for Heavy Track use. Production figures given were 262 to 295 ft. panel track per hour.

Mechanized operations for building panels with concrete ties were also observed. The operation was quite different than those previously described. Tie pads, tie plates and hold down fastenings are first applied to the concrete ties while moving on a rail mounted carriage. This is shown in Figures 52 and 53. A gantry crane handles 18 of these ties at a time, in groups of six, which are placed on the prefabricating bed as shown in Figure 54.
The rail is placed on the tie plate by gantry crane. The rail hold down fastenings are tightened by an ingenious piece of equipment. This machine hydraulically moves the ties from a lower carriage to a higher movable platform, while at the same time spacing the ties

TIES ENTERING TIE PLATE, GAUGING AND SPIKING MACHINE

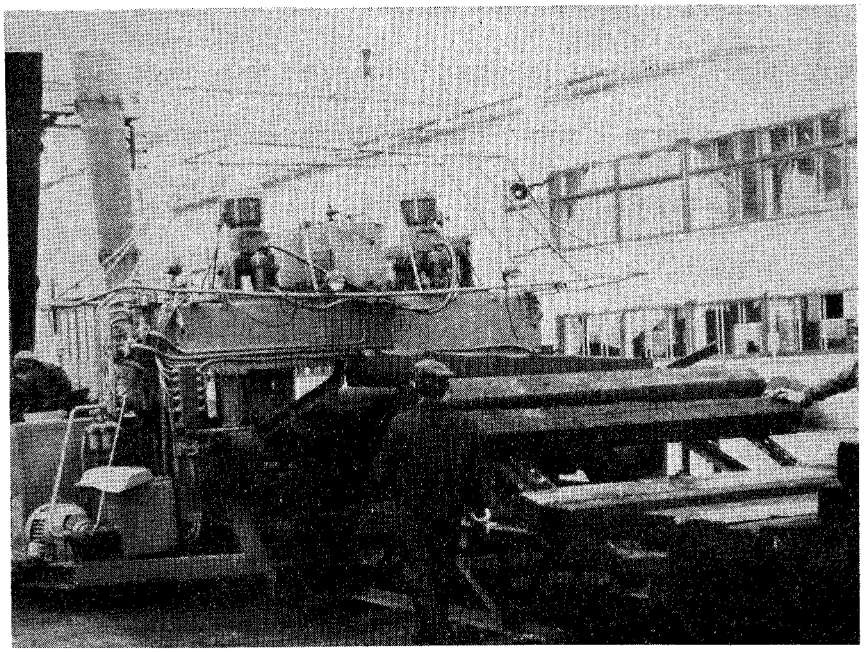


Figure 46

RAIL HOLD DOWN SPIKES BEING SET

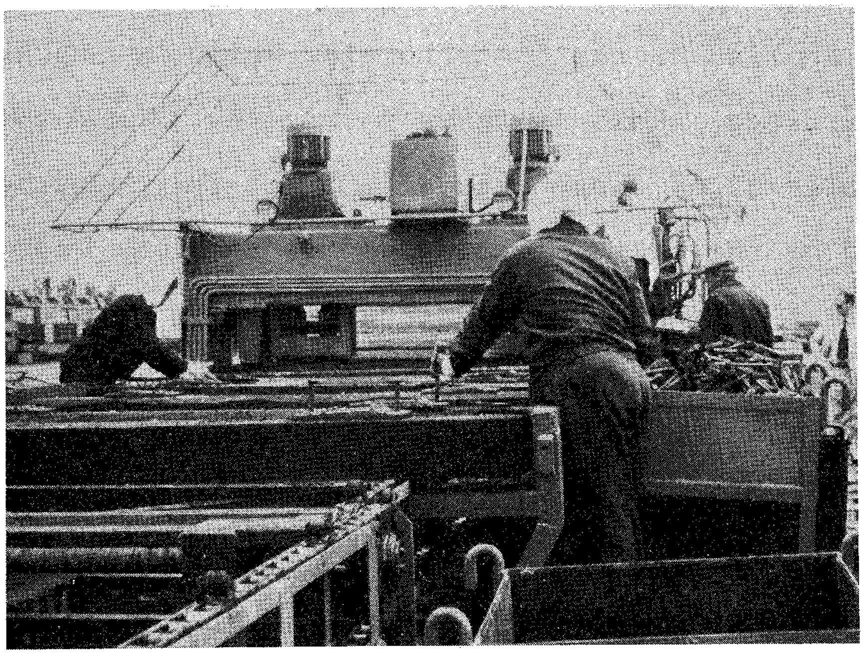


Figure 47

GANTRY CRANE HANDLING RAIL

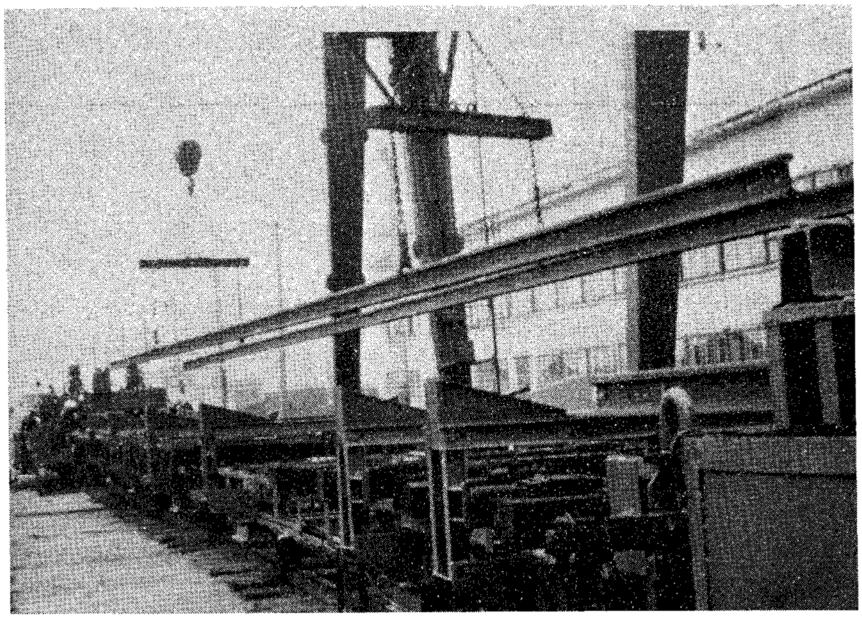


Figure 48

RAIL RESTING ON STEEL SUPPORTS
BEFORE TIES ARE RAISED FOR SPIKING

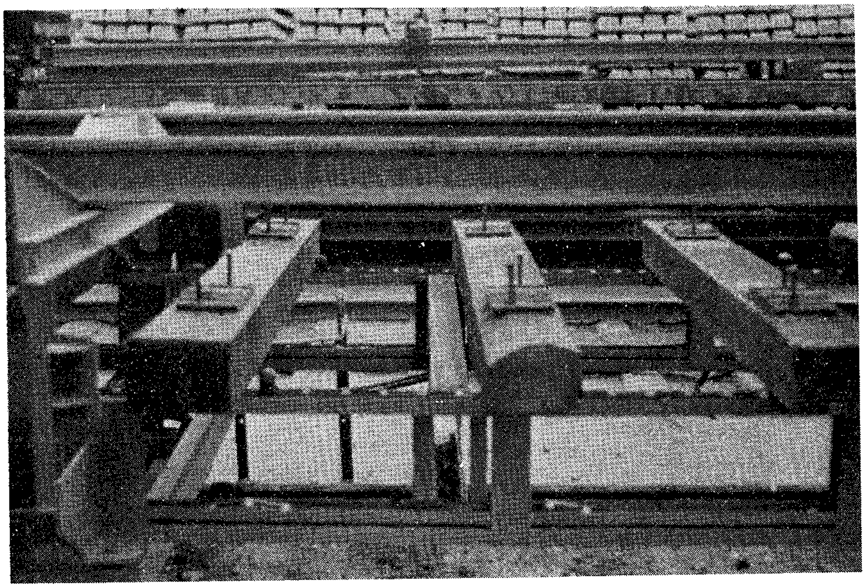


Figure 49

HYDRAULIC SPIKER DRIVING RAIL HOLD DOWN SPIKES

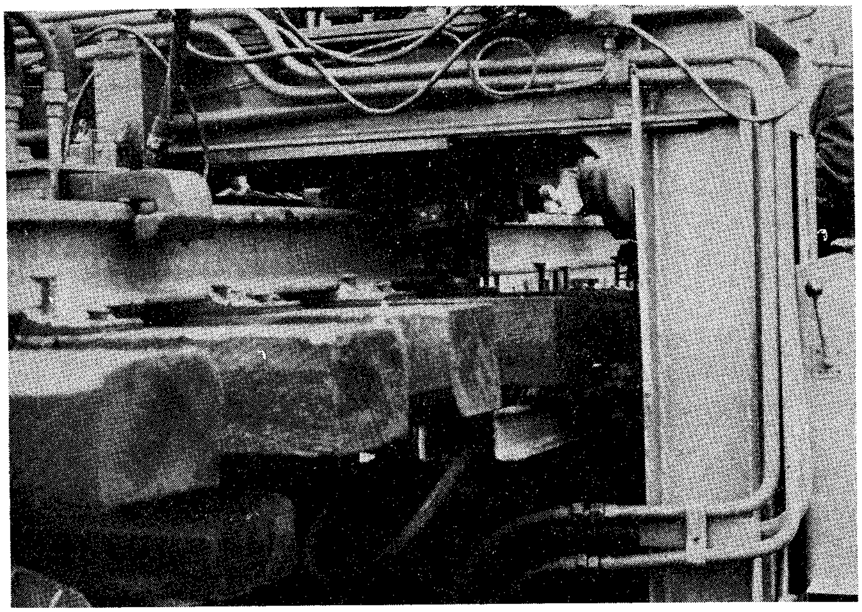


Figure 50

GANTRY CRANE MOVING COMPLETED PANEL
TO STORAGE AREA

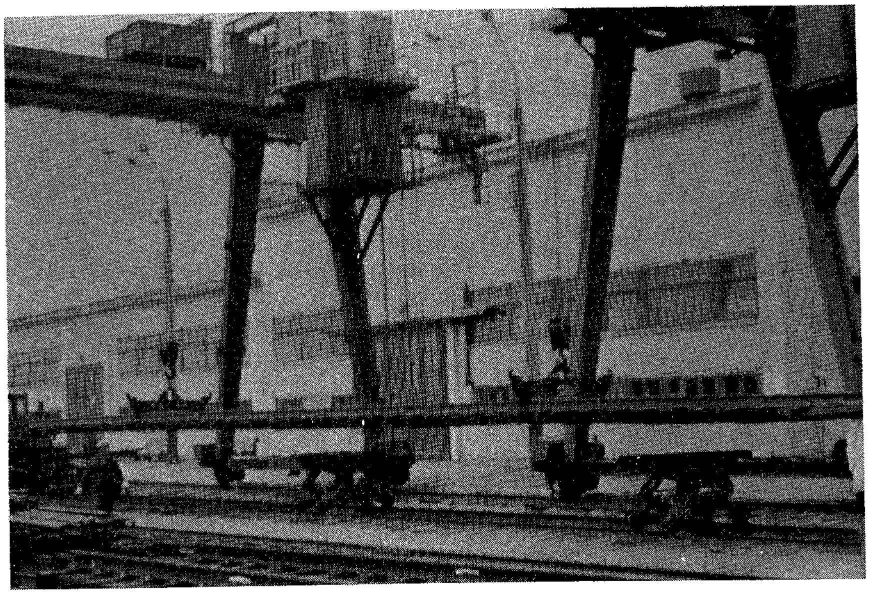


Figure 51

TIE PLATES, PADS AND FITTINGS FOR CONCRETE TIES

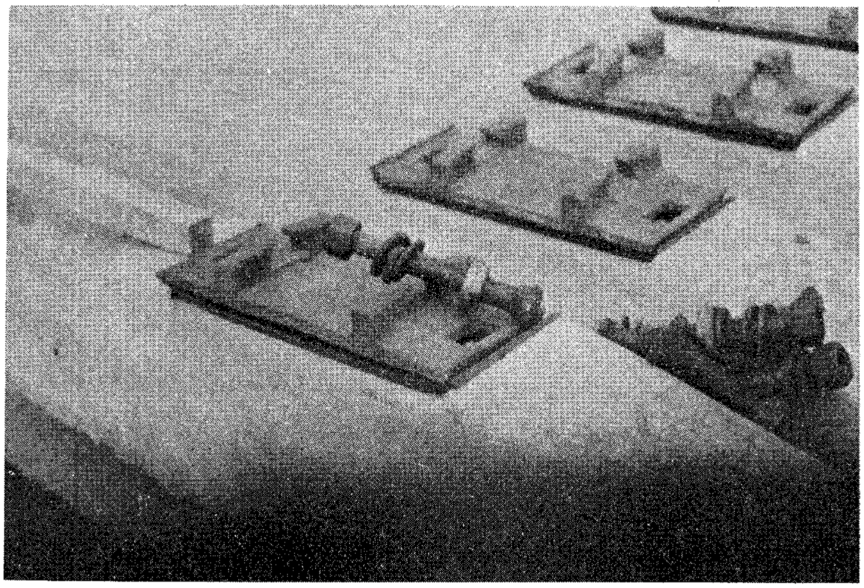


Figure 52

TIE PLATES ATTACHED TO CONCRETE TIES

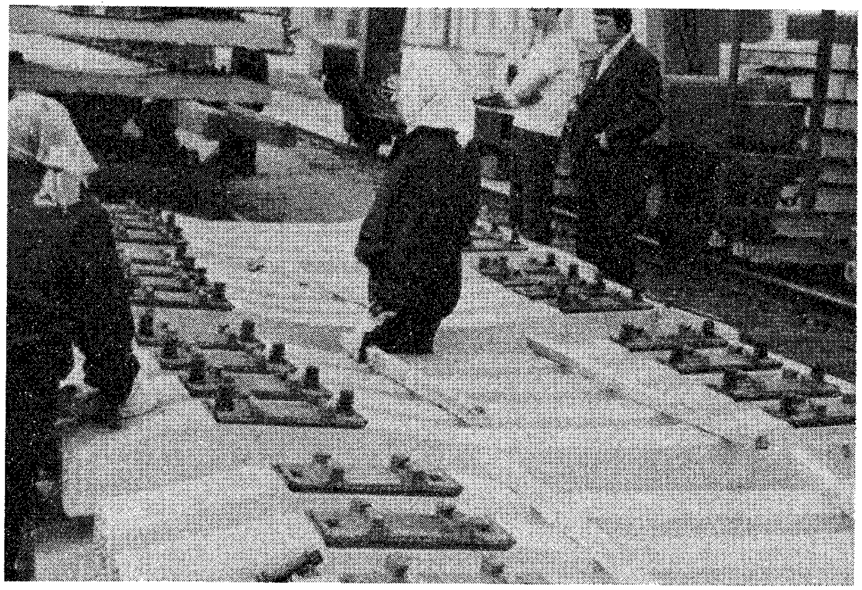


Figure 53

GANTRY CRANE HANDLING TIES TO PREFABRICATING BED

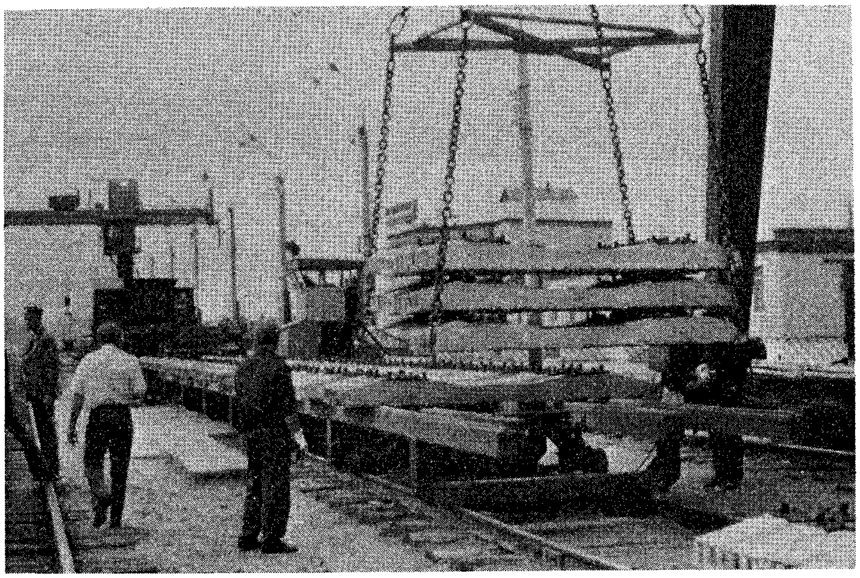


Figure 54

and tightening the fastenings. The entire panel is moving down the track during this operation. The sequence is shown in Figures 55, 56 and 57. Figure 58 shows the panel storage area.

Production figures given were 1,640 ft. of panel track per shift. One shift per day works during the good weather period. During the winter, production is increased by working three shifts, seven days per week, in order to meet the forthcoming season's requirements. Both of these operations were impressive, well laid out and productivity was good.

The Delegation observed a somewhat similar type operation in Kiev where main line welded rail had been torch cut in the field and the concrete tie panels brought in for rehabilitation. These panels, after reconstruction, will again be laid in the main line when it is time for the entire track to be removed and the ballast cleaned. The equipment used at this station is different, not completely mechanized, and the operation is much slower. Reconstruction involving concrete ties has not been required in the past. New equipment is under development.

After the rail is removed, it is tested mangetically for defects, cropped, drilled and ground. Approximately 15% of the rail is rejected for main line use. Most rejected rail is used for secondary lines and yards. The balance is scrapped. The rail we observed, which was to be reused, looked good for having handled 550 mgt. Very little plastic deformation was apparent. All failed concrete ties are replaced and brand new pads and

AUTOMATIC SPACING OF TIES

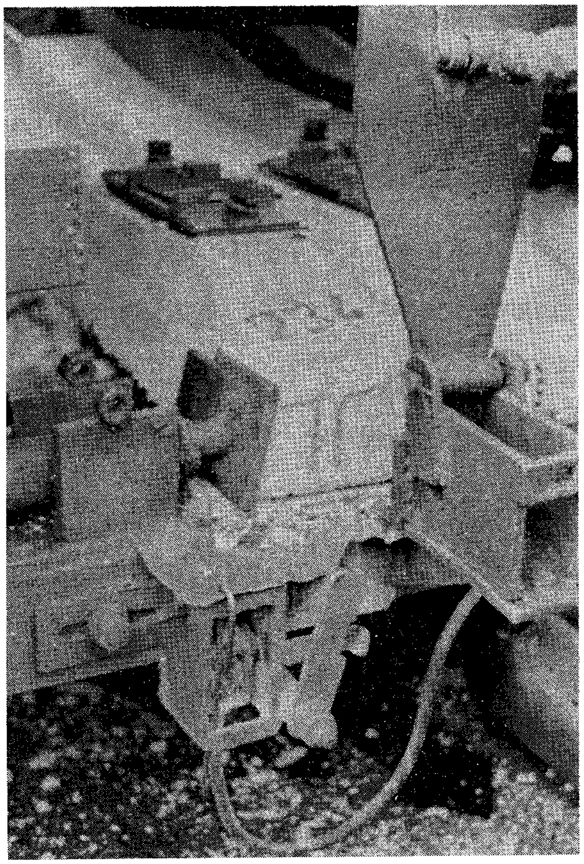


Figure 55

RAIL HOLD DOWN DEVICES HYDRAULICALLY TORQUES

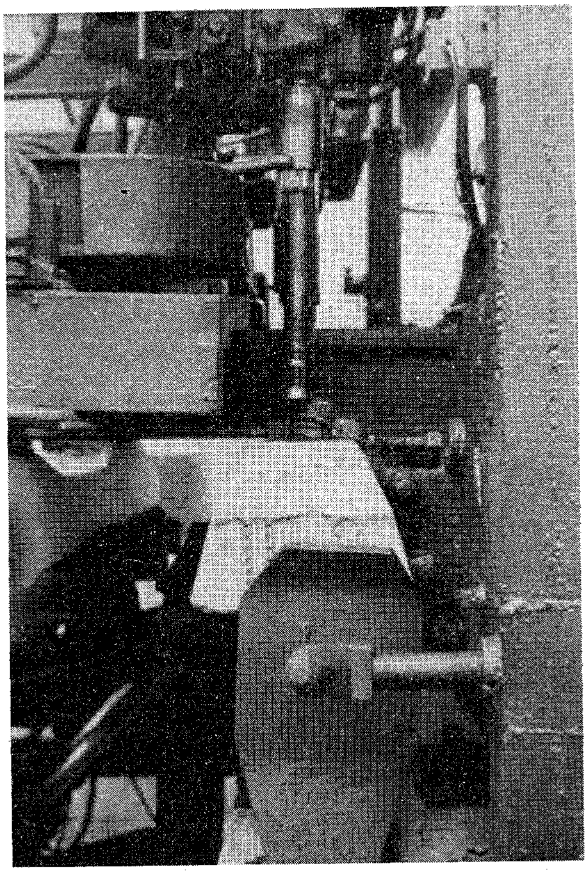


Figure 56

GANTRY CRANE MOVING COMPLETED PANEL

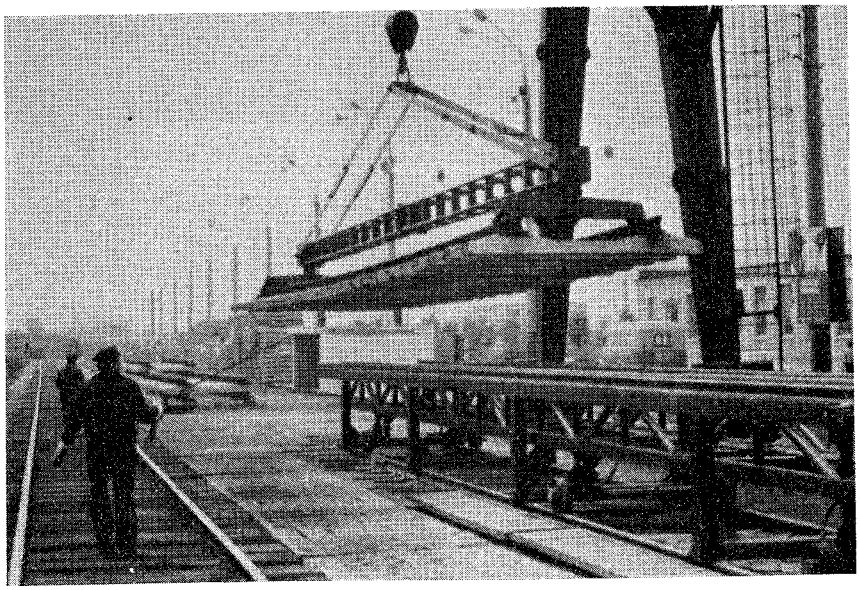


Figure 57

TRACK PANEL STORAGE AREA

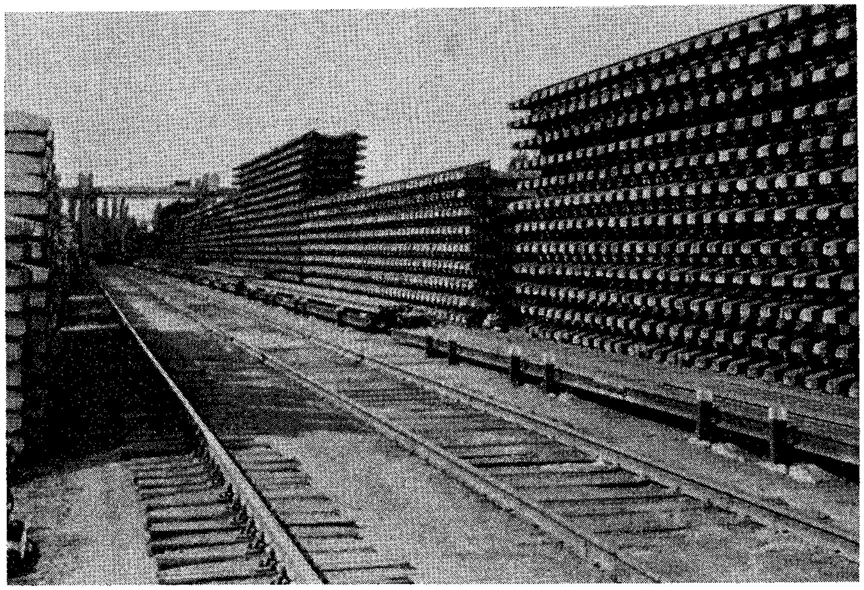


Figure 58

fasteners are applied. It is estimated by the Soviets that approximately 12% of the ties are replaced after 550 mgt. A rehabilitated panel for main line use is shown in Figure 59.

This was an interesting operation to observe because concrete tie, welded rail track panel rehabilitation is a relatively recent practice. The rail is referred to as, "Inventory Rail." The rail will periodically be returned to a preassembly station for reuse in constructing panels until it has reached the point where it is no longer safe for main line use. Most of it will then be relegated to secondary line and yard usage.

REHABILITATED PANEL FOR MAIN LINE USE

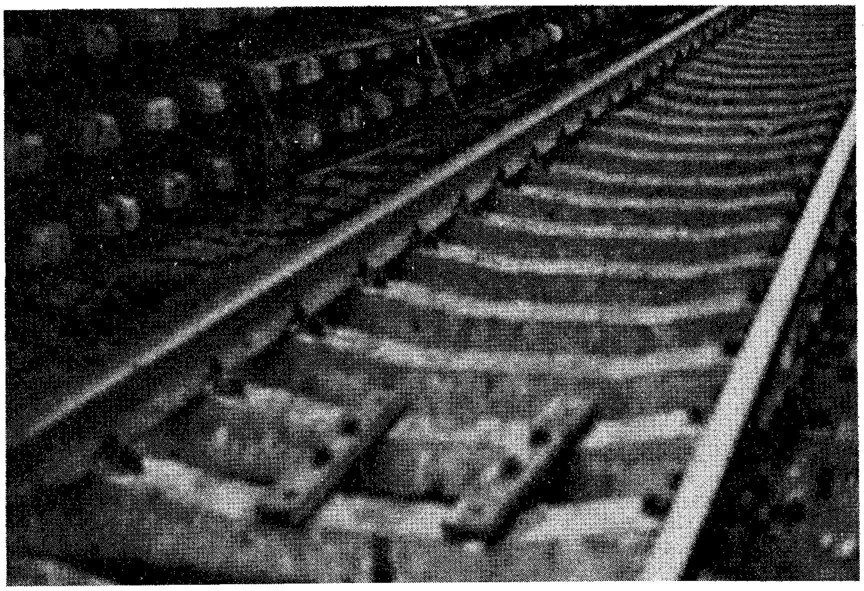


Figure 59

WELDING AND JOINING RAIL

The mobile in-track welding machine, PRSM-3, was seen in operation at the Track Preassembly Station in Kiev. The machine had a single welding apparatus, as shown in Figure 60. It was developed at the Patton Welding Institute in Kiev and uses the principle of electric resistance welding, commonly called flash butt welding in the US. The rails are welded in a continuous fusing process of the abutting rail ends at programmed ranges of voltages. This machine is said to have reduced the consumption of upset rail metal from 1.40 to 1.60 in., compared to 1.80 in. with the original equipment. The electrodes act as clamps to grip the rails hydraulically within the welder and pull the rails together at a pressure of about 50 tons. The machine is self-propelled and can travel at speeds up to 58 m.p.h.

Figure 61 shows the welder in operation. The production rate in track is said to be 10 welds/hr., although the head has the capacity of 20 welds/hr. Figure 62 shows the upset being removed by air operated chisels. This is a laborious process and is followed by a grinding operation.

The machine is used to weld longer than standard lengths of welded rail strings in the field, to weld rail inserts if a defective portion must be removed, and to weld bolted rail in track at some locations.

PRSM-3 MOBILE IN-TRACK WELDER

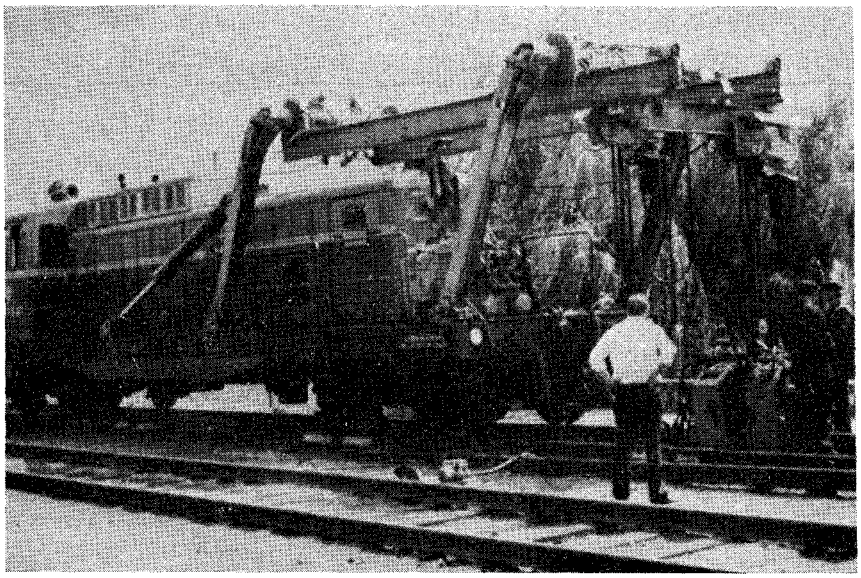


Figure 60

WELDER IN OPERATION

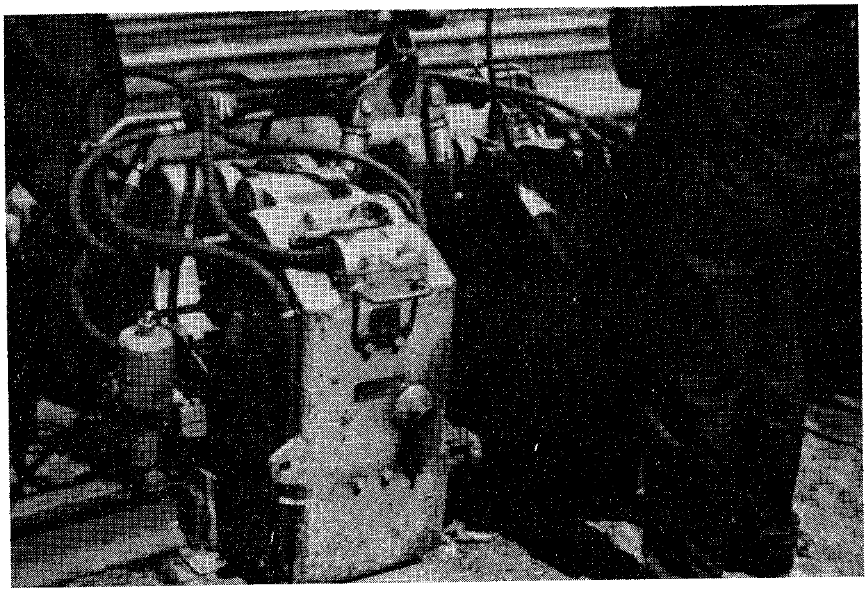


Figure 61

UPSET BEING REMOVED

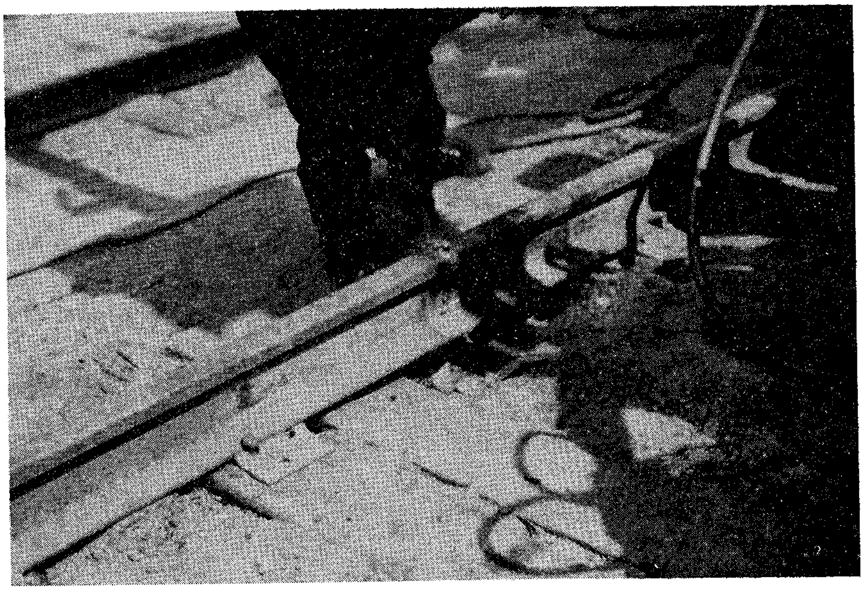


Figure 62

The Delegation had expected to see the newest version of the in-track welder and was disappointed at not seeing it. The new model has a hydraulic shear built into the welder unit, which is said to eliminate the time-consuming method of removing the upset with chisels. The new machine is also supposed to have reduced the welding time about one third by the introduction of hydraulically induced vibrations during the welding process. The consumption of metal is also said to be reduced by one half when compared to the older machines. A machine of this type is on the way to the US for tests.

The joining of rails by various methods was discussed. Only two methods have proved satisfactory. They are electric flash butt welding and oxyacetylene gas pressure welding. The latter is in very limited use, although both methods produce welds that are 92% to 98% as strong as the parent metal. Thermite weld testing has indicated the weld strength is only 70% of the parent metal. Its use has been abandoned and the mobile, in-track welder has taken the place of the thermite weld.

MAINTENANCE COMMENTS AND GENERAL OBSERVATIONS

MAINTENANCE COMMENTS

Some comments are in order concerning track maintenance practices and overall track standards, after traveling over three of the Soviet Railroads and observing track operations. As has been previously pointed out by other delegations, running repairs, middle repairs sometime during the life of the track structure, and capital repairs, when the entire track structure is removed and replaced, encompass the track maintenance cycle. Middle repairs occur somewhere in the 250 mgt. range and consist of ballast cleaning, spot rail and tie exchange, replacement of defective fastenings and surfacing and lining operation.

Concrete tie removal has been averaging 5.6 ties/mi. during middle repairs. It has been estimated by a previous delegation that 50% of section crew time is spent on tightening fasteners, many of which are the older types and are no longer used. Present standards call for the hold down fastenings to be taken apart twice a year, oiled and retorqued. It appeared that the practice was not followed. We were told that about 30% of current maintenance work is spent in shimming to keep the crosslevel within the 0.16 in. standard and low joints within the 0.08 in. standard. The standard concrete tie has an 0.80 in. recess. This allows for shimming 0.56 in. based upon a pad depth of 0.24 in. Track shimming is a most time-consuming practice. The rail fastener must be removed, the rail jacked up, shims placed, and the fasteners replaced and tightened.

The track surfacing equipment we saw in action appears to be incapable of skin lifting. This appears to be a drawback in this particular operation. The Soviets state that one of their major problems is running repairs on heavy density track. We learned that they are seeking outside assistance for developing more sophisticated, production lining and surfacing equipment, which, from our observations, appears necessary.

The inspections made on the South Western Railroad in the area we visited required flaw detection and gauge reading once per week by the local foreman with his hand push cart, a general inspection four times a month by the foreman, and an overall inspection once a month by the roadmaster. In addition, the track is inspected by a track geometry car and a flaw detector car once a month. All of these inspections, however, are determined by density and vary considerably throughout the system. Incentives are used for maintaining good track. They are based upon exceptions per km. This is obtained from the monthly track geometry car inspection. It was stated that these incentives can reach 25% of salaries. Again it can be seen that the safety and integrity of operations are absolute essentials. Personal safety, however, is a different matter. No safety equipment of any kind was provided for any of the track personnel we observed. Their personal safety record is not known.

The Delegation also observed considerable current maintenance work, especially in yards, being performed by the time honored method of hand tools. These gangs consisted of both men and women.

The ride quality of the railroads traversed was acceptable, with few minor exceptions. The overall level of maintenance was good in the areas we covered. Track drainage receives a high priority as was evident to the Delegation. Figure 63 shows typical main line trackage. The railroads appeared to be doing their job, which by any criteria is the final answer. It is also evident that upgrading is taking place, based upon the figures given us and reported herein. No trackage observed was as poorly maintained as some portions of US trackage.

GENERAL OBSERVATIONS

The scope of our assignment was extremely broad, time was very limited and at times, translation was frustrating. Thus, we were unable to deeply probe into many areas of considerable interest to us. We also were unable to visit some of the facilities on our agenda. Further delegations may wish to pinpoint specific target areas, limit the topics under discussion and secure assurance from the Soviets that all of these items can be accomplished, including visits to specific installations.

At the conclusion of our meetings, the Soviets were asked specifically what their major objectives are and what components in particular they are working on. They are not working on any

TYPICAL MAIN LINE TRACKAGE

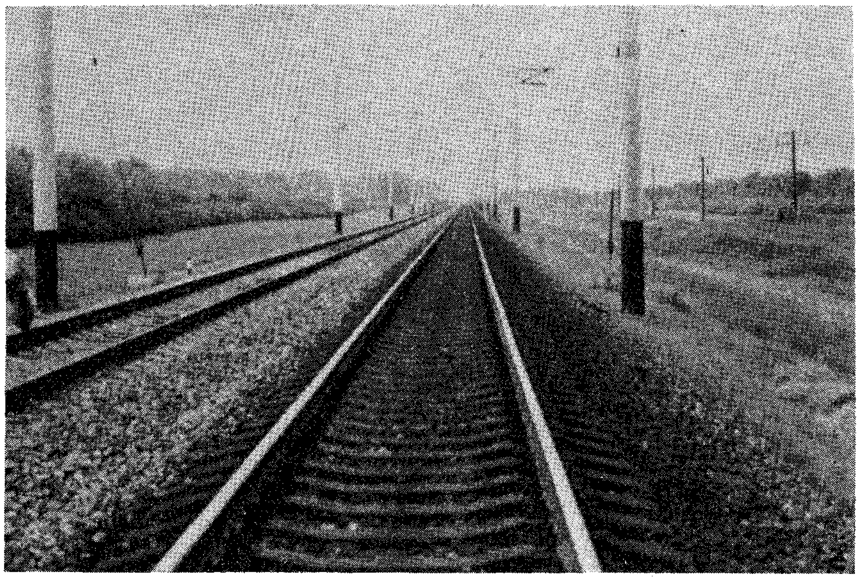


Figure 63

components in particular but on the whole track structure as a system. It was stated that not much could be accomplished by improving individual components. This was in line with previous statements we heard throughout the trip. It was admitted, however, that the elasticity of the fastenings and pads for concrete ties, and a better ballast section was required. In this respect, it was interesting to learn that in concrete tie, welded rail construction, wood ties are sometimes used at the square joints between welded rail strings to provide more track elasticity.

Considerable testing, however, continues on other track components. Asbestos ballast is a topic of considerable interest. The Soviets are very enthusiastic about its use because of its high carrying capacity and the elimination of contamination. Asbestos ballast has been in use for less than ten years. There is some concern about its cleanability, because of the very heavy crust and consolidation of the material. Its use is limited, however, because it is a by-product and is not economical to produce solely for ballast purposes.

SUMMARY OF FINDINGS

The following briefly describes the major findings of the Delegation. Considerably more detail and follow-up information is covered in the body of the report, including other items which may be of particular interest to some readers.

Just to compare the USSR's research, testing, construction, material components and maintenance procedures with those in the US would undoubtedly raise more questions in the eyes of the reader than answers because of the vast differences in philosophy and economics. It is therefore incumbent upon the reader to understand that the selection and use of all track components is not related to economics as we understand the term, but to the almost complete reliance on the Soviet railroads' ability to carry the nation's goods and passengers with minimum disruption to train operations.

Competition between railroads and other forms of transportation is nonexistent. The traffic densities are staggering, reaching 176 million gross tons (mgt) on some lines. It is said that with only 10% of the world's trackage, the USSR moves 50% of the world's rail tonnage. Traffic is increasing rapidly. Safety plays a most important role in all Soviet railroad operations. The track is under continuous surveillance by high speed magnetic detection cars, ultrasonic detection cars, track geometry cars, and hand pushed ultrasonic detection equipment operated daily over the line by local section men. Economics as we understand the term cannot play a leading role because the overall successful operation of the railroad with minimum outages must, of necessity, be the paramount factor.

The organization and operation of the Track Directorate and its relationship to the All Union Railway Research Institute (CNII) was studied. This institute plays a vital role in the scientific and technical progress of the Soviet's railroads through its field and laboratory testing, the development of standards and procedures, and their ultimate use.

The Railway Research Institute of Technical and Economic Information keeps well abreast of railroad developments throughout the world. This institute is also the focal point for the dissemination of information to the Soviet's individual railroads. This includes technical literature and the production of films on maintenance procedures and equipment.

Detailed information concerning the construction, operation, and testing of the Track Buckling Facility was obtained for possible use in the construction of a similar facility in the US. Thermal buckling of track under test conditions was observed and the relevant data secured. The Soviet's method for developing welded rail laying and maintenance specifications from these tests was obtained.

The complete operation of the Shcherbinka Experimental Test Rings and Laboratories was studied at length for possible application to the new US Facility for Accelerated Service Testing (FAST) at Pueblo, Colorado. This included track construction, train operation, track maintenance procedures, instrumentation, and laboratory and field testing of all track components. New designs of various type concrete bridges are under construction and will be tested under actual loading.

The retrieval and analysis of data from testing was discussed in terms of the development and modification of standards. It is apparent that the use of computer technology in track research lags far behind the US. The instrumentation at Shcherbinka consists primarily of strain gauges with no fixed facility instrumentation.

No equipment or component of any kind can be used on the Soviet rail network until it has been certified. The certification includes analytical and laboratory analysis at Shcherbinka, testing on the ring, field testing, and adoption of track standards.

A portable, battery operated, ultrasonic device which maps flaws in the rail head was observed. This device is used for determining flaw growth and could be put to good use in US rail research and development activities.

Track-train dynamic tests have taken place in the Caucasus, but were not observed. Discussions took place involving instrumentation, l/v ratios, relationship of field data to design procedures, and track loading criteria. The Soviets have determined that the ratio between the total lateral force per axle to the mean vertical axle load must not exceed 0.40, which is similar to US experience. The loading standard for track, which is expressed in tons per meter of track, was obtained, although we were unable to learn of its correlation to axle loadings. New cars are being built with six and eight axles, although the trend is toward the eight axle 138-ton capacity car. This, of course, is in direct contradiction to the present US practice of loading up to 263,000 lbs. (100 ton car) with four axles. This loading is increasing contact fatigue failures, plastic deformation of rail, rail corrugation, and muddy track in the US.

All rail mills, except one older one, have been converted to rolling 25 m (82 ft.) rails. Various combinations of alloys have been experimented with and tested but this approach has been abandoned. Several heat treating processes have been tested, with through hardening of the rail section using an oil quench winning out. This process eliminates hydrogen by annealing without control cooling. The rails are tempered and roller straightened. The microstructure is pearlitic. Presently, 45% of the annual production of R65 (132 lb.) and R75 (152 lb.) rails is heat treated with about 22,000 miles of heat treated rail now in service. The heat treatment is said to have increased production costs 8.3 %, but the service life has been extended 50%. Standards have been set for removing rail from main line service which equates to about 550 million gross tons (mgt) for conventional rail and 825 mgt. for heat treated rail. Even though service life has been extended 50%, the tonnage carried has increased 1.6 times since 1966, placing the track engineer about back where he started. Work, therefore, is underway on what is described as a super heat treated rail with tensile properties of 228 to 242 ksi., a Brinell Hardness

Number (BHN) of 450, and a main line rail life of 1.3 to 1.7 billion gross tons. If a similar type rail can be economically developed in the US to meet all service requirements, considerable interest could be developed. Considerable research is also underway in other areas to improve the quality, reliability, and service life of the rail. Vacuum degassing of rail has been under development, but its future does not look promising. Residual stresses in heat treated rail are carefully controlled; a test has been devised for quality control stresses.

Service life of rail in the USSR is determined by two criteria, the number of defects per km, and rail wear. Normally main line rail is removed for defects rather than for wear. An exception is gauge wear on some curves. This is different than US practice where most rail is removed because of wear. The defect formula for rail wear is found in the body of the report.

Rail defect data for 1974 R65 (132 lb.) conventional and heat treated rail is shown in the text. Shelling related defects, including transverse fissures, are in predominance with almost three fourths of the total defects in the head areas. The number of bolt hole failures is exceedingly small. The statistics indicate that the heat treated rails are performing better than conventional rail.

The number of concrete ties is expanding yearly because the consumption of high quality lumber is a national economic problem. The Soviets expect at least a 40 year life from the concrete ties.

At the present time, approximately 25% of the main line ties are of concrete. The tie has changed very little since 1966. Tie spacing is 21.4 in., which is less than most test installations in the US. The concrete tie in the USSR has gained widespread acceptance, which is far from true in the US. Under present standards, welded rail can only be placed on concrete ties, but an experimental section of welded rail on wood ties is now in service.

Although considerable experimentation and testing has taken place, the Soviets are still not satisfied with the harshness of the ride and the inelasticity of the concrete tie track. Testing is still underway to provide more elasticity. Different types of pads, fastenings, and additions of cohesive elements to the ballast section, which will hopefully reduce residual ballast deformation and contamination (fouled ballast), are under study.

The Soviet Railway System is still a predominantly wood tie railroad. They are still being placed on main lines. The ties are of creosoted soft wood and have an average life of 16 years. The tie spacing is the same as for concrete ties. The tie plate area is smaller and has different dimensions than those used in the US, which results in considerable tie plate cutting. Although wood ties are used for turnouts, concrete slabs and beams have been certified at Shcherbinka. About 120 concrete slab and beam turnout installations throughout the USSR are under study. Extensive testing of various types of concrete slab track took place between 1964 and 1968. They are now being evaluated under actual operating conditions. No further information was available.

New, on-track, self-propelled equipment has been introduced to remove rail from 82 ft. track panels and replace it with welded rail in 800 m (2,625 ft.) lengths. We observed the replacement of 1.5 mi. of bolted track within a two hour time frame. This was a most efficient operation but is probably not adaptable to US practice unless concrete ties and fastenings are used. Some of the strings had a rail plug containing an epoxy bonded insulated joint which was welded in at the central welding plant. This may be adaptable to some locations in the US. The track was surfaced but not lined.

The standard length for welded rail in track is 2,625 ft. separated by three 41 ft. rails with square joints on wood ties to provide more elasticity and take care of possible expansion. The Soviets are now field testing longer lengths of welded rail, the longest section being 7,874 ft. long. It appears they may have been influenced by recent visits to the US.

Electrical resistance or flash butt welding is the standard method of joining rails. Oxyacetylene, thermite, and consumable electrode methods have not been found entirely satisfactory. Although the mobile in-track PRSM-3 welder was observed in action, the Delegation was disappointed in not seeing the latest version which has a reduced welding cycle, automatic shear, and a reduced consumption of metal. A new machine of this type is in the US and shows promise for US application.

The disassembly and preassembly of wood and concrete tie track panels with usable or renovated components was observed. The equipment appears to be most efficient. These methods are not applicable to any great extent at the present time in the US because of the Soviet's practice of replacing the entire track structure with track panels after a predetermined amount of tonnage has been hauled over the line.

An automated wood tie reclamation plant was observed. About 50% of the wood ties from track panels removed from the field are renovated for further use. This facility was very impressive and appears to have potential in the US for some ties that are removed because of abandonment or upgrading of trackage.

Considerable difficulty is being experienced with running maintenance on high density lines. The preponderance of section gangs' time appears to be spent on tightening rail hold down fastenings and shimming track, because sophisticated high speed surfacing and lining equipment is not available. The Soviets are now seeking outside assistance in this area. Considerable running maintenance work, especially in yards and terminals, was observed. This work was accomplished by hand methods with gangs consisting of both men and women.

The ride quality of the track traversed was very good with very few minor exceptions. The track was in uniformly good condition with about average drainage. The railroad appeared to be providing reliable national transportation, which is the only objective in the USSR.

At the conclusion of our meeting, the Soviets were specifically asked what their major track objectives were. They answered that work is under way on the complete track structure to increase its service life, although considerable emphasis is being placed on improving the elasticity of the concrete tie trackage.

We were unable to probe deeply into many areas of considerable interest to us because of the limited time available and the time spent in translation. Future delegations may wish to pinpoint more specific areas and limit the topics under discussion after first receiving absolute assurance from the Soviets that the items will be discussed. The Delegation was disappointed that its metallurgists were unable to visit rail and axle mills and observe actual steel mill practices as was originally anticipated.

APPENDIX A

ITINERARY

June 14 - 25, 1976

June 14 - Moscow

Arrival at Sheremetyevo Airport	Malashko
Greetings	Lukov
Hotel accommodations	Statyeinov

June 15 - Moscow

Meeting at the USSR Ministry of Railroads	Alexandrov
	Avetikyan
Discussion and agreement on itinerary	Bassilov
Introductory presentations and background	Finitskyi
Visit to Institute of Technical and Economical Information	Kolodyazhnyi Lukov
	Malashko
Operation of institute	Pashinin
Current and future prospects of USSR Railways	Statyeinov
Inspect models of maintenance equipment	Verigo
View technical films on maintenance procedures	

June 16 - Moscow

Meeting at USSR Ministry of Railroads and CNII	
Technical presentations at Ministry and CNII	Albrekht
	Alexandrov
	Bassilov
Improving reliability of track	Bromberg
Increasing service life of track & components	Burmistrov
Continuous welded rail methods and equipment	
Description of track types and problem areas	Lukov
Description of rail defects	Pashinin
	Verigo

Visit to Track Buckling Facility at Lossino-Ostrovskaya

Observation of actual buckling test
Discussion of results, criteria and standards

June 17 - Moscow

Visit to Shcherbinka Experimental Test Ring - Moscow

Technical discussions and presentations of data

Activities including track and rolling stock design

Investigations carried out on track structure and components
Welded rail and all its ramifications
Types of rail - metallurgy - service life
Concrete ties, fastenings - wood ties
Residual stresses; measurements

Albrekht
Dolganov
Inozemtsev

Karetnikov
Lenov
Lukov
Melenteyev
Pustovoyit
Velikanov
Verigo
Vlossov

June 18 - Moscow

Shcherbinka Test Facility and CNII Headquarters

Operation of test ring - operations - maintenance
Design considerations related to test data
Track-train dynamic discussions
Visit of various laboratories
Discussion of problem areas
Overnight at Leningrad via October Railroad

Albrekht
Dolganov
Fufryanskyi
Inozemtsev
Karetnikov
Lukov
Melenteyev
Pustovoyit
Velikanov
Verigo
Vlossov

June 19 - Leningrad

Visit to Leningrad via October Railroad

Return to Moscow overnight

Lukov
Malashko

June 20 - Moscow

Visit to Moscow Permanent National Exhibition Moscow

Pavillion of transportation
Pavillion of metallurgy
Overnight to Bryansk via Moscow Railroad

Lukov
Malashko

June 21 - Bryansk

Visit Track Pre-Assembly Station N 99 at Bryansk

- Observed pre-assembly track panels
- Observed dis-assembly of track panels
- Observed wood tie reclamatory operation
- Overnight to Kiev via Moscow Railroad

Alexandrov
Kurov
Lukov
Millmann
Monekehov
Ovsyanik
Tokaryev

June 22 - Kiev

Observed continuous welded rail laying operation
Visit to Track Pre-Assembly Station OPMS 121

- Assembly of track panels with reconditioned materials

Observed PRSM-3 Mobile In-Track Welder
Overnight to Moscow via Moscow Railroad

Alexandrov
Goodz
Kovalnko
Lukov
Oleynik

June 23 - Moscow

Meeting at USSR Ministry of Ferrous Metallurgy

- Technical presentation and discussion of data
  - Metallurgical properties of rail steel
  - Rail defects - growth - occurrence
  - Hydrogen embrittlement
  - Production of heat treated and 82 m rails
  - Rail standards development of super rails

Albrekht
Alexandrov
Guvert
Lukov
Statyeinov
Vinokurov

June 24 - Moscow

Meeting at USSR Ministry of Railroads

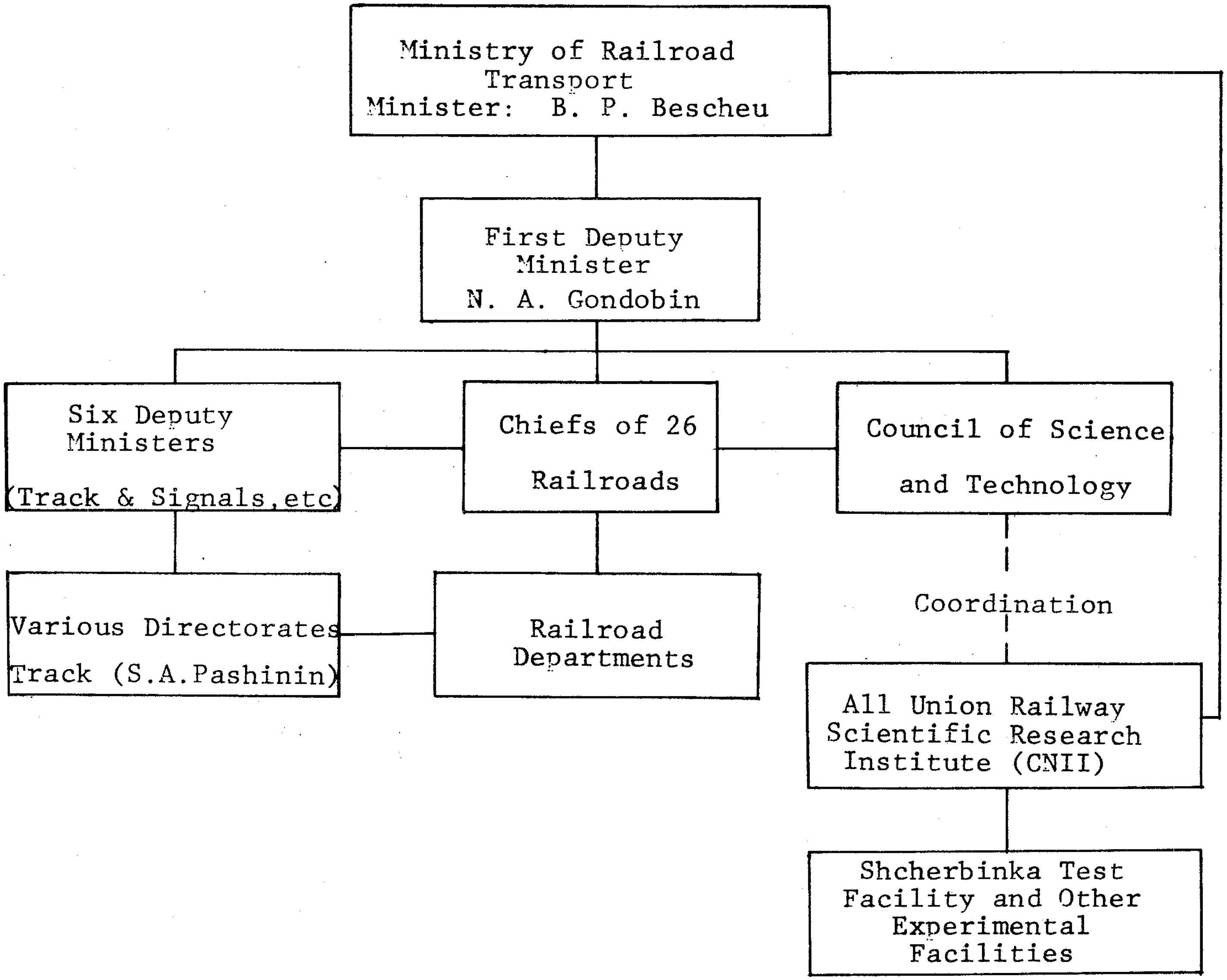
- Technical discussions on overall exchange information
  - Rail
  - Ties
  - Fastenings
- Signing of Memorandum on Exchange
- Television Interview

Alexandrov
Burmistrov
Finitskyi
Gondobin
Kolodyazhnyi
Lukov
Malashko
Pashinin
Verigo

June 25 - Moscow

Final discussions and departure	Alexandrov Lukov Malashko

USSR TABLE OF ORGANIZATION



USSR June 1976

APPENDIX B

DOCUMENTS

USSR

1. Railway Transport of the USSR and Prospects of its Development.
2. A comparative Technical-Economic Characterization of Track with Reinforced Concrete Ties and Those with Wood Ties.
3. Laboratory Tests of Prestressed Concrete Ties.
4. A Method for Conducting Tests of Experimental Rails at the Experimental Test Yard at Station Shcherbinka, Moscow Railroad.
5. A Method for the Measurement and Analysis of Dynamic Loads Acting on Railroads.
6. Studies Conducted by the Control Scientific Research Institute for Improving the Reliability of Rails.

US

1. Railroad Track Technology in the USSR: The State of the Art.
2. US-USSR Rail Inspection Information Exchange.

APPENDIX C