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## FINNISH RAILROADS

The following are selected translations from the document Valtionrautatiet 1912-1937 (Finnish State Railroads, Vol II), published 1937 in Helsinki.

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### Construction of the Oulu-Kajaani-Nurmes Line

On 1 June 1918 the Finnish Senate authorized the Highway and Waterways Construction Administration to initiate studies, with all possible haste, for the construction of railroad lines between Nurmes and Mieslahti, which would also extend to Oulu via Vaala, and from Mieslahti to Kajaani. Surveying operations were begun in June 1918 and were completed before the end of the year. The length of the main line from Oulu to Nurmes was to be 271.3 kilometers. The construction of a branch line of 25.8 kilometers and a terminal station at Kontiomäki was also recommended.

The Diet decision for the construction of a standard gauge line from Nurmes to Mieslahti via Vaala and to extend the Savo line from Kajaani to Mieslahti, as well as the decision to follow the south bank of the Oulujoki in the construction of the Vaala-Oulu line, was approved by the existing head of the Finnish government on 6 September 1918.

The Diet decision for the construction of the Vaala-Oulu line had been made already during the second session of the Diet in 1909 and according to these plans this line would have been constructed on the north bank of the Oulujoki. The decision for the building of the Nurmes-Mieslahti-Vaala line was made during the session of 1917.

The Highway and Waterways Construction Administration decreed on 24 October 1918 that construction operations would begin first on the Nurmes-Mieslahti-Kajaani line with the Oulu-Vaala section in next order. Work was consequently begun in November at Nurmes, Sotkamo, and Kajaani, but only preliminary operations of warehouse construction and procurement of construction equipment was completed by the end of the year.

p 68 The final surveying of the line was completed during 1919, a change in the course of the line at Sotkajärvi in Utajärvi parish was effected, and plans made for the Jaalanka and the Kiehimä harbor lines on the shore of Oulujärvi.

Part of the surveying operations which were begun at the end of 1918 were terminated in part during 1919 for lack of funds. This work was continued only at Kajaani and Sotkamo, while the projects in Nurmes and Valtimo parishes were dropped. Since the budget recommendation for 1920 was reduced to 1,000,000 marks, with a view to terminate the entire project by degrees, work was halted also at Sotkamo at the end of 1919 and operations continued then only on the Kajaani-Kontiomäki portion of the line.

Work completed in the Nurmes and the Valtimo parishes included the clearing of 12 kilometers of line, procurement of building stone and gravel at the sites of bridges and culverts, and the cutting and hauling of timber from state forests to construction sites and to streams for floating. Similar work had been completed at Sotkamo, plus work on an extensive cut near the Vuokatti wayside station. Most of the culverts and ditches were completed on the Kajaani-Kontiomäki portion and a sawmill had been constructed south of the Sotkamo lakes near Kajaani to produce lumber for the railroad project.

During 1920 work was in progress only on the Kajaani-Kontiomäki portion. This consisted principally of making cuts and fills, building culverts, and bridge construction. Construction of the ferro-concrete Petäisenkoski bridge at Kajaani by a private contractor was also completed that year.

In 1921 work continued, as before, only on the portion between Kajaani and Kontiomäki. Cutting and filling operations progressed, the Säräisjoki bridge was completed, and an underpass was constructed for the highway leading to the Petäisenniska wayside station. A three-unit and an eight-unit multiple family dwellings were built at the Kajaani station.

The work progressed to the stage during 1922 that it was possible to lay the rails as far as the Kontiomäki station. An excavating machine was procured for making cuts and fills, which was also used to load gravel on rail cars for the roadbed, applied directly from the cars to the road as the laying of tracks progressed. No residential construction was done during the year and temporary housing facilities were therefore provided for the operating personnel. The section of line was opened temporarily for traffic on 1 January 1923.

The uncompleted fills of the Kajaani-Kontiomäki line, located mostly at Kontiomäki and Jormua, were finished during 1923 and additional gravel was applied to the roadbed. Construction of special culverts and bridges still continued and the required housing was built. The line was tied to the network at the end of 1923.

The Diet decision of 1924 regarding the continuation of work on the Kontiomäki-Nurmes branch, made in conjunction with the annual budget report, was that operations would be resumed if the communes concerned, or private individuals, were willing to assume responsibility for that amount of monetary compensation claims arising from the damage or loss of value of land or water areas resulting from the construction of the railroad which was in excess of the amount deemed reasonable by the government. The route proposed for the line by the Railroad Administration on 9 January 1925 was approved by the Cabinet on 26 March 1925 as submitted. A simultaneous decision of the Cabinet decreed that those portions of the land required for the railroad which were owned by the state would be transferred without compensation to the State Railroad. A part of the cuts of the Kontiomäki-Vuokatti portion were completed during 1924 and work was begun on the remaining cuts. Only the most essential ditches were completed and a limited amount of work was done on culverts and bridges. The Kajaani station was expanded and an engine stall was built at Kontiomäki.

Much cut and fill work remained to be done on the Kontiomäki-Vuokatti portion at the beginning of 1925, but this was virtually completed during the summer as far as the site of the Tenetinvirta bridge. Most of the fills between the bridges were also completed. Four small bridges were built, as well as the abutments for the bridges over the Tenetinvirta, and rails were laid as far as Tenetinvirta. Housing units were constructed at several stations.

The Cabinet authorized construction of the Kontiomäki-Kiehimä portion on 28 May 1925 and approved the route on 10 June 1925 and operations were begun the same year. Most of the fills were completed, culverts were constructed, the foundations for the Miesjoki bridge were laid, and 5 kilometers of rails were laid that year.

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The construction operations entered a new phase in 1926 through an act of the Diet which specified the extent of these activities during the period 1926-30. The provisions of the act called for the completion in 1926 of the Kontiomäki-Sotkamo and the Kontiomäki-Kiehimä portions, and that after 1926 work would be carried on simultaneously on the Oulu-Nurmes, Oulu-Kontiomäki, and the Kontiomäki-Nurmes portions. Uncertainty regarding the availabiltiy of funds was thus removed and construction on a co-ordinated plan became possible. A condition specified for the construction of the Sotkamo-Nurmes line was that the communes concerned must make arrangements in advance for compensation for the land and water areas concerned.

Fills, culverts, bridges, and laying of tracks was completed on the Kontiomäki-Kiehimä section in 1926. The operations on the Kontiomäki-Vuokatti (Sotkamo) section reached as far as the gravel hill of Kuikkaharju and to the Sotkamo ~~harbor railroad~~ wayside spur, which the Cabinet had authorized for construction on 30 April 1925 at the request of the Sotkamo commune. Roadbed filling operations were completed on both of these lines, the rails laid, and final application of gravel on the roadbed was made during the year. Housing for personnel was built along the line virtually as far as Vuokatti.

Operations were extended to the Vuokatti-Nurmes section, where little work had been done thus far, in March 1926, chiefly to the portion of line 23.5 kilometers in extent between Vuokatti and Saviaho, and in lesser degree to the sections between Saviaho and Maanselkä and at the end of the year to the section between Maanselkä and Puukari. The latter two sections have a combined length of 26.5 kilometers. Ditching and cutting operations were completed on the Vuokatti-Saviaho section with the exception of the extensive cut at Laajamäki between Vuokatti and Juurikkalahti, from which 45,000 cubic meters of earth, or approximately one-half of the required amount, were removed. Culverts were constructed and work progressed on the foundations and masonry abutments of five bridges. Dwellings were constructed at several stations.

The uncompleted fills and bridges between Vuokatti and Saviaho were put in order during 1927. The cutting and filling operations of the Saviaho-Rumo-Kokkojoki section progressed rapidly, and while all of the cuts were completed during the year, only a minimum amount of roadbed fill was applied, especially between Saviaho and Maanselkä. All of the tracks of this project were also laid that year.

p 71 Since the funds had been used somewhat lavishly early in the year on the Saviaho-Maanselkä section a reduction of the number of workers would have become necessary during the latter part of the year. In order to forestall such an eventuality the Cabinet approved additional funds which were used to extend the roadbed filling operations to the Kokkojoki-Puukari section and to carry out preliminary work on the section between Puukari and Nurmes [redacted] toward the end of the year. Six bridges were built during the year and abutments were constructed for several others, numerous culverts were built, and dwellings were constructed as far as Puukari along the line.

During the winter the main labor force was concentrated in the section between Nurmes and Valtimo to make lake fills since these would have been difficult and costly to construct during the summer months of the 1928 work program. Cutting and filling operations were carried to such a stage [redacted] during the winter that it was possible to lay the tracks on the Kokkojoki-Nurmes section in the autumn. Hauling of gravel from the gravel hill of [redacted] Maanselkä to the Saviaho-Maanselkä and the Maanselkä-Rumo sections was begun in April 1928, and to the Pielisenjärvi [redacted] fill from the Porokylä gravel pit in Nurmes, and [redacted] to the Pölvijärvi fill from Valtimo. More than 50 culverts were built. Bridges were built over the Kokkojoki, Verkkojoki, and the Valtimojoki [redacted] and a number of other smaller rivers and two wooden overpasses were erected. Some housing was constructed on the Maanselkä-Karhunpää section.

All of the fills of the Kiehimä-Nurmes section were completed during the favorable weather conditions of 1929 and the necessary housing was constructed. Operations were impeded by extensive sinking of the roadbed which necessitated the moving of track in two places a total of 1,700 meters of track.

- p 72 Construction of the portion of line between Oulu and Kiehimä of the Oulu-Nurmes line was undertaken in 1926 under the provisions of the act covering construction of railroads during the period 1926-30. Construction of the Oulu-Vaala-Kiehimä section was undertaken on condition that the communes involved would assume in advance responsibility for obtaining the right of way. The route surveyed for the Oulu-Kiehimä line in 1918-19 was approved by the Cabinet on 25 February 1926.

Cabinet authorization to begin the work was not given until 21 May 1926 owing to the delay of some of the communes in fulfilling the stipulated conditions. However, the Cabinet granted permission before this date to begin certain necessary operations which of necessity had to be done during the winter, such as the procurement of gravel for roadbeds, building stone, and lumber. This type of work was accordingly begun on 1 March on the Saaristonkatu underpass and the Kaupunginoja bridge in the city of Oulu and subsequently on the Oulu-Muhos section of line. Delay was also brought about by a petition to use Kempele rather than Oulu as the terminus, which however, was rejected by the Cabinet. The route surveyed in 1918-19 was followed with only minor deviations.

The 1926 construction program called for operations on 44 kilometers of the line to a point between the Oulu station and the switch of the Hyrkkää wayside spur. Most of the roadbed fills of the Oulu-Muhosjoki section were completed, numerous culverts were constructed, foundations laid and masonry work was completed on three bridges, and work on the foundations of the Muhosjoki bridge was begun during the year. Cutting of 120,000 cubic meters of earth and rock between the Muhos and Hyrkkää stations got under way; tracks were laid on the section between Oulu and Muhos.

Extensions of the Saaristonkatu underpass and the Kaupunginoja bridge [redacted] at the Oulu station were finished.

The 1927 work program included the gravelling of the roadbed of the Oulu-Muhos section and of preparing the track for service. Work was to begin on the section to the Utajärvi station and tracks were to be laid on the Muhos-Utajärvi section, a distance of 22 kilometers. Fills and culverts of the 34-kilometer Utajärvi-Vaala section were to be built to the stage where tracks could be laid the following winter as far as Vaala to permit work to begin on the Vaalansalmi bridges during 1927. Expansion of the Oulu station was to be finished and dwellings were to be constructed in Vaala to relieve the housing shortage.

Since practically all of the objectives for the year were reached already in October, the plan for the year was increased to provide employment for the labor force. The additional funds obtained for this purpose were used chiefly for bridge and housing construction. The most important and difficult of the bridge building operations undertaken during the year was the construction of the abutments for the Muhosjoki bridge. The foundations for the [redacted] three supports for the Vaalansalmi bridge were laid and laying of track was begun at the end of the year.

p 73 The Railroad Administration changed the proposed course of the line on 4 March 1927 along a length of 8.5 kilometers between Nuojua and Vaala in order to by-pass a number of crossroads [redacted] and ravines. The new course was on the south side of the Oulu-Kajaani highway and resulted also in the moving of the Nuojua station [redacted] switching point one kilometer nearer Oulu. Surveys were made during the summer and fall to determine the most suitable location for the line in respect to grades on the portion near Kivesvaara on the north side of Oulujärvi.

The program for 1928 included the completion of the Muhos-

Utajärvi section and building the Utajärvi-Vaala section to the stage that it could be used for temporary service. The abutments of the Vaala bridge were to be completed and the steel structures of both the Vaala and the Muhosjoki bridges were to be erected. Housing was to be constructed as far as Vaala and a new freight office with connecting track was to be built at the Oulu station.

Most of the plan was completed before the end of the year and a large number of workers became unemployed after the gravel was applied on the roadbed of the Muhos-Utajärvi section. The Diet, therefore, on 13 September 1928 approved additional funds in the supplementary budget appropriation for 1928 to permit extension of construction operations to the entire length of the Vaala-Kiehimä section where no work had yet been done.

Surveys had been conducted during the previous year to determine the most suitable change in the proposed route of the line in the vicinity of Kivesvaara. The survey was now completed and the Cabinet approved the selected route on 30 October 1928. The selected route departed from the course proposed earlier along a length of 30.5 kilometers beginning at the switch of the Jaalanka station spur toward Kiehimä, following the south side of Kivesvaara, the proposed course having been on the north side of the mountain (Kivesvaara). The line thus became 2,820 meters
- p 74 longer, but the total grade was reduced by 31.5 meters and a more advantageous course in respect to proximity of waterways and populated areas was obtained.

Considerable cutting and filling work and procurement of gravel and stone for culverts and bridges was done on the portion between Vaala and Kiehimä during the final quarter of the year.

Cutting and filling operations were continued between Vaala and Kiehimä during 1929 and this work was extended to the portion between Utajärvi and Vaala, where it was carried to completion. Approximately 150,000 cubic meters of fill were removed from the Kankari and Vuokatti gravel pits for this purpose. The abutments for several bridges were completed, including those for the bridge over the Kiehimänjoki having a length of 84.0 meters. Rails were laid from Vaala to a point between Liminpuro and Kivesjärvi and 215,000 cubic meters of fill from the Kankari gravel pit were applied on the Utajärvi-Kankari section of line. The spurs to the harbors at Kivesjärvi and Kiehimä were completed and erection of the spans of the Vaalansalmi bridges begun in October 1928/was completed in April 1929. Housing construction at Vaala was finished and this work was extended to the Vaala-Kiehimä section.

During 1930, the final year of construction activities on this line, cutting and filling operations were done on the Vaala-Kiehimä section and even more extensively as winter operations between Kivesjärvi and Melalahti. Extra fill was transported by train from Kankari and Vuokatti mainly to the sinking fills on the bogs between Liminpuro and Kivesjärvi and also to the large fills/at either end of the bridge over the Kiehimänjoki. The steel members of the bridge over the Kiehimänjoki were erected in the spring and tracks were laid on the remainder of the line. A total of 500,000 cubic meters of fill and roadbed gravel was transported to the Vaala-Kiehimä section from the Kankari and Vuokatti pits. All of the housing for the Kankari-Kiehimä section was constructed and a switchyard was built at the Oulu station.

Numerous bridges were constructed on this line, some of which merit special mention. The Petaisenkoski bridge of the Kajaani-Kontiomäki section is a three-pier, concrete arch bridge, 50 meters in length. The Tenetinsalmi cantilever and panel bridges with spans of 60.0 and 22.2 meters at Sotkamo are the most notable of those on the Kiehimä-Nurmes section. The bridge over the Muhosjoki on the Oulu-Kiehimä section with panel and cantilever spans of 16.0 and 40.0 meters required much work for the laying of the foundations owing to the unfavorable terrain. The Vaalansalmi bridge over the Oulujoki with spans of 21.0, 60.0, 60.0, and 21.0 meters, and the cantilever bridge of 84.0 meters over the Kiehimänjoki are among the largest bridge structures in the country. The single lanes of the Vaalansalmi and the Kiehimänjoki bridges are also used to carry the traffic of the Oulu-Kajaani highway so that ferries are no longer necessary.

Construction of many buildings was necessary along a line of this length. In addition to the stations, way stations, and freight warehouses constructed at traffic points, 46 housing structures, 8 watchman's shelters, 2 overnight lodging houses, one restaurant (at Kontiomäki), 3 engine houses (a total of 7 stalls), 9 water towers were built, and the Oulu and Nurmes engine houses were both expanded to accommodate two more locomotives each. The expansion operations at the Oulu station included the construction also of a new freight warehouse and an administrative building.

p 75 The tracks of the Kajaani-Kontiomäki line were laid during 1922, as mentioned earlier, and the line was placed into temporary use at the beginning of 1923. Work on the Kiehimä-Nurmes line advanced sufficiently during 1925 to permit the laying of 5 kilometers of track from Kontiomäki toward Kiehimä and also from Kontiomäki to the Tenetinvirta. Tracks were laid during the following year on the remainder of the line between Kontiomäki and Kiehimä, and from the Tenetinvirta onward to a point beyond Vuokatti, as well as on the Sotkamo harbor spur. Tracks were laid during 1927 as far as the Kokkojoki and in the autumn of 1928 tracks were laid on the remainder of the section from Kokkojoki to Nurmes.

Laying of track was begun on the Oulu-Kiehimä section on 15 September 1926 from Oulu and reached the Muhos station on 1 December

1926. Tracks were laid in 1927 up to the Sotka way station and 40 kilometers of track were laid during 1928 from this point onward without interruption to the Vaalansalmi which was reached on 24 February 1928. After the completion of the Vaalansalmi bridge early in 1929, laying of track was resumed at the beginning of April to the Vaala station and from that point onward to the Kankari gravil pit and way station. This work was continued on 23 October, reaching to a point between Liminpuro and Kivesjärvi at the end of 1929. The work was carried on during 1930 as the fills were completed along the route and ended on 4 June at the Heinijoki bridge located between Melalahti and Kiehimä meeting the track laying operations begun from Kiehimä in May toward Vaala.

The Kiehimä-Vuokatti section was the first of the portion of line between Kiehimä and Nurmes to be placed into temporary service, on 16 Octo-
p 76 ber 1926, followed by the Vuokatti-Saviaho section on 23 January 1928, the Saviaho-Rumo section on 1 February 1929, and finally by the Rumo-Nurmes section on 1 March 1929. The Oulu-Muhos section of the Oulu end of the line was put into temporary service on 1 November 1927. The final application of gravel was completed on the Muhos-Utajärvi section, which was put into temporary service on 1 December 1928 and after the final inspection was connected to the completed sections between Oulu and Utajärvi on 3 December. The Utajärvi-Vaala section, 34 kilometers in length, was completed and opened to traffic on 16 October 1929 and joined to the network. Most of the construction operations of the Vaala-Kiehima section were completed early in October 1930 and the final inspection took place on 10 October. Completion of the construction of the Oulu-Nurmes line was observed with a celebration on 29 November and the entire line was opened for traffic on 1 December 1930.

The constructed lengths of the sections of the Oulu-Nurmes and the Kajaani-Kontiomäki line are as follows:

| | | |
|---|---|---|
| Oulu-Kiehimä section | 150.407 kilometers | |
| Kiehimä-Nurmes section | 123.700 | 274.107 kilometers |
| Kontiomäki-Kajaani branch | 25.296 | |
| Sotkamo branch | 5.712 | 31.008 |
| Total | | 305.115 kilometers |

In addition to the above, the following side tracks and spurs were built: Kivesjärvi harbor spur, 0.635 kilometers; Kiehimä harbor spur, 1.658 kilometers; Jormua harbor spur, 0.960 kilometers; other side tracks and borrow pit spurs.

The smallest radius of curvature on open tracks is 850 meters on the Oulu-Kiehimä section (radii of 400 meters and 500 meters exist at the Oulu yard and the approach curve at Kiehimä is 500 meters); the smallest radius on the Kiehimä-Nurmes section is 600 meters (the approach curves of the Tenetinvirta bridge and the Nurmes station are 500 meters); the smallest on the Kajaani-Kontiomäki section is 700 meters (the approach curve of the Petäisenkoski bridge is 500 meters); the smallest on the Sotkamo branch line is 400 meters (the initial curve at Vuokatti has a radius of 300 meters). The smallest curvature radii of the Kivesjärvi and Kiehimä harbor spurs are 300 meters.

The largest gradient on the Oulu-Nurmes section is 0.010 and the largest on the Kajaani-Kontiomäki section is 0.012. The Kivesvaara harbor spur has a gradient of 0.015 on a 300-meter curve.

The rail weights used on the main tracks are as follows:

| | | | |
|---|---|---|---|
| Oulu-Muhos section | 22.343 kilograms per meter | 34.9 kilometers | |
| Muhos-Meteli section | 30.0 | | 115.5 kilometers |
| Meteli-Puukari section | 22.343 | 89.5 | |
| Puukari-Nurmes section | 30.0 | | 34.2 |
| Kajaani-Kontiomäki section | 22.343 | 25.3 | |
| Vuokatti-Sotkamo section | 22.343 | 5.7 | |
| Totals | | 155.4 | 149.7 |

The 22.343 kilogram per meter weight was used on the harbor spurs and rails of both weights were used on the side tracks.

A total of 270,365,452.86 marks were expended in the construction of the Oulu-Kajaani-Nurmes line, of which 129,210,873.16 marks was used on the Oulu-Kiehimä section and 141,154,579.70 marks on
p 77 the other sections. The cost of construction per kilometer of track of the Oulu-Kiehimä section was 859,075 marks and 912,394 marks per kilometer on the Kiehimä-Kajaani-Sotkamo-Nurmes portion, averaging 886,110 marks per kilometer on the entire line.

The average number of workers employed each year on wages and on contract basis is revealed in the following table:

| | Wage Laborers | | Contract Workers | | Total |
|---|---|---|---|---|---|
| Year | Men | Men with Horses | Men | Men with Horses | |
| | | (Kiehimä-Kajaani-Nurmes section) | | | |
| 1919 | 57 | 3 | 242 | 30 | 332 |
| 1920 | 30 | 2 | 217 | 33 | 282 |
| 1921 | 38 | 1 | 223 | 36 | 298 |
| 1922 | 47 | 1 | 331 | 58 | 437 |
| 1923 | 102 | 1 | 251 | 28 | 382 |
| 1924 | 11 | 1 | 261 | 51 | 324 |
| 1925 | 39 | - | 652 | 195 | 886 |
| 1926 | 88 | 2 | 658 | 116 | 864 |
| 1927 | 168 | 2 | 476 | 117 | 763 |
| 1928 | 222 | 2 | 470 | 177 | 871 |
| 1929 | 164 | 1 | 221 | 12 | 398 |
| | | (Oulu-Kiehimä section) | | | |
| 1926 | 116 | 3 | 339 | 87 | 545 |
| 1927 | 298 | 10 | 523 | 82 | 913 |
| 1928 | 256 | 8 | 539 | 46 | 849 |
| 1929 | 240 | 8 | 717 | 203 | 1,168 |
| 1930 | 152 | 5 | 451 | 46 | 654 |

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Cross-sections of Roadbeds

Cuts and fills have been made to conform to the cross-sections specified in 1909 and 1924 for standard gauge railroads and to the amendments adopted in 1936 (Figs 103-105). The dimensions of the cross-sections specified in 1909 and 1924 are given as follows:

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| For earth cuts | 1909 | 1924 |
|---|---|---|
| Width of cut at grade level (meters) | 9.00 | 8.70 |
| Width of cut at outer edge of ditch bottom | 7.60 | 7.30 |
| Width of cut at inner edge of ditch bottom | 6.40 | 6.30 |
| Width of bottom of cut ditch | 0.60 | 0.50 |
| Depth of cut ditch below grade level | 0.47 | 0.47 |
| Slope of cut ditch walls | 1:1.5 | 1:1.5 |
| Slope of crown at bottom of cut | 1:20 | 1:16 |
| Width of gravel ballast shoulder at upper surface of tie | 3.50 | 3.40 |
| Thickness of gravel ballast at center line in sand cuts | 0.50 | 0.50 |
| Thickness of gravel ballast at center line in clay cuts | 0.80 | 0.50 |
| For rock cuts | | |
| Width of cut at grade level | 5.70 | 5.36 |
| Width of cut at outer edge of ditch bottom | 5.51 | 5.20 |
| Width of cut at inner edge of ditch bottom | 4.91 | 4.40 |
| Width of bottom of cut ditch | 0.30 | 0.40 |
| Depth of cut ditch below grade level | 0.47 | 0.40 |
| Slope of cut ditch walls | 1:1/5 | 1:1/5 |
| Slope of crown at bottom of cut | 1:20 | 1:6.5 |
| Distance between outer surfaces of ballast-retaining curbstones | 4.70 | 4.40 |
| Height of top of ballast-retaining curbstones above grade level | 0.50 | 0.50 |
| Thickness of gravel ballast at center line | 0.50 | 0.50 |

For roadbed fills

| | | |
|---|---|---|
| Width of fill at grade level | 5.70 | 5.40 |
| Slope of ~~fillxxxxxx~~ sides of fill | 1:1.5 | 1:1.5 |
| Slope of crown of fill | 1:19 | 1:16 |
| Width of ballast at upper surface of tie | 3.50 | 3.40 |
| Thickness of ballast at center line | 0.50 | 0.50 |
| For ditches | | |
| Average depth of ditches | 0.60 | 0.60 |
| Width of bottom | 0.50 | 0.60 |
| Slope of ditch wall | 1:1.5 | 1:1.5 |
| Distance between ditch and fill or cut | 1.50 | Must be computed in each case |

The depth of earth cuts in clay soil was increased by 0.3 meters in the specifications of 1909, the thickness of the gravel ballast being increased by the same amount. This feature was not observed in the specifications of 1924, but the following precautions were adopted in 1928 to minimize the ~~xf~~ heaving effects of ground frost:
p 170 (1) all underlying surface stones must be removed from the sites of roadbed fills 1.3 meters or less in thickness, to a width of the bottom of the fill, (2) where different types of earth fill are employed in a roadbed, these must be spread in uniform layers and not allowed to remain in heaps as formerly, (3) stones at the bottom of earth cuts must be removed and their cavities must be filled with material from the cut, (4) cuts and their ditches, with the exception of those made in gravel soils, must begin 10 centimeters below grade level and must rise in a distance of 30 meters to the normal levels; a similar rise must be made in fills which do not consist of gravel and are not laid on a gravel base, when progressing to a higher fill, (5) bottoms of cuts and top surfaces of fills must be levelled to the specified cross-section with material taken from cut, before application of gravel ballast; any depressions made by ties must be similarly filled, (6) gravel with clay mixture, or

gravel contaminated with clay during operations, must not be used as ballast, (7) except in tunnels, the gravel ballast must be applied to a thickness of 60 centimeters measured from the upper surface of tie.

Measures taken to overcome sinking and spreading of roadbed in unfirm terrain include decreasing weight of fill, locating ditches farther than normal from roadbed, construction of counterweight fills, removal by blasting of soft material, driving piles, laying a bed of brush, and relocation of route.

Tunnels

Three tunnels have been built since 1912: the Pönttövuori tunnel measuring 1,223 meters on the Jyväskylä-Pieksämäki line between the Metsolahti and Leppälahti stations, the Möykynmäki tunnel measuring 360 meters located to the east of the Vasanka station on the Haapamäki-Jyväskylä line, and the Halikko tunnel measuring 110 meters located west of the Halikko station on the Karjaa-Turku line. The cross-section illustrated in Figure 106 was employed in the Pönttövuori and Möykynmäki tunnels and that illustrated in Figure 107 was employed in the Halikko tunnel. A chamber 2.0 meters deep, 4.0 meters long, and 3.0 meters high is located at the center of the tunnel in addition to the recesses cut as refuges for track workers 50 meters apart on alternate sides of the tunnel and measuring 0.5 meters in depth, 0.7 meters long, and 2.0 meters in height. The tunnels are cut into solid rock and therefore do not require reinforcing arches.

p 171 Few tunnels have been constructed on the Finnish railroads since the terrain seldom requires tunnelling. Among tunnels planned but not cut two are worthy of mention here: that on the Pori-Haapamäki line to Virrat and that on the Varkaus-Viinijärvi line to Leppavirta. The first of these was abandoned when it was discovered that more fill was needed on the line than could have been obtained in cutting the tunnel.

p 172 **Ties**

Railroad ties are to be cut either from healthy growing pine trees or from barkless standing dead pine which show no indication of rot or blue stain. Trees for ties must be felled during the period 1 November - 1 March. The regulations of 1913 specified two types of railroad ties, one for heavy tracks and the other for light tracks. The heavy tie had the following specifications: length, 2.75 meters; diameter at thinner end, 250 millimeters; thickness between hewed surfaces, 160 millimeters; minimum width of hewed surfaces, 140 millimeters. The specifications for the light tie were: length, 2.50 meters; diameter at thinner end, 225 millimeters; thickness between hewed surfaces, 150 millimeters; minimum width of hewed surfaces, 130 millimeters. Only one type of tie has been employed since 1925, which has the following specifications: length, 2.70 meters; minimum diameter at thinner end, 225 millimeters; thickness between hewed surfaces, 160 millimeters; minimum width of hewed surfaces, 150 millimeters. Purchase of undersize ties with diameters less than 225 millimeters at thinner end, but not less than 200 millimeters, was authorized up to 10 percent of total procurement.

p 174 Three grades of railroad ties were approved for use in the procurement regulations adopted in June 1936. These have thin end diameters of 250, 220, and 200 millimeters; procurement of the smallest grade may not exceed 10 percent of total procurement. Thickness between squared surfaces is 160 millimeters in all grades and the minimum width of squared surface in the first two grades is 150 millimeters and 120 millimeters in the third grade. Unidirectional curvature up to 15 centimeters is permitted. These regulations specify that the trees must be felled between 1 October and 1 April (1 May in the area north of Oulu).

Placement of ties and other data are given in the table on page 174.

p 284 **Design and Maintenance of Bridges**

The Finnish State Railroad network of approximately 5,500 kilometers contains over 2,000 bridge crossings containing 1,990 steel spans, of which 215 are of cantilever construction with a combined length of 7,500 meters and 1,775 panel spans with a combined length of 11,100 meters. The amount of railroad line that is laid on bridges is therefore 18,600 meters, or 0.36 percent of the total network. The number of masonry and concrete bridges is approximately the same as that of steel construction, but the number of span crossings is considerably greater since these bridges often carry several tracks. Uncertainty also exists in the measurement of the length of masonry and concrete bridges, since, in the case of steel bridges the distance between abutments is taken as the length. The longest bridge spans in Finland are 125 meters in the cantilever bridges over the Isohaara of the Kymijoki and the Kyrönsalmi at Savonlinna. The longest Finnish bridges, however, are the Jyränkö bridge at Heinola (360 meters) and the Ounaskoski bridge at Rovaniemi (340 meters), each of which have several spans.

The total value of all railroad bridges was appraised at 397,604,935.00 marks as of 31 December 1935 and the turntables, which in many cases are thought of as bridges, were appraised at 25,541,762.00 marks. The cost of bridge construction on the newer lines approaches one-fifth of the total construction cost of the line. Bridge construction costs have been exceptionally high on those lines which
p 285 cross waterways, such as the Rovaniemi-Kemijärvi line where this item accounted for 25.8 percent of the cost. The expenditure for bridge construction on the Lahti-Heinola line was 25.2 percent of the total cost. The lowest bridge construction expenditure was on the Iisalmi-Ylivieska line where it was 10.5 percent of the total cost. The total fixed property valuation of bridges amounts to

9.8 percent of the overall fixed property valuation of the railroads.

A capital investment of this magnitude necessitates a centralized and controlled program of construction and maintenance. A special department for the designing, planning, construction, and maintenance of railroad, highway, street, and pedestrian bridges was formed from the various railroad offices in the reorganization of the Administration of the State Railroads, which took place after Finnish independence. In the course of its operations this office (known as the Bridge Construction Section of the Technical Rail Office since 1933) has, in addition to its regular duties, drawn up necessary regulations for its own use as well as for general railroad operation. The loading and computation regulations adopted for bridges in 1926 and the new
p 286 standards set for the manufacture, assembly, and procurement of steel members for bridges and buildings, also adopted in 1926, are results of the efforts of this office. These regulations have also been adopted as general directives by the engineers of the country in all fields.

The maintenance and supervision of bridges had been dependent upon irregular inspections until these regulations were issued in 1927. These regulations specify annual inspection of all bridges by the chief of each line, the results of which must be recorded in a "bridge book." A general or main inspection of all the bridges of a line must be carried out approximately every seven years by the chief of the line together with a bridge engineer of the Bridge Construction Section and a complete record and report must be prepared.

The main inspections have revealed that painting of bridges has frequently been deficient. Lack of funds, low quality of paints, and inadequate technical assistance were the chief reasons for the shortcoming. Regulations for the painting of bridges and other steel structures of the railroads as well as quality and procurement standards for paints were issued in 1934. Replacement of bridges as a result of rusting has never been necessary on Finnish railroads, however. Frequent replacement of bridges has been necessary owing to the unpredictably rapid increase in the weight of trains.

The lifetime of the spans of large bridges is dependent upon the amount of maintenance, and more specifically, upon the extent to which rusting can be prevented.

p 287

## RAILROAD YARDS

### General Plan of Yards

The futility of attempting to meet the growing traffic demands of large stations temporarily by the piecemeal installation of less expensive facilities became apparent even in Finland at the close of the 50-year period of railroad history of the country. A program of long-time planning ~~wasztherefore~~ in the reconstruction of yards was therefore begun early in 1900. Facilities of the current period bear evidence of the planning and construction program undertaken at that time.

Both the regular and the wayside stations of the network have, almost without exception, fairly modest beginnings. Experience gained during earlier decades of growth of smaller railroad yards has furnished the basis for a standard plan (Figure 208) for small yards which provides possibilities for future expansion. Observation of worldwide developments in yard technology has been necessary, on the other hand, in redesigning the larger railroad yards.

The importance of the railroad network as a medium of transportation to the country is demonstrated by the extent of the system and the importance of the stations is indicated by the total length of branch lines. A knowledge of these two factors and their relationship to one another is therefore necessary in order to gain an understanding of the development of the railroad system throughout the years. During the period 1905-30 the percentage of branch lines of the Swedish state railroads varied from 25.04 percent to 37.20 percent and 35.66 percent, the corresponding figures in Finland being 27.50 percent, 36.00 percent, and 34.00 percent.

The objective in the planning of railroad yards is the satisfaction of the common requirements of both community and railroad. Fundamentally only one best solution therefore exists for each project, though in individual cases several alternatives nearly as good may be present.

The plan of a large railroad yard generally includes three different types of sections; a passenger station with service yard, a freight station, and a classification yard. The fundamental problem of the plan is to solve all three phases, at least in regard to their
p 288 locations in relation to each other. If, however, some of the details may be left for future solution, the overall plan may then be considered all the more successful.

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Passenger stations are generally permitted to remain in their original locations in the redesign plans and additional space requirements are met by utilizing former warehouse and freight station areas. The freight station must then be relocated at the outskirts of the community where space is more readily available. Since the station building has a decisive influence on the future development of the community, these are located as near as possible to the original building. Another arrangement may be necessary in larger cities, as experience in other countries indicates, where new stations have in several instances been constructed as far as a kilometer from the original station building. The new station in Viipuri was built 200 meters to the north of the old building. The proposed site for the new Helsinki station has been the subject of much controversy during the past 20 years.

p 290 Plans for new passenger stations must also take into account the need for numerous loading platforms of sufficient length and width and pedestrian underpasses or the more usual overpasses. The plans of the stations are made with this in view by placing the system of tracks either above or below street level. This also serves as a solution to the problem of streets which cross the yards.

Transfer of baggage, express goods, and mail to the proper platforms generally occurs on the same level across the tracks. When required, depending on the basic type of passenger station, the volume of traffic, and the level of the tracks, special tunnels and elevators are built for this purpose.

The service yards (Figure 209) of large-volume passenger ~~xxx~~ traffic terminal stations or branch stations where trains are made up, are quite extensive. The express goods ~~xxxxxx~~ office is located in the station itself or nearby (Figure 210).

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P 291 Since most of the business and income of the railroad system is derived from the transportation of goods much attention has been given in railroad technology during the past 25 years to the development of these facilities. The greater demands of the business world for more rapid and economical service as well as the competition offered by other modes of transportation have encouraged this development.

The yard facilities required for goods transportation are of two types: goods (freight) stations and classifications yards. The freight station is that part of the ~~xx~~ freight yard facilities in which the sender and the consignee come into contact (Figure 212). The warehouses, office, loading and unloading tracks, and other facilities are of simple construction and may vary with requirements of the volume and quality of goods and local conditions.

Partially as a result of increased competition transportation of goods by rail is undergoing new development with such innovations as refrigerated cars and pickup and delivery service. Much room for improvement still lies in this respect since the handling and loading of parcel goods still takes 57 percent of the cost of this type of service; making of trains, 15 percent, and line transportation costs 28 percent. Fortunately, parcel service accounts for only a small portion of the goods transportation activity, approximately 10 percent. Freight transportation by the carload, which amounts to 90 percent of the volume, does not require much by the way of handling facilities at stations.

In addition to the tracks provided for the loading and unloading of freight by the carload at freight yards, special sidings are built at harbors, industrial locations and elsewhere in larger towns for this purpose. Construction of similar facilities for the handling of parcel freight at various points in a city only increases the cost ~~fxx~~ of parcel transportation, but such facilities are not even necessary since the railroads are increasing their pick-up and delivery service by the use of other ~~xxx~~ means of transport.

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Little attention was given in former times to the organization of trains and these were made up of cars without regard to any order. This method required little by way of added tracks for the making of trains since the trains were made up on the main track by the use of sidings. Much time was lost, however, at intermediate stations and as the volume of traffic increased and for considerations of safety, it became necessary to separate freight and passenger facilities at stations. The systematic formation of trains was recognized as the most expeditious and economical method of handling freight and the problem became that of designing systematic and mechanized classification yards.

p 292 The two main factors in a classification yard are the track system and the motive power.

The first development in classification yards was extension of existing tracks and the construction of tracks parallel to them. Use of the main line as the assembly track was the next to pass and assembly tracks were built at either or both ends of yards. Performance of several functions on one group of tracks soon became difficult with a consequent division of functions between separate groups of tracks. The classification yard thus developed includes four groups of tracks, i.e. the approach group (Figure 211), the directional or separation group, the station group, and the departure group. In addition, tracks are required for traction, collection, shifting, transfer loading, standing, empty cars, spare cars, fuel, warehouses, and other uses. The smaller classification yards do not include all of the above tracks and groups.

When the construction of a classification yard is included in the redesigning of a traffic center the selection of type and site must be such that it becomes part of the general scheme. The selection of the locations of each group of tracks in respect to their relative elevations and grades in such a center is one of the most difficult problems which face the planner. A well-designed classification yard must be able to handle a large volume of traffic, and must have low costs for the assembling of trains, and must have ample provision for expansion. Groups of tracks are designed to fan out at various
p 294 angles (1:8.5, 1:8, 1:7.5, and 1:7).

Separation of tracks in a classification yard is standardized at 4.8 meters, or may follow the smaller pattern of 4.5 meters separation, in which case the separation of the fifth to seventh tracks may be 9.6, 9.0, or 6.0 meters. Even in yards employing the standard separation where there are numerous tracks frequent use of a 9.6-meter separation is made in order to facilitate removal of snow and to provide space for telegraph and telephone poles. At least a few of the tracks of an approach group must exceed in length the longest trains, and those of the separation group vary from 250 to 700 meters, but even here some of the tracks must be longer if trains are to depart directly from this group. Dead end tracks are sometimes employed in station groups, but the through type of 200 meters or less is more commonly used. Approach, separation, and departure tracks are always of the through type. The number of tracks in each group depends on the volume and type of traffic and the method of assembling trains.

The classification yard may be basically either one-sided or two-sided depending on whether it has one or two trunks formed from track groups. Only one main type of classification activity can be performed at a time and only in one direction on the first type, while the latter can accommodate two processes simultaneously and in opposite directions. The one-sided type is the most common and suitable to small-volume traffic. The Viipuri classification yard is of the one-side, single section type where both incoming and outgoing trains are handled over a single down-grade. In larger classification yards or when the traffic in a station [illegible] from the lines is mainly of two types or of differing volume, some arrangement of a two-sided type of yard may be appropriate. For the same reason a one-sided yard may have two sections, in which case it may have two parallel trunks operating in the same direction for classification. The Pasila classification yard is of this type with two down-grades (Figure 213). One of these is used for the formation of departing trains and the other for the separation of incoming trains. The first has two tracks of differing heights, one for use during summer and one for winter use.

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The second chief factor in a classification yard is the motive power. Locomotive power continues to be the most common form, although manpower, horsepower, and motor power are employed to some

extent for the simpler operations, especially in small installations. Shifting of cars by locomotive frequently results in damage by jarring both to the cars and their cargoes. In earlier times when cars where equipped only with manual brakes, if any, this could be avoided by a brakeman on each car during shifting, but this method required large crews. Cars not equipped with manual brakes were slowed down by
p 295 means of wooden levers and other methods. A brake shoe to be placed on the rail was soon devised and/which operated satisfactorily in the hands of an experienced brakeman.

Use of gravity as the motive power began quite early in classification yards and was fully developed by 1870.

The amount and effect of gravity power employed is used as a basis in dividing classification yards into either level or graded yards. Either gravity or locomotives may be used to furnish the ini-
p 296 tial motive force in level yards, while only gravity is used in the graded yards, in which all four groups of tracks follow one another at the same grade. In this type of yard the cars coast from the effect of gravity all the way from the approach group to the outgoing group of tracks. Favorable terrain is required for the construction of graded yards so that the necessary difference of elevation of 20 to 25 meters between the ends of the yard may be obtained with a minimum of cutting and filling. The graded yard makes full use of gravity, but because of their extreme length and other disadvantages they are suitable only large volume traffic. The level yards can be made to fit terrain and space requirements much more easily and are suited to traffic of either large or small volume. Classification yards may also be a combination of the two types.

The most important part of a classification yard is the descent grade section between the approach and the separation groups (Figure 214). A train of 60 cars can be separated in six to seven minutes in a modern classification yard. Control of the coasting movement p 297 of cars has led to the development of mechanized, remote controlled, and electrically operated brakes.

Two parallel sloping tracks of different down grades x for summer and winter use were built in classification yards during earlier times, but with the mm improved modern system of braking cars two slopes are seldom employed.

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In the redesigning of classification yards the yards are relocated to new sites outside of the communities, and in the case of large railroad hubs, they may be located dozens of kilometers away in the direction of the approaching lines. The various lines must be so arranged that freight trains may enter the approach tracks simultaneously, therefore a sufficient number of tracks must be built at different levels.

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p 307

## RAILS AND RAIL ACCESSORIES

Two new types of rails have been adopted on the Finnish State Railroads since the time of the first 50-year report; these are the rails which weigh 43.567 kilograms and 33.48 kilograms per meter. Both are Russian types; the first was adopted in 1915 on the Terijoki-Koivisto line and the second in 1916 on the Jyväskylä-Pieksämäki and the Hiitola-Raasuli lines. Procurement of rails was difficult during the war and some of the base plates, fishplates, ~~xxxxxxxxxxxxx~~ and other accessories for the rails weighing 33.48 kg/m were obtained from the United States.

The 43.567 kg/m rail and joint are illustrated in Figure 220 as employed on the Terijoki-Koivisto line. The greater portion of these were removed in 1920 and installed on the Helsinki-Riihimäki line, 30 kg/m rail being to replace them on the Terijoki-Koivisto line.

A shorter, four-hole type of fishplate was adopted in 1919 to

replace the six-hole type owing to the cost element and the debatable efficiency x of the end bolts. The new fishplate is illustrated in
p 308 Figure 221. This type was standard until 1935 when the straight fishplate used with the wedge-shaped bearing plate was introduced.

The standard length of the 43.567 kg/m rail was originally 12 meters, but was increased in 1933 to 18 meters. Longitudinal movement of the shorter rails was prevented only by the edges of the fishplates bent downwardx against the bearing plates, "traveling" of the longer rails could not thus be prevented and rail slippage brakes were introduced (Figures 222 and 223). Even these have not been fully satisfactory since they tend to x sink into the wooden ties and to loosen. The wedge-shaped bearing plates were therefore adopted in 1935, produced in Belgium by the Ougree-Marihaye factory (Figure 224). During the short time they have been x in use they have proved fully satisfactory under all conditions, permitting the use of smaller joint spaces and xxx of longer rails (30 to 40 meters).

Another type of rail introduced from Russia, the 33.48 kg/m rail, is illustrated in Figure 225 with its bearing plate, xxx fishplate,
p 309 bolts and spikes. This rail was not generally adopted and xx none have been procured since the completion of the Jyväskylä-Pieksämäki line was completed owing to the fact that the joint assembly is expensive and the weight is too near that of the 30 kg/m rail, which continues to remain as the main type in use in the country. Only two changes have been made in the joint assembly of this rail. In 1916 (Figure 226) the spacing of the holes of the fishplate were changed from the 150 x 150 x 150 millimeter pattern to 170 x 110 x 170 millimeters, but this proved unsatisfactory. Consequently, a new broad base fishplate was adopted in 1924 (Figure 227) having the same spacing of holes as the 1916 fishplate, but much heavier. The resistive xxx moment of the 1924 fishplate is represented by its volume of 36.4 cubic centimeters as compared to the volume of 29.81 cubic centimeters

of the former type. The new size of plate has proved satisfactory.

Other changes in the accessories of the 30 kg/m rail include a larger bearing plate (Figure 227) and minor changes in the bolts and
p 310 spikes. Spikes now in use are illustrated in Figure 228.

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Economic development has led to the use of faster, larger, and heavier trains and locomotives which in turn demand heavier rails. The lighter Finnish rails weighing 22.343 kg/m and 25 kg/m are steadily giving way to the 30 kg/m rails and these to the 43.567 kg/m rails. The following table giving the number of kilometers of track of each type of rail indicates the trend during the period 1925-1935:

| | Steel Rails | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Year | 22.343 kg/m | 25 kg/m | 30 kg/m | 33.48 kg/m | 43.567 kg/m | Other Types | Iron Rails | Total |
| 1925 | 1,615 | 731 | 3,049 | 301 | 355 | 17 | 52 | 6,120 |
| 1930 | 1,371 | 727 | 3,929 | 362 | 547 | 14 | 33 | 6,983 |
| 1931 | 1,333 | 727 | 3,945 | 362 | 588 | 15 | 27 | 6,997 |
| 1932 | 1,271 | 704 | 4,164 | 362 | 572 | 18 | 20 | 7,111 |
| 1933 | 1,267 | 735 | 4,214 | 361 | 621 | 16 | 20 | 7,234 |
| 1934 | 1,216 | 734 | 4,430 | 360 | 641 | 16 | 18 | 7,415 |
| 1935 | 1,187 | 733 | 4,509 | 359 | 674 | 16 | 18 | 7,496 |

Replacement of the 22.343 kg/m rails of the Vaasa line with 30 kg/m rails was completed in 1910. The light rails were still in use at that time on the Pori, Oulu, and Savo lines and the greater portion of the Karelia line. Replacement of ~~xxtix~~ the light rails with 30 kg/m rails was then already in progress on the Karelia line and was continued slowly even during World War I and reached as far as Joensuu by the end of 1932. Light rails of 25 kg/m are still in use on the Joensuu-Nurmes portion of the line.

Replacement of the rails of the Oulu line with 30 kg/m rails was begun ~~x~~ in 1923 and has progressed as far as Oulu. The rails north of Oulu are 25 kg/m, except for a portion of the Tornio-Kauliranta line which has mixed types, and the Rovaniemi-Kemijärvi line which has, as do many of the lines built after World War I, 30 kg/m rails.

Replacement of rails on the Savo line was begun in 1923 and had reached the 494-kilometer post near Pöljä at the end of 1935. The Iisalmi-Ylivieska, Kajaani-Kiehimä-Puukari, and the Oulu-Muhos lines

p 311 are still equipped with 22.343 kg/m rails which removed from older lines and installed on these lines.

The 43.567 kg/m rail has been used since 1920 on Finnish railroads to replace lighter rails. Replacement of the Helsinki-Rajajoki line was begun that year and is completed as far as Viipuri with the exception of the other track of the line between Uusikylä and Koria which still has 33.48 kg/m rails. The Helsinki-Turku line has been in process of conversion to the 43.567 kg/m rails since 1927, the distance between Pasila and Tähtelä being completed by the end of 1935. Short sections beyond Tähtelä have also been converted. Portions of the Riihimäki-Tampere line were converted from the 30 kg/m rails already during World War I, and a systematic reconversion to 43.567 kg/m rails was begun in 1929. At the end of 1935 only 5 kilometers of the line remained unconverted, the remainder to be completed during 1936.

The specifications of 1935 for steel rails require a minimum tensile strength of 75 kilograms per square millimeter of cross-section with a distortion of 11 percent. The quality factor (tensile strength multiplied by distortion) must be at least 900. In the hardness test (in which a steel ball with a diameter of 19 millimeters is pressed with a force of 50 tons for one minute against the end of a rail) the depression must not exceed 4 millimeters. In the impact test the rail must be able to withstand the blows of a freely falling 1,000-kilogram as the bend in a rail reaches 100 millimeters. The blows are applied

to a piece of rail 1.2 meters long resting on supports a meter apart.
p 312 The height of fall of the first blow must be at least 3 meters and 1.5 meters in ~~the~~ successive blows for the 43.567 kg/m rail and 1.2 meters for the 30 kg/m rails. A new test is that of the transverse bending of the foot of the rail (Figure 229) in which bending before failure must be at least 2.17 millimeters for the 30 kg/m rail between supports 85 millimeters apart under the foot, and at least 3.0 millimeters for the 43.567 kg/m rail between supports 100 millimeters apart.

The manufacturer must furnish a complete chemical analysis of each heat to the inspector of the State Railroads. At least one impact and steel ball test must be made of each heat and any number of tensile strength and transverse tests that the inspector may require.

The phosphor content of the steel used for fishplates and bearing plates must not exceed 0.06 percent (same as for rails) and the tensile strength of the fishplates must be at least 44 kg/sq millimeter and of the bearing plates ~~at~~ 42 to 52 kg/sq millimeter. The fishplate must withstand a bend of 90 degrees before failure, the bearing plate 60 degrees likewise.

p 313

## SWITCHES AND CROSSINGS

The Model A curved tongue switch made from 30 kg/m rails was adopted by the Finnish State Railroads in 1912. In addition to the simple switches, both "half British" and "full British" as well as double tongue (duplex) switches have been made. To date only double type tongue double switches which are generally used in yards, as are the British types, have been produced.

The crossing, or frog, is fastened either with rivets or with bolts and clamp plates to a long base (switch) plate, 12 millimeters thick. The flangeway between wing rail and point of frog has been increased from 49 millimeters to 50 millimeters. Guard rails were formerly made from a section of rail 2.7 meters long, are now made from an angle iron 3.3 meters long and 20 millimeters thick and 40 millimeters higher than the rail and is attached to the rail by means of fillers and bolts.

The simple Model A switch is approximately 27 meters long and has a radius of curvature of 236 meters.

The Model B switch was adopted in 1914. The design of these is the same as of those used prior to 1912 but having the flangeways of the Model A switch. The crossing is has the same design as the Model A but is riveted to four frog plates. The guard rail is 3 meters long and is made of standard rail. The slide plates were made at first of cast iron, but since 1925 they have been made of cast steel. This factor has brought the cost of production nearly to that of the Model A switch and production of Model B switches was therefore discontinued. Nor are new switches made any longer from the 25
p 314 kg/m and 22.343 kg/m rails since they do not withstand modern traffic and all are gradually being replaced by the Model A switch.

The crossing angle of switches is 6 degrees. Since an angle of this size reduces the useful length of tracks in a large yard a crossing ratio of 1:7, equivalent to an angle of $8^{\circ}7'48''$, was adopted in 1925. Various types of Model C switches have been made using this angle. The simple Model C switch employs the tongue assembly of the 6-degree Model A. The crossing, however, departs from the standard type in that one side is curved since the curve of the switch passes through the crossing. The radius of curvature of the switch is 185 meters and the total length is about 26 meters.

During World War I when procurement of rails was difficult, rails and complete switches were obtained from Russia. Simple switches made from Russian Model Ia and Model IIIa rails were imported in 1915 which had crossing ratios of 1:11 and 1:9. Enough of the Model IIIa rails and switches were imported to furnish the tracks of the Jyväskylä-Pieksämäki line and for use elsewhere. Production of simple, British, and double twin switches of Model A2 with crossing angles of 6 degrees and 8°7'48" was begun at the Viipuri machine shop in 1922 from rails similar to the Russian Model Ia weighing 43.567 kg/m which are imported annually from France and Belgium. They are similar in structure to those made from the 30 kg/m rails except that the tongues are made longer (Figure 231), 6.14 meters in the simple switch and 5.5 meters in the British type. The guard rail is 4 meters long and is made from 20-millimeter angle iron which is 20 millimeters higher than the rails. The radius of curvature of the simple switch is 231 meters and the total length of switch is about 29 meters.

Owing to the rapid wear of the wing rails and the switch points themselves, switches are now being made with the point cast of manganese steel and manganese steel inserts are attached with bolts to those parts of the wing rail which support the wheels. Experiments in the hardening of wing rails and points by tempering have also been conducted, but results based on experience are still inconclusive.

Production of simple switches of the spring tongue construction from rails of 43.567 kg/m weight was begun in 1934. The tongue is longer than that of the standard type by half a length and is rigidly fastened at the base end to a long tie plate, the base being made narrower near the point of attachment to permit the tongue to bend
p 315 during switching, thus obviating the use of the common turnpin assembly (Figures 232 and 233). The crossing angle is 3°48'52" (1:15) and the radius of switch curvature is 530 meters. The total length of the switch (Figure 232) is approximately 43 meters. The crossing is 9 meters long and of straight design and is attached by means of bolts and clamping plates to a frog plate 5 meters long. The point

is of manganese steel and the wing rails have manganese steel inserts. The guard rail, 6.3 meters long, is made from 20-millimeter angle stock.

The large radius of curvature and heavier construction of these switches permit trains to pass over them at 65 kilometers per hour, which is the maximum permissable speed of non-stopping trains through stations.

Production costs of switches have varied considerably with the
p 316 costs of materials. The following table gives an indication of the installed costs in marks of Model A and Model A2 switches in 1925:

| | Made of 43.567 kg/m rails | Made of 30 kg/m rails |
|---|---|---|
| Simple switch | 26,000 | 17,500 |
| Simple crossing switch ("half British") | 53,000 | 37,500 |
| Double crossing switch ("full British) | 70,500 | 50,500 |
| Double twin switch | 51,000 | 33,500 |

The production costs were considerably greater in 1934; cost of the spring tongue switch was approximately 55,000 marks.

Various types of switch stands are in use on the Finnish State Railroads. The type in which the weight is attached to the throwing lever in such manner that it may be shifted has been in use since 1911. The switch stand known as the Norwegian type is used in addition to the oldest, the Bender stand, in stations handling a small amount of traffic.

The switch stand illustrated in Figure 234 has been employed since 1922, in which the connecting rod may be moved a distance of 250 millimeters and is therefore especially suitable for use with a switch locking device. A sliding bolt lock plate may be attached to the base of the stand to which the safety lock on the throwing lever is fastened, permitting positive locking of the switch in the desired position.

p 317

## SIGNALS AND SAFETY DEVICES

Approved methods and signaling devices have been employed for guiding railroad traffic since the beginning of the State Railroad system.

Signal regulations issued in 1870, 1885, 1896, and 1903 have been in force on the Finnish railroads at various times. The 1903 regulations with minor changes and additions, and although already somewhat antiquated, is still in force; a new set of regulations is in process of preparation.

The signals and signaling devices covered in this discussion are of the type specified in the 1903 regulations as modified by directives of the Railroad Administration dated 18 February 1908 and 7 May 1912. The first directive was concerned with semaphores for double crossing switches (full British type) and the second specified that the arm of the semaphore must point upward at 45 degrees ("at 10 o'clock"), rather than downward as heretofore, to signal clear passage. The signal regulations of 1903 and imported safety systems provided a new basis for the development of signals and safety devices. The development reached in the period to 1913 is indicated in the semaphores illustrated in Figures 235, 236, and 237. The semaphores (total of 60 in use) of that year were generally of the one-arm type constructed of wood and operated by a single control rod, but there were about ten of the double-arm type and one with three arms made of steel (located at the south approach of the Seinäjoki station).

The prerequisite for the use of semaphores with several arms was the integration of all control mechanisms into a standard system, or otherwise stated, that the station must be equipped with a signaling and switching safety system. Two mechanical types of interlocking machines, the crank type and the lever type (Figures 238 and 239), were in use at that time. In all, four lever type interlocking machines with

centralised switching were in use, two at Pasila and two at Viipuri. In all, six of the crank type machines for the centralised interlocking of swit-
p 318 ches were in use, namely at Helsinki south, Seinäjoki south and north, Pitäjänmäki, Kauniainen (Grankulla), and Espoo. The following turn-bridges were equipped with signaling and interlocking machines: three near Kuopio, the Kirkkosaari bridge in Viipuri, the Särkisalmi, Punkasalmi, Tuunaansalmi, and the Kyrönsalmi bridges on the Savonlinna-Elisenvaara line, and the Joensuu, Uimaharju, and Lieksä bridges on the Joensuu-Nurmes line.

Electrical blocking systems were put into use on 17 February 1913 between all stations of the Helsinki-Espoo line and station safety
p 319 devices were installed at Helsinki and Pasila. These safety devices prevent the routing of trains head-on or in the same direction on one block section. Electrical blocking devices were installed between all of the stations near Viipuri in 1915.

Only gates, either guarded or unguarded by a watchman, were generally provided as safety features at highway crossings at that time. Only 12 barriers of the boom type were in use, the largest across the Linnakatu in Turku which formed a barrier 69 meters long over this street. A few electrically operated bells for the warning of gate watchmen of approaching trains were in use.

### SEMAPHORES

### Visible or Optical Signals

The use of semaphores of wood construction as principal semaphores increased considerably in the period 1914-1918 as the result of the great volume of through traffic of the wartime years (see curves of graph, Figure 240). A portion of these became superfluous with the return of normal conditions and were removed. The number of wooden semaphores continued to decrease with the installation of safety switching and signaling equipment with steel semaphores at stations. The wooden semaphores (Figure 241), of which there are approximately 30 still in use, were similar to those of steel construction in that the semaphore arm is actuated by a wheel at ground level, which in turn is actuated by the semaphore crank and a pair of cables. The greatest distance from which these semaphores could be operated was only about 500 meters and a very simple suspension tightener without a support pole (or rod) was employed.

The graph (Figure 240) depicting the employment of the various types of semaphores indicates that/the use of the twO-arm type has increased more rapidly than of the three-arm type since 1930. This development represents the adoption of a new system. The two-arm approach semaphore is now used when the service tracks all separate to the same side from the main track and the tree-arm type (Figure 242) is used only

p 320 when the service tracks separate to both sides of the main track and in other special cases. The tree-arm approach semaphores are replaced by the two-arm type whenever safety systems are being replaced, especially when the change results in a simpler and more economical installation. There are currently in use 145 of the one-arm type, 207 of the two-arm type, and 61 of the three-arm type steel semaphores.

The use of light signals as principal semaphores has increased considerably during recent years, especially in installations of electrical interlocking and automatic blocking devices, to replace the arm /type of semaphore. A single two-light signal and a single three-light departure signal, which give light indications during night and day of signals corresponding to those of the two and three-arm types, installed in 1921 at Riihimäki, were the first of this type used in Finland. At the end of 1936 there were 40 light signals in use as principal semaphores (Figure 243), of which about 20 were of the one-light type, i.e. which give the "go ahead" signal with one green light only. Since the light signals currently in use

are not provided with rear lights, it is generally necessary to indi-
p 321 cate their positions (aspects) at the point of control. The same is
now generally true for the semaphores when the semaphore is not visi-
ble from the point of control or the observation point.

*

The rapid increase in the speed of trains soon necessitated the use of distant signals a sufficient braking distance from the main (or home) signal, especially where the visibility of semaphores was unsatisfactory. The first distant signal was installed in 1904 and was of the oil-burning disk type. The number of distant signals increased rapidly in the installation of switching and signaling systems during World War I, but the growth has been somewhat slower thereafter (see curves of graph, Figure 240).

p 322 The first AGA distant signal of the disk type and equip-
ped with a blinker light was put into use in 1912. When the efficiency, safety, and visibility of the AGA signal became a demonstrated fact, it was decided that all of the most important disk type signals would be eventually equipped with blinker lights (Figure 244). Blinker lights were installed in 34 distant disk signals in 1917, and in 1934, when there were 193 distant signals, all were equipped with the blinkers.

The maximum distance from which a signal may be operated mechanically, i.e., by cables, is 1,200 meters. The speeds of trains require, however, that the distant signal be located at least 700 meters and up to 1,200 meters beyond the home signal, which in itself may be located a considerable distance from the interlocking plant. The problem was solved completely by the AGA-designed light distant signal, and mechanical methods of operation are now used only in semaphores. An electrical switch attached to the arm of the semaphore controls a 3-volt circuit which operates the distant signal light at the required distance to give the light signals (without rear lights) of all signals (aspects) approved for the distant signals during both daytime and darkness. The first distant signal of this type was installed 15 April 1924 on the north approach of the Oulunkylä station. This one was replaced by a newer type in 1932. Since these distant signal lights have also been proved economical and positive in action (Figure 245), wider application is being made of them. A model in which the disk is inclined forward (Figure 246) to improve visibility of the light during daytime was adopted in 1936. A total of 86 distant signal lights are currently in use.

*

Yard track signals equipped with the AGA-type of light have been employed in Finland, but their number has steadily decreased since 1913, being replaced in many instances by semaphores. None remained in use after 1937.

*

p 223 The installation of large switching plants brought the need for signals to indicate when trains are not permitted to switch. The disk type signal (Figure 247), a few equipped with the AGA blinker, where used for this purpose, but these have proved somewhat unsatisfactory owing the confusion created by additional red light signals. A new "no-switching" signal has therefore been approved, but 65 of the disk type, 12 of which are equipped with AGA blinkers, are still in use.

p 324 The ~~fixxx~~ new, improved mechanically operated "no-switching" signals were first installed in 1929 (Figure 248) at the Kouvola yards. These consist of a mast 10-12 meters high with a rectangular cross-arm painted white which is illuminated by white light during darkness. When the arm is in the normal or vertical position traffic and switching movements are permitted; the horizontal position prohibits movements which may endanger arriving or departing trains. Only ten of these signals (semaphores) designed and constructed in Finland and which have proved efficient are ~~ixxxx~~ currently in use.



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A light signal has been designed for this purpose also. The "no-switching" indication is given with three amber colored light points in horizontal line; the clear indication is given with the lights in vertical line. Conditions permitting at the humps of the classification yards at Pasila and Viipuri, light signals in which the lights are extinguished when in the clear position, have been installed for this purpose.

*

Track signals are intended to replace the disk type signal in locations where trains are not to proceed beyond the signal when displaying the halt aspect. These are of two types: the track signal lamp (Figure 249) which is operated mechanically, and the track signal light (Figure 250) which is similar in design to the conventional signal. These signals
p 325 are used at large yards to speed traffic. A third type of light signal is required on separated tracks to give the proceed cautiously indication by means of two colorless lights inclined at 45 degrees above the horizontal toward the left (at "10 O'clock").

The first track signal lamp was put into service in 1930 at the Hovinmaa station and the first track signal light the same year at the Viipuri station. Only two of the first type and 14 of the second are currently in use.

*

A classification signal device of the semaphore type was adopted in 1916 at the hump of the Viipuri yard, the first Finnish railroad yard to employ the hump method of classification. This semaphore enables the classifier to give such indications as "halt", "push slowly", and "push fast" to the engineer.

p 326 When the classification hump of the Pasila yard was completed in 1927, a signal light (Figure 251) was designed for this purpose. The signal proved so effective that when a parallel classification hump was built at Pasila in 1929, a similar signal was installed on the new tracks, and the old classification semaphore at the Viipuri yard was replaced with this type in 1930.

*

Because of the difficulty of dispatching and transferring of locomotives where visibility is limited (curves in cuts, adverse weather) by manual and whistle signals, unofficial use of light signals for this purpose was made at a number of local stations such as Kirjokivi and Hillosensalmi which were later removed.

The first official engine dispatching and transferring signal (Figure 252) was installed experimentally in 1931 at the Kouvola station where the Savo line departs on a curve. This signal has three lamps, the uppermost green in color and the two lower lamps colorless, mounted on a square backboard.

*

p 327 Green signal lights were used unofficially as wayside station signals on several lines including the Karjaa-Turku line as far back as 1907, but these were removed in 1921 to avoid confusion with the green distant signals. The need for official wayside station signals increased with the increase in the number of unattended stations and an experimental model was installed in 1932 (Figure 253) at the Yli-Vekkoski

p 328 stop of the Porvoo line. These semaphores are generally operated by the passengers themselves at unattended stations and are also used at other stations by regular personnel.

*

The old type Bender lamp (Figures 255 and 256) and the lamp approved by the State Railroads (Figures 257 and 258) were both employed as switch signals in simple switches before the opening of the period under discussion. Both are still in use. Switch signal lamps currently installed are similar to a German type manufactured to

Finnish specifications adopted in 1922. These signals may also be employed at water columns, turntables, and track blocks without changing the signal indication. A semaphore type of switch signal has also been employed since 1926 in yards where the exterior illumination permits their use.

The windmill type of lamp has been used since 1923 (Figure 259) as the switch signal in double switches in which the points are parallel, to replace the old four-lamp type. Approximately 160 of these switches are currently in use; they have been produced to Finnish specifications at the Viipuri machine shop since 1934. Another type specified in the signal regulations of 1903 for crossing switches in which the four pairs of points are controlled simultaneously at one throw are also in use.

*

p 330 The track block signal (Figure 254) lamp is in use; the regular closed track signal was approved in 1933 for this purpose at unattended stations.

*

The signals on water columns are still as specified in the regulations of 1903. These give a red light indication when the spout is extended over the track and a colorless light when the spout is parallel to the track.

*

The regulations of 1903 make no mention of signals for track scales and various types of semaphores which are part of the scale itself are in use. The arm of the semaphore is at right angles to the track when the scale is in position for weighing, and parallel to the track at other times. The new regulations will specify a V-shaped indication (V is for "vaaka", a scale).

*

Various types of indications have been used for railroad turn bridges specified in each instance by the senate in earlier times and later by the Cabinet. These varied with local conditions and with the nature of the bridges. The Railroad Administration and the Highway and Waterways Construction Administration conferred in 1931 to draw up regulations for standardised indications, which have been used on all new installations since that time.

*

Signals for turntables were not mentioned in the regulations of 1903. A light signal which gives a red indication in the crosswise position to bar entry of engine upon table and a white light indication when in position parallel to track to permit entry of engine has been employed.

*

A number of fixed signals are in use. The following types have been officially approved:

1. The halt sign (Figure 260) is used where the approach track ends, beyond which point trains may not proceed; 11 are in use.

2. The speed signal (Figure 261) indicates the maximum speed for a section of track; 11 are in use, all on bridges.

p 331 3. The whistle sign (Figure 262) is used to indicate when the engineer must give a whistle warning at grade crossings to highway traffic.

4. The obstruction sign ("penalty pole") is a post of steel or wood construction used to indicate the point beyond which rolling stock may not proceed in order ~~xx~~ not to obstruct movement on adjoining tracks.

*

p 332 Portable ~~xxxxx~~ circular semaphores are used in track maintenance operations. These have a green disk for the caution indication and a red disk for the halt indication.

*

Manual signals as specified in the regulations of 1903 are still in use with several amendments. The manual signal for airbrake testing was amended in 1918; the method of indicating the signal for passing at dispatching stations was specified in 1925; and the method for signaling is switching operations was modified in 1936.

*

Identification signs on rolling stock have likewise remained practically unchanged during the past 25 years. Signs used to indicate the passage of special trains are now considered superfluous and have been eliminated. The Railroad Administration approved front end signs for motorized coaches (Figure 372, page 455) in 1931.

* *
*

The original form of illumination for fixed signs was the oil lamp which has a number of shortcomings. Introduction of the acetylene lamp which generates the gas from carbide therefore represented a considerable advancement; these lamps are produced in the
p 333 Viipuri machine shop.

The electric lamp is even more efficient and its use has increased greatly in fixed signals. Practically all light-type home signals are electrically lighted.

At the end of 1936 electric lighting was employed in 166 fixed signs, 31 switches, 6 turn bridges, 20 highway crossing gates, and 10 highway crossing warning lamps. Use of electric hand lamps has not increased materially.

Employment of sound and acoustic signals such as whistles, steam whistles, warning bells, and explosive warnings is still governed chiefly by the regulations of 1903.

## SAFETY EQUIPMENT

### Use of Safety Equipment at Stations

The control lock (or safety lock) is the simplest and most commonly used safety device in the smallest stations. This lock is so designed that the key may be removed only when the device is properly locked. They were, however, adopted only quite recently. Signaling and switching safety devices were generally installed at the largest stations, which of course are attended by personnel. The

p 334 unattended line switch points received less attention. Since the safety of trains is largely dependent, however, on the positive locking of switches the Railroad Administration issued a special directive in 1922 regarding traffic at line switches and the use of safety and control locks at those points. Several main line switches have subsequently been provided with switch point locks which securely lock the fixed point to the support rail. Coasting of rolling stock from side tracks to the main track or beyond the safety point is prevented at the most important places by car stops, which are also provided with safety locks. In addition, electrical apparatus to verify the operation of safety locks remotely in the dispatcher's office has been installed at several stations. Safety locks are also employed in switch safety devices and in semaphores. Approximately 500 safety locks were in use at the end of 1936, of which 313 were in main track switches (181 switch point locks and 132 installed in switch stands).

*

Regular switching and semaphore installations are so designed that the switches and semaphores are dependent upon one another in their operation. This is accomplished by means of the safety lock which secures the fixed point of the switch to the support rail. Unless this locking is positive none of the other safety devices of the track will operate to give the clear track indication. The most common type of switch lock in use in Finland is the toggle (or "knuckle") type (Figure 263) and only a small number of the hook type (Figure 264) are in use. The wedge type (Figure 265) recently developed abroad has been successfully tested in Finland and the Railroad Administration therefore obtained manufacturing rights in 1935 from the Vögel firm for this type of switch. Domestic production should begin shortly.

*

The first mechanical switching plants were installed in 1903 at Hyvinkää and Pasila. The centralization of switches at Viipuri begun early in the period under discussion progressed to the point that two manually operated interlocking plants (Nos I and II) could be put into operation at the beginning of 1915. Both of these were of the Max Jüdel type. A total of 6 manually operated interlocking plants were in operation in Finland at that time, 4 at Viipuri and 2 in Pasila, the Hyvinkää installation having been dismantled. They contained a total of 118 switches controlled from centralized plants.

Installation of mechanical interlocking plants ceased for the time, however, owing to procurement difficulties during World War I of special accessories manufactured in Germany. The two additional manual interlocking plants ordered for the Viipuri yard thus were not installed. The adverse economic conditions following the war did not favor the centralizing of switchgear. The
p 336 number of such installations has continued to increase slowly, however, in the expansion of yards and where safety devices have been installed. The mechanical interlocking plant at Pasila was replaced in 1926 and installed at the east end of the Karjaa yard to centralize the control of 16 switches (Figure 283) and the mechanical interlocking plant at Viipuri was replaced in 1936 and installed at Lahti (Figures 267 and 268) to centralize the controls of 29 switches. The centralized switching plants installed at the Oulunkylä yard at Villähde in 1923 (Figure 269) and that installed at the north end of the Pasila yard in 1926 may also be mentioned here. At the end of 1936 there were

219 switches controlled from centralised plants. Electrical interlocking plants to control a total of approximately 80 switches are being installed at Riihimäki and Tampere.

p 337 A mechanical type of approach switch locking designed to prevent switching while a train was passing over the switch frequently employed were the switch is not visible from the point of control was used/formerly in conjunction with centralised switching plants. Owing to their high cost of maintenance and uncertain operation, all of these have been replaced with electric types (Figure 270) which close the lock when a pair of wheels enters an insulated section of track in front of the lock.

*

p 338 The progress in centralized locking of switches has been far more rapid in Finland than in the centralization of switching mechanisms since locking devices are more economical to install, especially at smaller stations, and because they operate with less attention under winter conditions. The lever type of mechanism has been employed most extensive in Finland at places where a greater number of switches and semaphores are concentrated and the switch stand type (Figures 266 and 271) is employed where only one or two controls are required.

The mechanical interlocking plant with centralized locking generally functions in the following manner: When the device is in the basic position with the approach semaphores in the halt aspect all switches are unlocked and may be switched, which condition is usually indicated at the interlocking plant by the crank position indicators (Figure 238, p 318). The internal design of the crank type interlocking machines (Figure 269) is generally such that only one track may be switched at a time, unless the tracks are independent of one another or are protected by safety lock switches.

The route is prepared by the train dispatcher or his assistant by setting the locking cranks indicated on the panels into the prescribed positions (either to right or left) and become locked when the appropriate route lever is set in the position required for the direction of the route. The route lever in turn locks when the crank of the home signal is turned, having become unlocked by the previous steps. The locking devices of the route cannot then be opened until the home signal is returned to the halt aspect.

p 339 The centralized locking of a switch is accomplished with the appropriate crank by ~~[illegible]~~ the crank cable which turns a locking bolt into an opening on a semicircular cam on the locking wheel (Figure 272) located at the switch, simultaneously actuating the tongue of the switch. As many as two or three switches may be controlled by a single cable depending on local conditions.

Since the ~~[illegible]~~ operation of mechanical safety devices is dependent upon the ease with which the mechanical elements controlled by the cables turn on their shafts, approximately 6,500 ball bearings and roller bearings have been installed in these devices.

Only 13 stations were equipped with locking devices at the beginning of 1915. An appropriation of 1,119,200 marks granted by the Senate in 1915 to equip all of the stations of the Valkeasaari-Riihimäki-Tampere line with locking devices gave an impetus to this development, although progress was slow in the postwar period.

The most important of the centralized locking installations in switching and signal interlocking plants built in recent years are those at Kouvola, Kuopio, and Malmi which have, in addition, route diagrams (Figures 273, 274, and 276) in the dispatcher's office to indicate the operation of the ~~[illegible]~~ switching mechanisms.

Installation of an electrical interlocking plant, the first of its kind in Finland and designed ~~in~~ by the Railroad Administration, was completed at the Kauniainen station in 1936. The approach signals, including p 340 the distant signals, and the electrical locking devices on the route (Figure 277) are all controlled by setting two buttons in the dispatcher's office. The electrical locking devices, which operate on 24 volts direct current, lock the switches when they become de-energised. Pilot switches indicate the position of the switch points; the pilot switches are controlled by the point indicator devices in the locking system. The dispatcher determines from the route diagram (Figure 276) when the switches at the individual locations have been turned for the required route and then turns the appropriate switch knob for the desired direction of travel. This action locks all of the switches concerned and when the switch knob is rotated to the final position the approach signal of the route turns to the proceed aspect. When the first wheels of the approaching train pass over an electrical contact in the track the approach signal turns to the halt aspect.

The electric locking installation is equipped with a rectifier, a set of storage batteries, and a motor-generator unit with automatic starting device to provide emergency power during power network failure.

In 1936 there were 135 stations with safety switching and signaling installations equipped with locking systems with a total of 928 switches with centralized locking facilities; 87 crank-operated switching mechanisms and 209 switch stands of the same type were in use, 70 of which were not equipped locking devices.

*

p 341 The first electrical switching machine in Finland was put into operation in the dispatcher's office at Pasila in 1926 (Figure 279). The switching machine, the automatic blocking system of the Helsinki-Pasila line, and the Pasila yard blocking system located at the top of the control installation, are all integrated electrically. The dispatcher clears, or gives the permission to prepare the routes, in the block sections of the mechanical switching machines of the northern and western approaches by means of the

station blocking control. The switching machine proper, which was
built by the Oy L. M. Ericsson Ab, has places for 12 switch controls.
These controls enable the dispatcher to set the
following components which are equipped with motorized throwing mecha-
nisms: 2 single-arm approach semaphores, one double-arm approach
semaphores, 3 single-arm departure semaphores (Figure 280), 2 switches,
and actuates the safety locks of 3 switches and one car stop.
Of the 7 routes on the switching machine, 4 are completely equipped
with automatic route locking devices which open when the last pair
p 342 of wheels of the train pass over an insulated electrical contact
(Figure 281) in the tracks. The throwing mechanisms of the semaphores
are powered by an electric motor with a rating of 0.25 KW and the
necessary gear drives and friction coupling, one each for each arm
p 343 of the semaphores, and is provided with control and indicator
switches. The switch throwing mechanisms are powered by electric
motors rated at 0.5 KW (Figure 282) with gear and worm drives and
friction couplings and control and indicator switches. The switch
mates are equipped with devices known as switch point adjusters which
prevent the electric indicator contacts from closing unless the points
of the switch are fully in the correct position. Alternating
current from the regular power source of the station is passed through
two mercury vapor rectifiers to supply the operating power and to
maintain the charge in the 22 ampere-hour nickel-iron storage battery which is used
as a source of emergency power. The mercury vapor rectifiers were
replaced in 1936 by metallic types. The motors operate on 127 volts,
direct current, and the indicator devices on 36 volts, direct current.
The lamps which illuminate semaphores and switches also operate on
a current of 127 volts, and may thus be supplied during emergencies
with power from the batteries which normally furnish current for
operating the motors.

Additional indicators were installed in 1932 to enable the dispatcher to observe the movements of trains on the block sections between Helsinki and Pasila and the operation of the Alppila block signals.

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Explanation of symbols, Figure 278, p 342

Figure 278. Distribution of Switching and Signaling Safety Equipment in the Finnish Railroad Network, 1937

1. Station equipped with safety switching and signaling installation. Continuous black line indicates such xxxxx installations exist at all stations of line.

2. Station equipped with home signals which are independent of switch locks (one, or number indicated by numeral).

3. Turntable with home signal.

4. Bridge which has a single passage common to railroad tracks and highway and is equipped with home signals.

*

The second oldest electric switching machine in Finland is the
p 344 one installed in 1930 to replace the mechanical switching machine at the western end of the Viipuri yards near the Kirkkosaari turntable in a three-story building with central heating (Figure 285) and which affords an excellent view of the area controlled. This machine (Figure 287) controls 17 regular routes and 11 alternate routes, sets 31 switches, 9 home xxxxxxxxx light signals, and 5 track light signals, and gives the "permit" signals to 6 routes and also locks the Kirkkosaari turntable (or turnbridge?).

Illustrations, page 345:

Figure 284. The electric station blocking machine in the office of the Viipuri train dispatcher. The handles of the switches by means of which mechanical dependence between blocking sections is attained to reduce their number xxx may be seen in the lower part of the photograph.

Figure 285. Building which houses the interlocking plant at Viipuri.

Figure 286. Powerplant of the electric interlocking machine at Viipuri.

p 346 Figure 287. The electric interlocking plant at Viipuri.

p 347

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Electrical blocking controls by means of which the track sections and their switch gear are made dependent upon one another, either manually or automatically, are among the most essential of the various types of safety equipment. The controls manufactured in Finland are generally based on the same system as those of Germany and Sweden.

Manual blocking controls (Figures 288 and 284) have been employed in Finland since 1913 for station blocking and for line blocking. The controls are employed in the following manner: the crank of a magneto is turned 6 or 8 revolutions while depressing the appropriate blocking control button to effect integration between blocking sections, either mechanically or by electrical means, for locking, clearing, and transmitting signals.

The first station and line blocking systems in Finland were put into use in 1913 on the Helsinki-Espoo line. The line blocking system was later removed from that section of the line between Pasila and Espoo which was converted into a double track line. The four interlocking plants of the Viipuri yards and the stations nearby at Tienhaara, Säiniö, and Tammisuo, as well as the line switches at Hiekka and Teurastamo were equipped with blocking controls in 1915.

Traffic between Viipuri and Tienhaara had increased in volume by 1916 that the installation of an intermediate blocking station at Linnansaari became necessary, which however, was removed to the new wayside station at Sorvali in 1920 (Figures 288 and 289). A manually operated intermediate blocking station was installed in 1923 at Alppila on the double track blocking line between Helsinki and Pasila.

p 348 The line blocking systems of the Pasila-Huopalahti and the Pasila-Oulunkylä lines were completed in 1927 and 1928. The ~~interlocking~~

interlocking plants (Numbers II, III, and IV) of the Kouvola yards were integrated with station blocking systems in 1929, as were both of those at Joensuu, which are situated at either end of the turn bridge. When the Kyrönsalmi bridge was adapted in 1934 to accommodate highway traffic also, integrated blocking systems were installed in the control booths at either end to control railway, highway, and waterway traffic.

A total of 93 station blocking sections and 41 line blocking sections were in operation in Finland at the end of 1936.

The manually operated Alppila intermediate blocking station built in 1923 was removed in 1925 in the course of the changes which were made in the yards. The first Finnish automatic intermediate blocking station was installed on the new passenger train tracks parallel to the original tracks and was put into service immediately after removal of the manual system. Since the distance of 3.1 kilometers which separates Helsinki and Pasila includes approximately 1.3 kilometers of the Helsinki yard and a section of about 1.4 kilometers having an upgrade of 0.010, it was necessary to locate the intermediate blocking station in such manner that three trains traveling in each direction simultaneously between Helsinki and Pasila could be accommodated with a minimum time interval separation of five minutes. The block signal lights (Figure 290) of both tracks of the intermediate blocking station were placed side by side in such manner that they divide the line leading from Helsinki to Pasila (exclusive of the portions within the Helsinki and Pasila yards) into blocking sections of 725 meters and 775 meters and the line leading from Pasila to Helsinki into block sections of 730 meters and 600 meters.

p 349 The automatic operation of the blocking system is based upon use of the isolated track section. This is accomplished by joining electrically all of the rails of a section of x the track to form a pair of conductors, the ends of which are insulated from adjoining sections by means of special rail connectors. A source of electric current is connected to one end of each such section and a sensitive relay is connected to the other end. The points of the relay make the proper contact at the moment the energising current is cut off from the solenoid of the relay by the short circuit produced by the first pair of axles of the train as it enters the section of track. Wooden fishplates of oak were originally employed to insulate the track sections from one another, but currently only fiber insulating pieces are used to separate standard fittings and rails. Since ties are made of wood, insulation of the rails themselves is not necessary. Two steel wires tightly wedged to the webs of the rails were used to obtain electrical continuity between rails on the track sections between Helsinki and Pasila, but only copper conductors are currently employed which are attached to the rails by oxy-acetylene welding. Edison storage batteries with a rating of 500 ampere-hours, housed separately in racks outdoors, supply the current to the tracks. The operating drain of the track relays is 0.1 ampere and the resistance is 4 ohms. The intermediate blocking signals use 12-volt, 40-watt signal lamps which have been produced in Finland since 1930. The required transformers are located in the cast iron boxes of the signals. The system has been in continuous operation resulting in considerable economy annually in operating cost.

The automatic line blocking system put into use on the Viipuri-Liimatta line in 1928 is similar in technical respects to the system described above. The intermediate blocking station situated on the Susisaari bridge divides the double-track line of 3.5 kilometers between Viipuri and Liimatta into two blocking sections of which the Viipuri section is 1,600 meters long and the Liimatta section 1,900 meters long. The blocking system of the Liimatta portion is of a temporary nature and is completely independent of the departure signals. Blocking section indicator lights have been installed, however, in the office of the Liimatta train dispatcher.

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p 357 **DEVELOPMENT OF SIGNAL EQUIPMENT AND TRAFFIC SAFETY DEVICES**

**Installation Operations**

A new phase in installation operations was reached during the period under discussion. The switching and signaling safety gear used in Finland prior to 1916 was manufactured to foreign design, principally to the designs developed by the Max Jüdel and the Södertelge Verkstäder firms, and were installed under supervision of their technicians, since the State Railroads did not have the necessary trained personnel. A training program for domestic installation personnel
p 358 was undertaken as a result of the large order for equipment placed in 1915 and the installation of this gear begun after the war. Two track superintendents who had worked under direction of the foreign installation experts were selected in 1920 for an educational tour in Sweden where they had an opportunity to learn the mechanical aspects of installation operations while working as signalmen. A telegraph technician who had worked on the installation of electrical safety gear was similarly dispatched in 1924 to learn intallation procedure in Sweden and Germany. A supply of capable installation personnel xxxx has gradually been developed under the direction of the nucleus trained abroad as far as this has been possible within the available funds and extent of operations.

The Safety Equipment Division proposed in 1924 that the system of installation and maintenance of safety equipment then in use be reorganized. In line with the proposal the Railroad Administration appointed a committee in 1929 which drew up the "Regulations for Signal Officials" which was adopted in 1931. The committee recommended, among other things, that the installation and maintenance functions be delegated to specially trained officials to be known as signal superintendents and signal installation men. The various railroad lines were to be independent of one another as far as possible in regard to these functions and personnel. The responsibility for the maintenance of electrical gear was to be transferred from the telegraph engineer, who is under the supervision of the Mechanical Division, to the Track Equipment Division. This recommendation was adopted by the Railroad Administration in 1931, in regard to the mechanical phases only, since even the committee did not consider the electrical phase urgent at that time (the capital investment ratio of electrical to mechanical equipment was 1:10 at that time). The qualifications of the technical personnel were also specified. The committee also recommended the procurement of 4 signal superintendents and 19 signal installers for the maintenance and inspection of the mechanical signal equipment on existing lines; two working crews, each headed by a signal superintendent were to be recruited for work on lines under construction. A total of 25 signal officials was therefore to be employed.

Owing to the lack of qualified applicants only a third of the recommended procurement program has been achieved to date. For the time being the railroad network is divided into three signal superintendent districts in respect to maintenance of mechanical signal equipment. Each of the districts are in turn divided sections supervised by the installers, although only five installers have thus far been appointed from those considered most capable to take the lead in training additional personnel. Five railroad watchmen are currently in training as apprentice signal installers. One installation crew is available for work on new lines under direction of a railroad superintendent. This work section is currently stationed at the Riihimäki repair shop.

The railroad network is temporarily divided into two districts for the installation and maintenance of electrical safety equipment. Each district is supervised by a telegraph engineer who has had

special training for this work. Three working parties are maintained to do the electrical work, all of which are under the administration of the telegraph instrument workshop at Riihimäki. Each working party has, in addition to the necessary tools and instruments, a rail-
p 359 road car for use as a workshop and mobile living quarters. The track maintenance division has at its disposal a total of 9 cars, of which only three are combination workshop and living quarters cars offering overnight facilities for only two signal superintendents and four skilled workers. The electrical signal working parties of the telegraph instrument repair shop have three mobile shops for their use.

The signal superintendents and installers are subordinate to the chiefs of each railroad line and the telegraph technicians and installers who work on electric signaling devices are subordinate to the telegraph engineer, but follow the technical directives of the safety equipment division in their work on signal devices.

A necessary prerequisite to the systematic construction and maintenance of safety equipment is a body of trained personnel. Since neither the Technical Institute, the trade schools, nor the industrial schools of Finland have not yet undertaken the training of signal technicians, and since no private enterprises in Finland are engaged in this work, the responsibility for the training of personnel therefore falls upon the railroads themselves by the organization of specialized courses according to a program soon to be approved.

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P. 460 Table 1. Number of Passenger Cars at the End of 1912, 1919, 1927, 1932, and 1935.

| Type | Code | 1912 (a) | 1912 (b) | 1919 (a) | 1919 (b) | 1927 (a) | 1927 (b) | 1932 (a) | 1932 (b) | 1935 (a) | 1935 (b) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Official cars | A | 7 | 1 | 15 | -- | 8 | 5 | 8 | 5 | 8 | 6 |
| 1st class day coaches | B | 24 | 3 | 18 | -- | -- | -- | -- | -- | -- | -- |

/Note: (a) Number of 2- and 3-axle cars; (b) Number of 4-axle cars/

| Type | Code | 1912 (a) | 1912 (b) | 1919 (a) | 1919 (b) | 1927 (a) | 1927 (b) | 1932 (a) | 1932 (b) | 1935 (a) | 1935 (b) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1st and 2d class sleepers | Cm | -- | 37 | -- | 47 | -- | 43 | -- | 53 | -- | 48 |
| 1st and 2d class day coaches | C | 29 | -- | 59 | -- | -- | -- | -- | -- | -- | --- |
| 1st and 2d class day coaches | Ci | -- | 25 | -- | -- | -- | 16 | -- | 20 | -- | 20 |
| 2d class day coaches | D | 171 | -- | 163 | -- | 105 | -- | 136 | -- | 116 | -- |
| 2d class day coaches | Di | -- | -- | -- | -- | -- | 29 | -- | 35 | -- | -- |
| 1st, 2d, 3d class sleepers | CEm | -- | 12 | -- | 7 | -- | 25 | -- | 35 | -- | 38 |
| 2d and 3d class day coaches | DE | 49 | -- | 58 | -- | 36 | -- | 34 | -- | 40 | -- |
| 2d and 3d class day coaches | DEi | -- | 6 | -- | -- | -- | 41 | -- | 81 | -- | 89 |
| 3d class day coaches | E | 419 | -- | 487 | -- | 317 | -- | 340 | -- | 329 | -- |
| 3d class sleepers | Em | -- | 9 | -- | 11 | -- | 21 | -- | 26 | -- | -- |
| 3d class day coaches | Ei | -- | 43 | -- | -- | -- | 108 | -- | 145 | -- | 155 |
| 3d class and trainmen's cars | EF | 14 | -- | 13 | -- | 8 | -- | 8 | -- | 6 | -- |
| 3d class and mail cars | DP | -- | -- | -- | -- | -- | -- | -- | -- | 1 | -- |
| 3d class and mail cars | EP | 13 | -- | 15 | -- | 5 | -- | 5 | -- | 4 | -- |
| Hospital cars | Es | -- | -- | -- | -- | 1 | -- | 1 | -- | 1 | -- |
| Workmen's cars | T | -- | -- | 27 | -- | 28 | 49 | 20 | 33 | 19 | 10 |
| Conductor's (trainmen's) cars | F | 244 | -- | 292 | -- | 359 | -- | 392 | -- | 389 | -- |
| Conductor's (trainmen's) cars | Fo | -- | -- | -- | -- | -- | 5 | -- | 30 | -- | 30 |
| Prison cars | N | 24 | -- | 27 | -- | 26 | -- | 26 | -- | 26 | -- |
| Prison cars | No | -- | -- | -- | -- | -- | -- | -- | 3 | -- | 3 |
| Total | | 994 | 136 | 1,174 | 65 | 893 | 342 | 970 | 466 | 939 | 460 |
| Totals by Years | | 1,130 | | 1,239 | | 1,235 | | 1,436 | | 1,399 | |
| Temporary dwelling cars | | -- | | -- | | 9 | -- | 3 | -- | 2 | 1 |
| Auxiliary engine cars | | -- | | -- | | -- | -- | 3 | -- | 3 | -- |
| Dwelling and repair cars | | -- | | -- | | -- | -- | -- | -- | -- | 3 |
| Telegraph instrument repair shop dwelling cars | | -- | | -- | | 3 | -- | 11 | -- | 17 | 3 |
| Total miscellaneous types | | -- | | -- | | 12 | -- | 17 | -- | 22 | 7 |

p 461 Table 2. Number of Freight Cars at the End of 1912, 1919, 1927, 1932, and 1935.

(a) Number of 2-axle and 3-axle cars; (b) Number of 4-axle cars

| Type | Code | 1912 | | 1919 | | 1927 | | 1932 | | 1935 | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | (a) | (b) | (a) | (b) | (a) | (b) | (a) | (b) | (a) | (b) |
| **Box cars** | | | | | | | | | | | |
| Old style cars | G | - | - | 7,149 1/ | - | 300 | - | 262 | - | 239 | - |
| Old style cars | Ga | 5,272 | - | - | - | 2,842 | - | 2,691 | - | 2,766 | - |
| Horse "Pullmans" | Gaa | 1 | - | 1 | - | - | - | - | - | - | - |
| New style cars | Gb | - | - | - | - | 815 | - | 1,900 | - | 2,290 | - |
| New style cars for transit freight | Gd | - | - | - | - | 2,915 | - | 2,916 | - | 2,913 | - |
| Old style cars for transit freight | Gav | - | - | - | - | 437 | - | 382 | - | 322 | - |
| Transit style cars | Gkk | - | - | - | - | - | 2 | - | 2 | - | 2 |
| Through-freight cars | Gf | 4 | - | 4 | - | 4 | - | - | - | - | - |
| Larger capacity cars | Gdk | - | - | - | - | 214 | - | 137 | - | - | - |
| Baggage cars | Ge | 66 | - | 91 | - | 73 | - | 72 | - | 78 | - |
| Heated and refrigerated cars | Gg | 213 | - | 210 | - | 312 | - | 459 | - | 422 | - |
| Yeast transporting cars | Ggkk | - | - | - | - | - | 1 | - | 1 | - | 1 |
| Mortuary cars | Gi | 5 | - | 5 | - | 3 | - | 4 | - | 3 | - |
| Gunpowder cars | Gk | 8 | - | 8 | - | 4 | - | 4 | - | - | - |
| Lime cars | Gt | 30 | - | 30 | - | 614 | - | 766 | - | 741 | - |
| Meat cars | Gli | - | - | - | - | 20 | - | 18 | - | 17 | - |
| Meat cars (Gg model) | Ggl | - | - | - | - | - | - | - | - | 55 | - |
| Manure cars | Gpl | - | - | - | - | 46 | - | 43 | - | 34 | - |
| Milk cars | Gma | - | - | - | - | 57 | - | 28 | - | 24 | - |
| Cars for small animals | Gak | - | - | - | - | 8 | - | 12 | - | 21 | - |
| Heated cars | Gga | - | - | - | - | - | - | - | - | 57 | - |
| Tank cars, oil | Go | - | - | 20 2/ | - | 16 | - | 13 | - | 11 | - |

1/ Total for G, Ga, and Gb models

2/ "Tank cars"

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Tank cars, gasoline | Gob | - | - | - | - | - | - | - | - | 33 | - |
| Steam boiler cars | Gh | - | - | - | - | 2 | - | 2 | - | - | - |
| Totals by axle types by years | | 5,599 | - | 7,518 | - | 8,682 | 3 | 9,709 | 3 | 10,026 | 3 |
| Totals by years | | 5,599 | | 7,518 | | 8,685 | | 9,712 | | 10,029 | |

Open Freight Cars

| Type | Code | 1912 (a) | 1912 (b) | 1919 (a) | 1919 (b) | 1927 (a) | 1927 (b) | 1932 (a) | 1932 (b) | 1935 (a) | 1935 (b) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Low wall, old style | H | 5,023 | - | 5,187 | - | 3,837 | - | 2,590 | - | 2,128 | - |
| High wall | Ha | 9 | - | 8 | - | - | - | - | - | - | - |
| New style | Hdk | - | - | - | - | 1,616 | - | 5,400 | - | 6,202 | - |
| Short, with low walls | Hb | 235 | - | 200 | - | - | - | - | - | - | - |
| Transit traffic type | Hd | - | - | - | - | 547 | - | 568 | - | 570 | - |
| Cars with walls of o.8 meters height | Hh | - | - | - | - | 10 | - | - | - | - | - |
| Short cars with low walls, for firewood transport | HL | 4 | - | - | - | - | - | - | - | - | - |
| Old style for transit traffic | Hv | - | - | - | - | 49 | - | 28 | - | 24 | - |
| Timber cars | I | 74 | - | 72 | - | 59 | - | - | - | 290 | - |
| Cars without side walls | K | 469 | - | 402 | - | 223 | - | 120 | - | 38 | - |
| Cars with rack walls for firewood | L | 63 | - | 56 | - | 8 | - | - | - | - | - |
| Timber and plank transporting cars | Ik | 603 | - | 601 | - | 471 | - | 486 | - | - | - |
| Timber and plank transporting cars | HI | 20 | - | 20 | - | 20 | - | - | - | - | - |
| Gravel cars | M | 2,054 | - | 2,215 | - | 610 | - | 1,187 | - | 1,412 | - |
| Gravel cars with high end walls | Mp | - | - | - | - | 1,105 | - | 519 | - | 216 | - |
| Gravel cars, dumping type | Ma | - | - | 16 | - | 432 | - | 299 | - | 453 | - |
| Gravel cars, dumping type | Mao | - | - | - | - | - | 17 | - | 17 | - | - |
| Cars with sidewalls | O | - | 114 | - | 486 | - | 147 | - | 78 | - | 74 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Larger capacity cars with side walls | Ok | - | - | - | - | - | 1,461 | - | 1,538 | - | 1,509 |
| Ore cars | Okm | - | - | - | - | - | - | - | - | - | 67 |
| Transit traffic type | Ov | - | - | - | - | - | 4 | - | 4 | - | - |
| Totals by axle types | | 8,554 | 114 | 8,777 | 486 | 8,987 | 1,629 | 11,197 | 1,637 | 11,333 | 1,650 |
| Totals by years | | 8,668 | | 9,263 | | 10,616 | | 12,834 | | 12,983 | |
| Artillery cars, 8-axle type | Os | - | - | - | - | | 2 | - | 1 | - | 1 |
| Large-capacity cars, 8-axle type | Osk | - | - | - | - | - | - | - | 1 | - | 1 |
| Artillery cars, 12-axle type | Oss | - | - | - | - | - | 2 | - | 2 | - | 2 |
| Total freight cars, box and open types | | 14,267 | | 16,781 | | 19,305 | | 22,550 | | 23,016 | |

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| | Code | 1912 | | 1919 | | 1927 | | 1932 | | 1935 | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | (a) | (b) | (a) | (b) | (a) | (b) | (a) | (b) | (a) | (b) |
| Freight cars used by the railroads | | | | | | | | | | | |
| Box cars | XG | - | - | - | - | 75 | 3 | 101 | 3 | 105 | 11 |
| Disinfecting cars | XGdf | - | - | - | - | 1 | - | 1 | - | 2 | - |
| Trash cars | XGp | - | - | - | - | 45 | - | 55 | - | 60 | - |
| Watertank cars | XGv | - | - | 2 | - | 1 | - | - | - | - | - |
| Equipment cars | XGd | - | - | - | - | 2 | - | 2 | - | - | - |
| Gas tank cars | XGs | - | - | 18 | - | 20 | - | 24 | - | 24 | - |
| Oil Tank cars | XGo | - | - | - | - | 44 | - | 47 | - | 40 | 1 |
| Equipment cars | XGav | - | - | - | - | 1 | - | 1 | - | - | - |
| Emergency dynamo cars | XGsm | - | - | - | - | 1 | - | - | - | - | - |
| Total box-car type | | - | - | 20 | - | 190 | 3 | 231 | 3 | 231 | 12 |
| Open cars with low walls | XH | - | - | - | - | 17 | - | 14 | - | 9 | - |
| Ice grader cars | XHr | - | - | - | - | 4 | - | 4 | - | 4 | - |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Firewood cars | XL | - | - | - | - | 83 | - | 76 | - | 76 | - |
| Artillery cars | XOt | - | - | - | - | 1 | - | 1 | - | - | - |
| Total open type | | - | - | - | - | 105 | - | 95 | - | 89 | - |

Cars in Use by the Postal and Telegraph Establishment

| | Code | 1912 (a) | 1912 (b) | 1919 (a) | 1919 (b) | 1927 (a) | 1927 (b) | 1932 (a) | 1932 (b) | 1935 (a) | 1935 (b) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Mail cars | P | 22 | 22 | 22 | 28 | 22 | 41 | 23 | 55 | 22 | 59 |
| Dwelling cars for postal workers | Tp | - | - | - | - | - | - | 7 | - | 7 | - |
| Totals by axle type | | 22 | 22 | 22 | 28 | 22 | 41 | 30 | 55 | 29 | 59 |
| Totals by years | | 44 | | 50 | | 63 | | 85 | | 88 | |

* * *

Table 3. Dimensions and Weights of Newer-type Passenger Cars

| Code and Type | Wheel-base (mm) | Interior Dimensions Length (mm) | Width (mm) | Sidewall Height (mm) | Weight (tons) | No of Seats |
|---|---|---|---|---|---|---|
| Cm, 1st and 2d class sleepers | 14,920<br>17,120 | 19,540 | 2,920 | 2,250 | 37.59 | 20 |
| CEm, 1st, 2d, and 3d class sleepers | 14,920<br>17,120 | 19,540 | 2,920 | 2,250 | 36.90 | 10+18 |
| Em, 3d class sleeper | 14,920<br>17,120 | 19,540 | 2,920 | 2,250 | 36.60 | 39 |
| Ci, 1st and 2d class with day compartments | 14,920<br>17,120 | 19,540 | 2,920 | 2,250 | 37.55 | 8+33 |
| Di, 2d class day coach without compartments | 12,800<br>15,000 | 17,420 | 2,920 | 2,250 | 33.20 | 56 |
| DEi, 2d and 3d class day coaches | 14,920<br>17,120 | 19,540 | 2,920 | 2,250 | 33.72 | 32+49 |
| Ei, 3d class day coaches | 14,920<br>17,120 | 19,540 | 2,920 | 2,250 | 33.60 | 100 |
| D, 2d class day coach (2-axle) | 9,000 | 13,020 | 2,970 | 2,250 | 18.07 | 46 |
| DE, 2d and 3d class day coaches (2-axle) | 6,400 | 10,740 | 2,980 | 2,250 | 16.75 | 16+25 |
| E, 3d class day coach (2-axle) | 9,000 | 13,020 | 2,970 | 2,250 | 17.60 | 61 |

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Table 4. Dimensions, Capacities and Weights of Most Common Types of Freight Cars

| Code and Type | Wheel-base (mm) | Interior Dimensions Length (mm) | Width (mm) | Sidewall Height (mm) | Capacity (cubic m) | Weight (tons) | Load (tons) |
|---|---|---|---|---|---|---|---|
| **Box Cars** | | | | | | | |
| Ga | 3,660 | 6,480 | 2,450 | 2,100 | 32 | 7.40 | 10-12 |
| Gb | 4,500 | 7,928 | 2,642 | 2,200 | 46 | 10.00 | 15.0 |
| Gd | 3,810 | 6,400 | 2,644 | 2,220 | 36 | 8.85 | 16.5 |
| Gg | 4,500 | 7,780 | 2,800 | 2,363 | 34 | 14.75 | 10.0 |
| Gli | 3,660 | 6,480 | 2,450 | 2,100 | 32 | 8.50 | 10-12 |
| Ggl | 4,500 | 7,780 | 2,800 | 2,363 | 34 | 15.10 | 10.0 |
| **Open Types** | | | | | | | |
| H | 4,120 | 7,556 | 2,640 | 1,500 | 28 | 6.30 | 10.0 |
| Hdk, short | 4,120 | 7,556 | 2,640 | 2,000 | 40 | 7.60 | 16.5 |
| Hdk, standard | 4,500 | 7,900 | 2,790 | 2,000 | 44 | 8.65 | 16.5 |
| Hd and Hv, formerly Hb | 5,500 | 9,104 | 2,840 | 2,000 | 52 | 8.80 | 16.5 |
| M, with steel chassis | 2,800 | 5,166 | 2,696 | 448 | 6 | 6.65 | 12.0 |
| M, all wood construction | 2,440 | 4,800 | 2,440 | 485 | 6 | 4.50 | 9.0 |
| O | 9,200 | 13,900 | 2,650 | 1,570 | 56 | 14.60 | 20.0 |
| Ok | 8,200 | 12,900 | 2,650 | 2,000<br>1,570 | 68<br>52 | 13.85 | 30.0 |
| Os | 19,500<br>15,000 | 15,300 | 2,360 | - | - | 30.00 | 35.0 |
| Osk | 20,000<br>15,500 | 11.36 | 2,535 | - | - | 31.95 | 50.0 |
| Oss | 16,400<br>25,600 | 16.85 | 2,320 | - | - | 60.00 | 105.0 |

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## Box Cars

Box cars of the Ga type with wooden chassis and with the walls constructed of vertical boards were built until the end of the first 50-year period of the Finnish railroads. Although satisfactory, and in many respects more advantageous from the manufacturing aspect, this type of construction was terminated in 1913 when the production of the Gd type (Figure 391) for transit traffic was begun. These cars have a steel chassis and the walls are boarded horizontally upon the inside surfaces of vertical supports. In the period from 1913 to 1920 private machine shops built a total of 2,083 of the Gd-type cars and the Pasila shop built 2,145 in the period from 1914 to 1923, for a total of 4,228 cars.

The 2,083 cars built by private shops were apportioned as follows: Karhula machine shop, 116; Turku car factory, 1,398; Kone- ja Silta Oy, 210; Hietalahden Laivatelakka, 145; Tampereen Konetehdas, 164; and the Pori machine shop, 50.

The old Ga-type cars, already in bad condition, were converted into lime cars and finally into manure cars. Then as they reached the stage where reconstruction was necessary the old bodies were replaced with bodies of the Gd type, with a view toward standardization of car sizes. The Gd bodies are readily adaptable to the Ga chassis, since the Gd chassis is only 76 millimeters longer than the Ga chassis, which measures 6.53 meters.

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The Gd-type of box car is being replaced as the standard type, owing to its small capacity. A new standard type for box cars, the Gb type (Figure 393) built on the 8-meter chassis used also for flat cars and following the structural features of the Gd type, was therefore
p 479 designed in 1924. The frames for the bodies of the first order of the Gb cars were of structural steel, but all bodies have been constructed entirely of wood since 1926. The side doors were also widened to two

meters.

The wall thickness of the original Gb cars was 22 millimeters, but this thickness proved to be of insufficient strength to withstand shifting loads which damaged the rabbet joints in the boards of the walls, especially at the ends of the cars, permitting ~~the~~ entry of the elements into the cars. The thickness of the boards of the end walls was therefore increased to 36 millimeters and ~~the~~ of the side walls to 24 millimeters, and that of the floor planks to 56 millimeters.

The end walls and side walls of the cars are reinforced with diagonal steel braces attached to the chassis of the car; the braces on the side walls are equipped with turnbuckles. The corner posts are equipped with Z-brackets at the roof level to furnish anchorage for the intermediate posts of the end walls. A total of 2,293 Gb cars were built in 1935.

The weight of the Gb cars equipped with air brakes and manual brakes is approximately 10 tons and the specified load was 15 tons, which was increased in 1936 to 16.5 tons. All of the Gb cars fall within the serial numbers ~~22~~ 36,001 - 46,160 and the former Russian Gav cars are numbered from 29,501 to 29,950.

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## Couplings, Draft Gear, and Buffer Equipment

With the continued increase in the size of trains it has also been necessary to change periodically the dimensions of couplings, draft gear, and of buffer equipment. For example, when a heavier type of car was adopted in 1897 in addition to the 2-axle cars then in use, it became necessary to increase the diameter of the turnbuckle screw of couplings from 30 millimeters to 33 millimeters. The turnbuckle screws of screw couplings (Figure 406) made since 1920 have a diameter of 45 millimeters, measured from the bottom of the thread. Stronger material is also employed in the construction of these couplings.

p 493 Similar increases in the dimensions of other components of the couplings, as well as in the draw-hook (clevis) and drawbar, have been necessary. The diameter of the drawbar was increased from 38 millimeters to 42 millimeters in 1897 and to 52 millimeters in 1913. Drawbars of the latter dimension are now installed on all cars during major repair operations.

The wedge connections (friction joints) of drawbars are a constant source of trouble in that they gradually loosen and upon breaking often cause much damage to the under carriages of cars. A great improvement was effected in this respect by the adoption of the tubular or sleeve type of drawbar ixxi92 joint in 1926.

The extension type of thrust buffer is most commonly used for cars, but greater numbers of piston type buffers have been manufactured recently as these are stronger in all respects. The stems of extension type buffers frequently bend out of shape or may even break off as a result of non-linear thrusts,since the buffers of all cars are not at the same height. Repeated attempts to overcome this source of trouble have been made by increasing the diameter of the stem (extension rod) from 60 millimeters to 75 millimeters and finally to 85 millimeters (Figure 407).

The piston type buffers first used in Germany were first imported into Finland in 1928 in considerable quantity. These were made in presses (Figure 408), but domestic production was soon undertaken by welding from steel plate which type is less expensive and lighter.
p 494 A relatively large number of buffers have been constructed in Finland in which the internal tubular piston is welded to the plate of the extension rod of the older type (Figure 409). Buffers of this type must, however, be considered only as a temporary expedient until a more satisfactory type is developed.

p 503 **Manufacture and Repair of Cars**

The first passenger cars and freight cars used in Finland on the Helsinki-Hämeenlinna line were imported from England and these were then used as models in the construction of additional cars at the railroad machine shop in Helsinki as needed for this line. When
p 504 more cars were needed for the Riihimäki-St. Petersburg line, the order was placed in the Pori machine shop in 1870, but when the Pori shop was destroyed by fire some time later, the major share of subsequent orders was transferred to Germany, a source thereafter for several orders of passenger cars. A considerable number of cars was also ordered in 1883 for the Vaasa line from the Atlas factory in Stockholm. With the exception of one official (state) car ordered from Prague, all other final ~~xxxxx~~ orders of foreign passenger~~x~~ cars have been from Riga and St. Petersburg, the figures being 20 of the 2-axle type in 1898 from Riga and 50 of the same type from the St. Petersburg car factory in 1900. The last Finnish orders for foreign freight cars consisted of 180 box cars of the Ga code from Riga and 100 timber cars from Belgium in 1899.

In addition to the Pori machine shop mentioned above, the Osberg & Baden factory in Helsinki produced its first 50 freight cars as early as 1872, but the Helsingin Laivatelakka (Helsinki Shipyard) did not begin production of railroad cars until 1889. Among the private enterprises which later entered the field the following are most notable: Kone ja Silta Oy, Porin Konepaja (Pori Machine Shop), and the ~~Kxkkx~~ Veljekset Friis Oy, all in Kokkola; Turun Rautateollisuus Oy (Turku Iron Works Corporation) in Karhula; Jakobssonin Konepaja (Jacobsson's Machine Shop) in Pori; Sommers, af Hällström & Waldens factory in Tampere; and the Tampereen Pellavatehdas (now a part of Tampella) in Tampere.

After the car-building activities of the State Railroads was transferred in 1903 from Helsinki to the large modern machine shop at Pasila which has facilities for the construction of freight cars on a large scale and also produces passenger cars, the number of orders placed with private builders gradually decreased until the final order of major proportions for freight cars was placed in 1920 at the Turku car factory. After that time the yearly demand for new cars has been much smaller owing to the business depression.