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HOLD-DOWN FASTENINGS FOR TIE PLATES, INCLUDING PADS UNDER PLATES: THEIR EFFECT ON TIE WEAR

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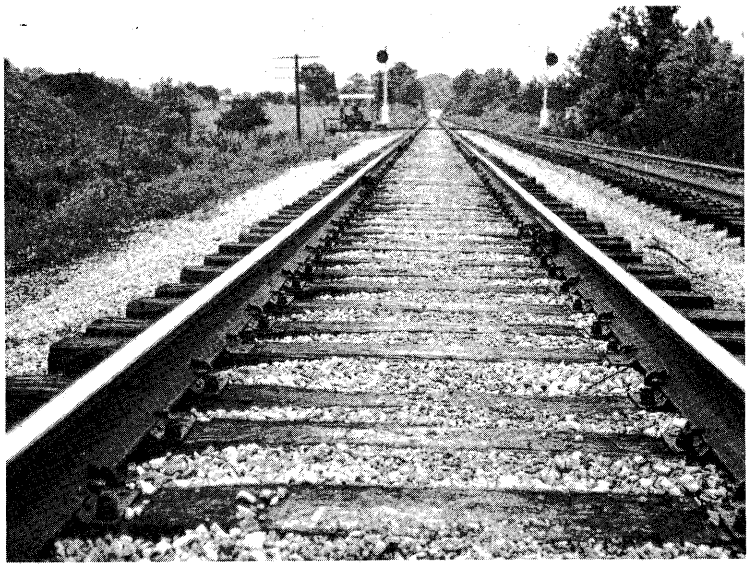

HOLD-DOWN FASTENINGS FOR TIE PLATES, INCLUDING PADS UNDER PLATES: THEIR EFFECT ON TIE WEAR

Conducted Under Sponsorship of
AREA Committee 5 - Track

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Introduction

Service Tests

Under the sponsoi hip of the AREA Committee 5 - Track and with the cooperation of the Louisville and Nashville Railroad, an extensive service test was established in 1947, on the northbound main track of that railroad north of London, Kentucky. The test track was selected because it provided good traffic density of approximately 20 million gross tons per year on a 4 1/2 deg curve, 0.4 miles long, and a tangent nearly 1 mile in length. This permitted the same types of construction on creosoted oak ties on curves, creosoted oak ties on tangent and creosoted pine ties on tangent. All installations were made on new ties with 24 ties per 39 ft panel. Some additional installations were made after 1947, and in 1950 the next curve to the north, a 5 deg curve at East Bernstadt, was taken over for expansion of the test area. The rail section is 131 RE with four-hole joint bars and ballast in crushed stone of 1 1/2 in maximum size. Since installation, periodic inspections have been made and progress reports submitted to the committee as information. It was necessary to terminate the tests in 1963 as the L&N is installing centralized traffic control and will abandon the test track for main line traffic. The ultimate service life has not been reached on many of the installations, but it is believed that sufficient data have been obtained to permit an appraisal of their worth in service.

Laboratory Tests

While excellent results may be obtained from service tests, the time required is so great that many products may be obsolete before an appraisal can be made. When the engineering laboratory was built at the AAR Research Center in 1957, one of its purposes was to make accelerated investigations and it was equipped with two tie wear machines designed and built by the AAR staff. These machines are capable under conditions of continuous operation of simulating, in a period of two to three weeks, tie wear comparable to 10 years of service under moderately heavy traffic.

Acknowledgment

The service test installations at London, Kentucky, were a cooperative effort with the AAR furnishing the tie plates (except the 14 in length) and the hold-down fastenings and the L&N furnishing all labor and other materials, including the new ties, stone ballast and standard fastenings for placing in track including a general surfacing of the track. Tie pads and some of the special fastenings were donated by the suppliers.

The activities of the AAR were carried out as a function of its Research Department, W. M. Keller, vice president. The field work on the L&N and the laboratory investigations together with the preparation of this report were under the general

direction of G. M. Magee, director of engineering research, Engineering Research Division, assisted by H. E. Durham, research engineer track, and L. R. Lamport, assistant research engineer track, who prepared the report.

The AAR is indebted to the L&N for their aid in the initial installations as well as subsequent additions to the test track and help furnished in connection with obtaining test measurements and performing the maintenance work on the fastenings. Gratitude is expressed to the supplie s for the aid furnished by them.

AAR - L&N SERVICE TESTS - LONDON, KENTUCKY

Foreword

This test was primarily for the purpose of determining the effectiveness and economy of various types of hold-down fastenings, tie pads, etc., as related to tie life, re-gaging and re-adzing. The traffic density was approximately 20 million gross tons annually through 1953 with some reduction in both freight and passenger traffic since 1953. The line was comp] tely dieselized in November 1956.

Description of Test Installations

Figs. 1 and 2 and Tables 1 and 2 give the location and description of the test sections. The various types of hold-down fastenings, tie pads, etc., were selected to cover all suitable existing designs in the original installation with subsequent installations including fastenings and other materials developed by the supply industry. Fig. 3 shows views of the test track.

Four cut spikes were used for line on the 4 1/2-deg curves of the original installation where no anchor spikes were specified, and this plan provided four spikes of some type per tie plate throughout the test curves. All ties were prebored and adzed to a 16-in width before treatment. This involved changes in boring plans to cover different tie plate designs as well as different size of holes for special fastenings.

Spring washers were provided in the sections where needed to increase the effectiveness of the fastenings and to increase the interval between retightening or tapping down.

Design of Tie Plates Used

For most of the test sections of the initial installations in 1947, 7 3/4-in by 13-in by 25/32-in double-shoulder tie plates with flat rail seat, flat bottom, level shoulder extensions and 1/4-in eccentricity, similar to AREA Plan 5B, as shown in Fig. 4, were used. In section 17, the Pennsylvania Railroad standard 14 3/4-in tie plate for 131 lb RE rail, sheared to a 13-in length with 1/4-in eccentricity, as shown in Fig. 5, was adopted for use with the AAR spring rail clips because the shoulder design was more suitable for keeping the clips in correct alignment. The drawing also shows an assembly view of the clips and screw spikes with the clips unflexed. The Erie Railroad standard single-shoulder 13-in outside joint tie plate with rolled circular crown, diamond bottom and zero eccentricity when used with a rail base width of 6 in, shown in Fig. 6, was used in sections 18 and 19 for comparison with comparable sections 2 and 16, respectively, having flat bottom plates. In Fig. 7 are shown the plan and punching for the L&N standard 14-in tie plate which is the same design as AREA Plan 6B, except for the punching as shown. Fourteen-inch tie plate AREA Plan 12, adopted in 1948, and comparable to Plan 6B, was used in later installations involving 14-in plates.

Section 1, Adhesives

Each portion of this section was divided into subsections 1.1 to 1.10, incl., as shown in Table 1. The materials used were those considered at the time to have the greatest possibility of providing protection to the ties through their adhesive qualities or their ability to seal the wood surface against wear and decay. Applications were carefully made in accordance with instructions of the manufacturer or good practice in order to obtain the best possible results.

Section 2

This section, which had no anchor spikes, was representaive of considerable existing main track mileage and was installed to provide a basis of comparison. The portion on curved track had four cut line spikes per plate.

In 1949, rubber spike cushions, developed by the Dunne Rubber Company, of Ashtabula, Ohio, were installed on the north 24 ties of the sections in tangent track with both oak and pine ties. These cushions were a molded product having a square hole through which the line spike was driven and a projection reinforced with fabric between the throat of the spike and the rail base for the purpose of preventing the spike from resting on the rail base and being pulled up from the tie by the wave action of the rail.

Sections 6, 7 and 8

These sections involved the use of Racor Drive Tight (Sandberg) spikes which had fluted surfaces for better holding power. Section 6 in the oak and pine tangents had two line spikes only. Section 7 on the 4 1/2-deg curve and the tangent had the special spikes for both line and anchor and section 8 on the curve and tangent had cut spikes for line and the special spikes for anchor.

No benefits were obtained from the Drive Tight spikes in the line position in section 6 and the construction was changed to two cut spikes in 1949. Because of change in design of the Racor stud, section 6 was withdrawn from the test in 1957 as the new design was under test in sections 43, 48 and 49.

Sections 7 and 8 on the 4 1/2-deg curve were replaced in 1952 with new installations involving the use of Racor studs. The sections on the oak and pine tangents were withdrawn from test by the manufacturer in 1953 as the Drive Tight spike was no longer made.

Section 9

Section 9, shown in Fig. 8, had two each of cut spikes for line and anchors, typical of the standard construction of many railroads. This section was for the purpose of comparison and evaluating special hold-down fastenings.

Rubber anchor spike cushions, Fig. 9, were applied to the North 10 pine ties in 1949.

Section 10

The round head cut spike was similar to the regular cut spike except for the round head designed for use with 7/8-in single coil alloy spring washer, Fig. 10. The purpose of the spring washer was to increase the effectiveness of the fastening in reducing mechanical wear. Previous tests had indicated that two standard cut spikes each for line and anchors would have little effect on plate cutting compared with cut spikes for line only.

Section 11

The hold-down fastenings in section 11 were two round head dowel studs, Fig. 11, with two double coil helical spring washers, upper right, Fig. 16. The dowel studs were by the Pittsburgh Screw and Bolt Corporation and the washers were developed by the Reliance Division of the Eaton Manufacturing Company. It was believed that the double coil washer should have a large deflection for a moderate change in load which would keep the tie plates tight on the ties for a much greater amount of traffic, reduce the number of retightenings and possibly obtain less mechanical wear over a longer period of time. The dowel studs were driven by hand, into prebored holes 9/16-in and 1/2-in diameter in creosoted oak and pine ties respectively, until the washer was almost closed and the final tightening was done with a hand wrench. The advantage claimed for this type of fastening was that tightening could be accomplished without disturbing the bond with the wood.

Section 12

The construction of section 12 and a plan of the Oliver hold-down drive spike are shown in Fig. 12. The double coil helical washers were the same as those used in section 11. The fastening, a standard product of the Oliver Iron and Steel Corporation, was driven by hand in the same size holes provided in section 11 and the square head was provided only for its removal. Tightening was done by tapping down to take up slack due to mechanical wear.

Section 13

Two standard line spikes and two Elastic spikes of design No. 93 were used in section 13 except that tie plate lock spikes were applied as anchors in the north 12 ties of the 4 1/2-deg curve only. Prebored holes of 5/8-in and 9/16-in diameter were used in the oak and pine ties respectively. These hold-down fastenings were designed and furnished by Bernuth Lembcke Co., Inc. The Elastic spike is shown in Fig. 13 and the tie plate lock spike in Fig. 14. The Elastic spikes were driven for a deflection of about 3/8-in which placed a 1000 lb load on the tie plate for each spike. The lock spikes were a new product made by hand and installed in a small test installation to explore their

possibilities. They were driven so that the tapered portion of the shank would take up the slack in the tie plate holes transversely to the rail and restrain the movement of the tie plate in that direction.

Sections 14 and 15

Sections 14 and 15 have the same number and type of fastenings per plate, Fig. 15, and differ only in method used to preload the plates. Two 3/4-in by 9 1/2 or 10-in carriage bolts, threaded through a 2-in by 3/8-in by 15-in headlock bar, punched to fit the square shank of the bolts, were used with alloy spring washers to fasten the tie plates to the ties. Holes 3/4-in diameter were prebored in the ties for a drive fit and tie plates were fastened to the ties prior to insertion in the track. For section 14, final tightening of the bolts to approximately 7500 lb tension was done 2 to 4 days after insertion and before unloading ballast. For section 15, the ties with fastenings attached were sent to the L&N shops at Corbin, Kentucky, where, after positioning to standard track gage, the tie plates were loaded to 15,000 lb with a hydraulic press and the bolts tightened to approximately 7500 lb tension.

Section 16

Section 16 was established as typical screw spike construction with two cut spikes in the line position and two 15/16-in by 6 1/2-in screw spikes as anchors with double coil spring washers. The tie plates were 13-in AREA Plan 5B (modified) having a flat bottom. The screw spikes were driven with a power track wrench in prebored holes 3/4-in and 11/16-in diameter for oak and pine ties respectively. The screw spikes were applied two to four days after insertion of the ties and eased down to obtain a solid washer without overdriving or stripping the threads in the timber. A view of the construction and plans of the two kinds of washers used are shown in Fig. 16. The experimental double coil helical washer was applied in the half of each portion of this section and the Thackery washer in the south half.

Section 17

The AAR spring rail clip, Fig. 17, fastened to the tie with a 15/16-in by 6 1/2-in screw spike, was designed to serve as a tie plate hold-down fastening, a rail anchor and a line spike. In the tangent construction the temporary line spikes were pulled and the holes were plugged, while on the curve the standard line spikes were left in place to provide four spikes of some design per tie plate to conform to other sections. Laboratory tests showed that the force required to slip the rail longitudinally, when fastened with two clips per tie plate, was 1100 to 1500 lb. For an average installation, the clip exerted loads of approximately 1200 and 2200 lb on the rail and tie plate respectively. For this test the rail clip was designed to fit the 131 lb RE rail base on a Pennsylvania Railroad 14 3/4-in tie plate which had a shoulder with a short radius which would prevent the clip from rotating about the screw spike. These tie plates shown in assembly drawing, Fig. 5, were sheared to 13-in length to make them comparable to the AREA Plan 5B plates used in most of the sections.

Sections 18 and 19

Some maintenance engineers preferred and some railroads were using tie plates with Sellers or diamond bottoms. Accordingly, a number of 13-in tie plates with the diamond bottom were obtained from the Erie Railroad and used in sections 18 and 19. This design of tie plate, shown in Fig. 6, had a single shoulder, level shoulder extension for lag construction, rolled circular crown and zero eccentricity when used with a rail base of 6-in. Section 18 was installed on both curve and tangent track without anchor spikes for comparison with the section of similar construction, but with flat bottom tie plates.

Section 19 also utilized the 13-in Erie diamond bottom plate but with two standard line spikes and two 15/16-in by 6 1/2-in screw spikes for anchor with double coil experimental helical washers in the north half of the section and Thackery washers in the south half thereof. Fig. 18 shows the construction which is comparable to section 16 with the 13-in double shoulder plate with flat bottom.

Section 22

Section 22, installed only on tangent track, consisted of two 11/16-in by 6-in Oliver tie plate drive spikes and 3/4-in single coil alloy spring washers as anchors. The spikes were driven in 11/16-in square tie plate punching and prebored holes of 7/16-in and 3/8-in diameter holes in oak and pine ties respectively. Fig. 19 shows the construction and a plan of the drive spike which is similar to but smaller than the Oliver hold-down drive spike in section 12 and would be a more economical installation due to not requiring special tie plate punching.

Sections 23 and 24

For comparative purposes the L&N built two track panels of its standard construction in each of three locations with the 14-in plate, as shown in Fig. 7 on two new cut spikes for line and two second hand cut spikes for anchors. The construction of sections 23 and 24 was the same except that in section 24 the Rails Company clip was added to the field side on alternate ties as shown in Fig. 20. From section 24 it was hoped to determine if the clips had any material affect on plate cutting of the ties.

Section 26

At the suggestion of the Lackawana Railroad, two panels of its 7 1/2-in by 13-in double shoulder, diamond bottom tie plates with flat rail seat, 1 to 40 cant and 1/2-in eccentricity were installed in 1948 on the short 4 1/2-deg test curve with creosoted oak ties. These tie plates have a 6-hole unsymmetrical punching, a 2-in spacing of the ribs on the bottom and a thickness of 53/64-in at the outer shoulder. Two each of cut spikes were applied for line and anchors. The Erie Railroad diamond bottom tie plates installed in 1947 in sections 18 and 19 had only a single shoulder and zero eccentricity when used with rail with a 6-in base.

Section 31

G. & H. Controls, Inc., suggested the fastening used in this section with a 14-in tie plate. Twenty-four ties, alternately spaced except where rail joints interfered had one G. & H. No-Creep anchor on the gage end of each tie plate, one cut spike for line on the field side of the rail and two Oliver drive spikes (without spring washers) as anchors. The Oliver drive spikes were of the same design as those used in section 22. The other 24 ties had two line spikes without anchors. The special construction is shown in Fig. 21. The lags on the tie plates were electric welded at London, Kentucky, by the L&N welder under the supervision of the sponsor. It was not expected that this installation in 78 ft of track would develop any information regarding the merits of the fastening as anti-creeper but would be information in the matter of plate cutting compared with standard construction.

Section 34

This section consisting of 48 creosoted oak ties and 14-in tie plates had two cut spikes for line and two tie plate lock spikes of revised design for anchors, shown in Fig. 22. The original design shown in Fig. 14 was applied to only 12 ties in section 13 on the long test curve in 1947, which section also included Elastic spikes. It was decided to install a longer section to better judge the performance of the lock spikes and also to utilize the new design which the manufacturer claimed to be superior to the old one and more economical to produce. Asphalt roofing paint was applied to the bottom of the tie plates and the adzed surfaces of the south 24 ties in this section. Line and anchor spikes could not be staggered properly because only two prebored holes were provided in the anchor position.

Section 37

This section on the 5-deg curve at East Bernstadt, consisted of two panels of standard L&N construction with 14-in tie plates and 2 each of cut spikes for line and anchor to be used as a control section.

Section 43

The Racor stud was first installed in 1949 on tangent track section 6. For the purpose of subjecting this hold-down fastening to a more accelerated test, it was decided to make a second installation on the 5-deg curve. Fig. 23 shows the construction used in two panels of track on creosoted oak ties.

Section 44 and 45

The construction in these sections, Fig. 24, were sponsored by the Dayton Rubber Company which donated the material. The tie plates were 9-in by 12 7/16-in by 25/32-in thick at the outer shoulder, and have a 1:40 $\pm$ cant and 5/32-in eccentricity.

The raised rubber insert pads were made 3/16-in thicker than the plates and were intended to cushion the shock loads between the rail and the tie. Section 44 was installed on new ties and section 45 on existing hardwood ties after careful hand adzing. This construction on tangent track increased the maximum unit bearing pressure three fold compared with the 13-in plates with 1/4-in eccentricity.

Sections 48 and 49

In July 1952, a derailment created severe damage to tie plates and fastenings on the inner rail of sections 7 and 8 on the long 4 1/2-deg curve. The sections had the Racor Drive Tight spikes (Sandberg design) which were no longer manufactured as the Racor stud was considered better and more economical. At the request of the sponsor, sections 7 and 8 were discontinued. Both sections were rebuilt with new creosoted oak ties and 14-in AREA Plan No. 12 tie plates because the 13-in plate was no longer standard on the L&N. Section 7 was rebuilt with Racor tie pads (coated) with two cut spikes for line and two Racor studs for anchors. This section, having 58 ties, was designated as 48. Section 8 was renumbered section 49 and 60 ties of which the north 30 ties have 3 Racor studs for anchors and the south 30 ties have 4 Racor studs for anchors. All of the studs were partially driven by hand and later driven home with a pneumatic hammer.

Section 51

This short section of 10 creosoted oak ties was established in tangent track to determine if the wooden pegs, used in connection with the Dun-Rite gaging machine of the Nordberg Manufacturing Company, would be effective in reducing plate cutting. The construction shown in Fig. 25 consisted of 14-in tie plates AREA Plan No. 12 with two cut spikes for line and two Nordberg pegs as anchors. The pegs made of creosoted maple utilize the same principle as the Racor stud in wedging out the play between the peg and the tie plate punching. The pegs 21/32-in diameter were driven into 5/8 in diameter holes bored in the ties after the line spikes were driven. All pegs were driven home carefully, but a few were broomed slightly.

Section 57

Section 57 was installed in 1956 on the south spiral of the 5-deg test curve where the curvature was about 4-deg. The section consisted of 24 new creosoted oak ties with 9/16-in holes, new 14-in tie plates and two each cut spikes for line and Spring Lags for anchors (Fig. 26). The Spring Lag is a double leaf spike made of a 9/32-in by 11/16-in half oval bent into the approximate shape of a cotter key, except for 1/8-in separation of the leaves along the spike shank. This spike has an overall length of 5-in and when driven, the oval shank has major and minor diameters of 11/16-in and 9/16-in. The lags, when driven in the anchor position, have the major axis coincident with the diagonal of the tie plate punch to provide equal horizontal reactive spring force against all four sides of the hole in the tie plate.

Gage of Test Curves

Fig. 27 indicates the gage of the test sections on the two 4 1/2-deg curves. It will be noted that the special fastenings in sections 14 to 17, incl., were still holding gage well after 16 years of service. The excess widening in section 16 was caused by changing out the north outer rail of the curve September 1953. Sections 48 and 49 with Racor pads and/or studs in service 11 years had a good record of holding gage. Sections 18 and 19, Erie single shoulder plates with diamond bottoms, had a good average performance but the gage had considerable irregularity which is characteristic of single shoulder plates.

The short 4 1/2-deg curve section 26 with 13-in DL&W double shoulder diamond bottom plates and three spikes per plate continued to have good gage. Sections 21 and 25 with Fabco and Johns-Manville pads respectively have not performed too well in this respect. Section 21 was regaged in 1956, but was again 5/16 in wide. The circular curve between the spirals is so short that maintaining good alignment creates a problem and no doubt contributes to the gage widening.

Fig. 28 shows gage measurements on the 5-deg curve at East Bernstadt. There continued to be irregularity at the joints except in section 38 which was only 5 years old. It is believed that this condition is partially due to heavy trains starting on the curve after stopping to pick up or set out cars for coal loading.

Fig. 29 is the gage drawing for sections 04 and 05 on the 5-deg, 36-min curve, 0.5 miles north of East Bernstadt where Bird 5 ply tie pads together with lock spikes were installed on three rail lengths of existing ties for comparison with the adjacent three rail lengths of standard construction with two cut spikes for anchors. In the 5 year period since installation in 1958 there had been little change in average gage although the gage in section 05 with standard construction had been more erratic than that in section 04. The maximum widening in section 05 was 0.14-in compared with a maximum of 0.08-in for section 04.

Tie Wear Measurements

The results of the final tie penetration readings for sections having hold-down fastenings and coatings of adzed surfaces are contained in Table 3, together with gross tons of traffic and years of service. Fig. 30 shows gage used for obtaining tie wear measurements. Penetration was not measured on the tie pad sections as the pads are generally effective in protecting the ties from abrasion. Based on gross tons of traffic, the tie plate fastenings may be appraised as to efficiency in reducing tie wear. The maintenance for the test period will be found in Table 6.

A comparison of the 1947 installations of hold-down fastenings and coatings using section 2, with only cut line spikes for controls, is shown in Table 4. There have been some changes in order of effectiveness since 1957 data were reported in Vol. 59, page 1046, but section 15 with through bolts applied in the shop continues to

have the best showing particularly on the oak ties. Included in the top group in order of efficiency are the through bolts applied in the field, AAR spring rail clips, screw spikes with double coil spring washers and dowel studs. The next group includes elastic spikes, Oliver hold-down drive spikes with double coil spring washers, round head cut spikes with single coil washers and Oliver tie plate drive spikes with single coil washers. A comparison with the 1957 report indicates that there is some decrease in efficiency of the special fastenings in that the ratio to the control section had risen five percentage points in 1963.

Table 5 covers the relative wear of hold-down fastenings installed subsequent to 1947. The best performance is indicated by the north 1/2 of section 49 with three Racor studs on the 4 1/2-deg curve and the lock spikes in section 34 in the oak tangent. The studs in section 43 on the 5-deg curve and those in the south 1/2 of section 49 with four per plate have not done as well as the others. As previously indicated the condition on the East Bernstadt curve are very severe due to operating conditions. The findings in the south 1/2 of section 49 tend to confirm results of other test installations where four anchor fastenings do not perform as well as two. The spring lags in section 57 and the Nordberg plugs in section 51 show up fairly well for their limited service period. The G&H controls in section 31 appear to have been of little if any benefit.

In reports covering 1953 and 1957 data, sections 2 and 9 with cut spike construction were used for comparison of tie wear on curves and tangent portions of the test. In prior years both sections 2 and 9 showed greater tie wear on the outer rail of the 4 1/2-deg curve, but in 1963 the difference was reduced from 25 percent to 17 percent in section 2 and wear was equal in section 9. This would indicate reduced speed on the curve, part of which would be the result of two passenger trains being taken off and possibly some change in freight train operation. For the two rails, the wear on the creosoted oak ties on the long curve was 26 percent greater than that for the oak ties on tangent track. In tangent track the creosoted pine ties were plate cut 20 percent more than the oak ties. Section 37 with cut spike construction on the 5-deg curve continues to show an excess of tie wear on the inner rail, but this excess was only 6 percent in 1963 compared to 11 percent in 1957 and 30 percent in 1953. This is difficult to explain in view of the findings on the 4 1/2-deg curve, but diesel operation which became 100 percent in 1956 may have been a contributing factor in changing speed of trains throughout the test area.

Inconclusive results were obtained from the use of rubber line spike cushions on the north 24 ties of section 2 of the oak tie and pine tie tangents and rubber anchor spike cushions on the north 10 ties of section 9 of the pine tie tangent. Section 2 in the oak tie tangent shows greater plate cutting where the rubber cushions were used whereas less penetration was recorded in the pine tie tangent of that section. The difference in both instances was only about 5 percent which is too small to have any significance. Many of the cushions were cut in two and missing. In section 9 and 10 ties with rubber anchor spike cushions (Fig. 9) in the pine tie tangent showed 14 percent less plate cutting than the rest of the section. This reduction of plate cutting would appear to indicate limited benefit from the use of the cushions.

In Table 3, section 24 with Rails Company clips on alternate ties and section 31 with G&H controls No-Creep rail anchors on alternate ties were subdivided between

anchored ties and unanchored ties to show the difference in plate cutting. In the early stages of the tests there was an indication that greater plate cutting was occurring on the anchored ties, but there has been some reversal of the trend to the point that the difference is not significant.

The values for sections 9 and 23 in Table 3 will serve as a comparison of wear of 14 in versus 13 in length tie plates. The ratio of 13 in (Sec. 9) to 14 in lengths (Sec. 23) is 0.93, whereas the plate cutting in reverse ratio as measured in 1953, 1957 and 1963 was as follows:

Year	4 1/2-Deg Curve	Oak Tang.	Pine Tang.	Composite
1953	0.92	0.94	1.10	0.99
1957	0.80	0.88	1.10	0.93
1963	0.69	0.79	0.99	0.82

The ratio of 14 in to 13 in plates is decidedly in favor of the 14 in plates in the oak tie sections on the curve and the tangent has shown improvement in the pine tie section since 1957. While more accuracy might be obtained from larger track sections the above results appear to indicate a definite trend in favor of the larger plates.

Moderate benefits appear to have been obtained from the adzed surface coatings shown in Table 3 with effectiveness indicated in Table 4. The cements in section 1.5 applied in the shop before treatment have obtained the best results. As the coating sections were short with only 3 to 12 ties, it would be difficult to establish any definite conclusions.

Surface coatings applied subsequent to 1947 are compared in Table 5. Section 33 with material applied under laboratory conditions is showing up well with the same percent of the control section as similar material in section 1.5. The least favorable showing is in section 53 with plate cutting 8 percent greater than the control section. Sections 50 and 52 with 63 percent and 72 percent of controls respectively, appear to have some merit. Sections 1.10 and 32 are in very short sections and have not done well enough to warrant consideration.

Maintenance of Hold-Down Fastenings

Throughout the life of the tests the AAR staff members have made periodic detailed inspections of the special hold-down fastenings and the L&N forces have carried out such maintenance and repairs as needed in keeping with good practice. Table 6 shows by number of fastenings and percentage the maintenance carried out throughout the life of the test sections. This table, used in conjunction with Tables 4 and 5 and Figs. 27 and 28 covering gage, should be helpful in evaluating the fastenings.

While they performed well otherwise, the maintenance was high in section 17 with the AAR clips. The screw spikes were last tightened in 1960 when many were stripped in the wood. In 1963 the stripped spikes amounted to more than 20 percent of

the total and had the test been continued it would have been necessary to reverse the stagger to maintain their usefulness.

The elastic spikes in section 13 did well in the oak ties, but heavy maintenance was required in pine ties. During the life of the test, stagger was reversed in 14 of 94 plates because of loss of holding power in the wood. Similar difficulties were encountered with the dowel studs in section 11 in the pine ties where stagger was reversed in five plates during the test.

Due to tie wear and compression of the wood, it was difficult to keep some of the special fastenings tight. This was particularly true in the pine ties where the spring washers, provided as a means of taking up tie wear, were more difficult to maintain than in the oak tie sections.

It will be noted that the tie plate lock spikes in section 34 required no maintenance during their 14 years service life. The Racor studs in sections 43 and 49 were driven down once after installation, but it is probable that this would not have been necessary had proper driving equipment been available at the time of installation.

General Inspection

Annual inspections were made by the subcommittee during the life of the test and on two occasions the entire AREA Committee 5 - Track, went over the test area examining fastenings and removing tie plates and pads for detailed observation. The results of these inspections with photographs were made a part of the AREA reports and included in the Proceedings. The most recent such inspection was made by the subcommittee accompanied by an AAR staff member and L&N personnel in May 1963 together with sufficient track men to remove tie plates and pads.

Figs. 31 to 45 with photographs from the 1963 inspection show in the captions the conditions found. While they have given reasonably good service insofar as wear is concerned, the pads of Railroad Rubber Products, Johns-Manville, Fabco and Racor in Figs. 31, 32, 33 and 34 had not held their seal which is desirable in order to maintain dry wood in the tie plate area.

The Fabco pads in Fig. 35 and the Konvex pads in Figs. 36 and 37 have held their seal reasonably well, but they still had a rather short service life on which to judge their performance.

The Bird duck burlap pads in Figs. 38, 39, 40 and 41 have given generally good results over nealy 15 years in service. The ratchet action on the low rail of the 4 1/2-deg curve has tended to cause delamination of this type of pad and in the case of the 5 ply pad, Fig. 38, the seal was entirely gone. In spite of the poor pad condition, the wood was still protected from wear. The 7 ply pad, Fig. 40, gave somewhat better performance on the low rail.

The Racor fiber-rubber pad in section 48 on the 4 1/2-deg curve, Fig. 42, where two studs were also used, gave a good performance over a period of nearly 11 years.

Considering the severity of service on the low rail of the curve, the pad illustrated, did well. It is probable that the studs were beneficial.

The Railroad Rubber Products Company rubber tie plate in section 58, Fig. 43, had less than 5 years of service. The splits at the spike holes were caused by the spikes at the time of installation and had little if any growth during service. There has been 0.07 in tightening of the gage since installation, but otherwise the section is essentially as it was when built in 1958.

The ties in section 35, Figs. 44 and 45, are discussed in this report under "Tie Coating."

Tie Coating

Sections 35 and 36 were established in 1950 when Koppers No. 16 sealing compound was applied to the top and ends of new and existing creosoted hardwood ties to investigate its capacity for retarding the splitting, checking and weathering of the timber. In section 35, consisting of 120 ties, the coating was applied to all odd numbered ties leaving the even numbered ties for controls. In addition, the ends of the coated ties in the south half of the section received an application of the coating. In section 36 with existing ties, the tops of all 118 ties were coated as were the ends of the south 58 ties. All coated ties were sprinkled with 1/4-in washed gravel for protection. Frequent annual checks were made of moisture content and width of splits in both coated and uncoated ties which indicated that the coating was beneficial in those categories. In 1958, the north 30 alternate ties were recoated and covered with crushed rock screenings.

From the standpoint of moisture content and number of splits, the coated ties appeared to be doing a superior job, but as of 1963 the tie renewals in section 35 favored the uncoated ties. Only 3 uncoated ties or 5 percent had been renewed compared with 7 ties or 12 percent of those with coating. A check of renewals of oak ties in the 4 1/2-deg curve since 1947 shows 5 percent the same as the uncoated ties in section 35. Possibly a longer service period would show an improvement in the performance of the coated ties, but at this time a favorable report cannot be made. Figs. 44 and 45 show coated and uncoated ties in the north half and south half of the section respectively. From these pictures there is no basis on which to favor the coated ties. In section 36 where existing ties were coated, 29 ties or 25 percent have been renewed. This is a normal rate of renewal for the period involved and affords no basis for any conclusion.

Sections 04 and 05

These sections were established in 1958 with section 04 having Bird 5 ply coated tie pads and Bernuth Lembcke gage lock spikes and tie plate lock spikes applied to three 39 ft rail lengths of 132 lb RE rail on the 5-deg, 36-min curve in the northward main track 0.5 miles north of East Bernstadt, using the 72 existing creosoted oak ties and 13 in double shoulder tie plates. Section 05, adjoining section 04 on the south was

established as a control section also having 72 existing ties, 132 lb RE rail and 13-in double shoulder tie plates. These test sections were established to determine if installation of the tie pads and special fastenings would increase tie life on the sharp curve. At the time of installation a record was made of the date of each tie in the two sections. The average age of ties in sections 04 and 05 at the time of installation in 1958 were 10.4 years and 8.9 years respectively, indicating a slightly better tie condition in section 04. During the 5 year period, 11 ties were renewed in section 04 and 9 ties in section 05, bringing average age to 12.3 years and 11.9 years respectively. The short test period does not permit any conclusions regarding the effectiveness of the pads and the special fastenings insofar as tie life is concerned. Gage of the two sections was discussed earlier in this report.

Tie Pads

Rubber or Rubber Composition Pads

The Railroad Rubber Products pads in section 54 have given good service since installed in 1955 although slightly stretched at the anchor spike holes. Only the south 10 ties were sealed and this seal had disappeared; hence, the pad offers no protection against moisture or sand in the area under the plate.

The Dunne Rubber Company's molded rubber pads in section 43, installed in 1950, were only 1/8-in thick and uncoated. These pads were of insufficient strength and all squeezed out, badly torn with the field end gone on many of them.

The Johns-Manville rubber-vegetable and asbestos pads and rubber composition pads in section 39, installed in 1950 and 1951 respectively, were nearly all badly split with many torn. The coating of the 1951 pads squeezed out soon after installation. These pads have been too weak and without suitable seal.

Fiber-Rubber Pads

Fabco fiber-rubber pads were installed in sections 21, 41 and 56 with various dates from 1947 to 1959. The original installations in section 21 on the short 4 1/2-deg curve, oak tie tangent and pine tie tangent were uncoated; hence, had no seal. The pads in section 21 stretched and wore badly although offering some protection of the tie. The section 41 installation at East Bernstadt, in 1950, was primarily to try out coatings on the south 1/2 of the section, but these coatings did not hold a seal very long and the majority of the pads were stretched, Fig. 32. The installation in section 56, also at East Bernstadt, was first made in 1955 and replaced in 1959 to try a new super-seal coating. Neither had sufficient service for a good test, but the 1959 pads, Fig. 35, were holding a good seal and appear to be satisfactory.

Racor fiber-rubber pads were first installed in section 46 in 1951 with a subsequent installation in section 48 in 1952. The pads in section 46 had considerable splitting at the anchor spike holes, Fig. 33, and had lost their seal but had given fair service for nearly 12 years. The pads in section 48 were accompanied by Racor studs for anchors. After almost 11 years, they were giving good service with a few splits at the anchor spikes but still retaining some seal as indicated in Fig. 42.

Johns-Manville fiber rubber pads, section 55, Fig. 34, had performed well over a period of 8 years except that the coating was no longer effective. A few pads were stretched slightly.

Bird fiber-rubber pads were installed in section 29 and section 3 on the 4 1/2-deg curve in the years 1949 and 1952 respectively. Neither section had held its seal with the tie. Section 29, without anchor spikes, was in good condition with very few splits, whereas section 3, with two cut spikes for anchors, had a considerable number of splits, the majority of w ich were on the field end of the pads under the low rail. The pads in section 3 were to have been an improved version, but this is not substantiated by the results.

Laminated Tie Pads

The Bird duck-felt pads, 7 ply in section 5 on the 4 1/2-deg curve, oak and pine tangents and 5 ply in section 4 on the oak and pine tangents were discontinued by the manufacturer due to the tendency for the paper felt plies to work out of place. Jute burlap was substituted for the felt. Over the 16 service years, these duck-felt pads had afforded protection for the ties, but had become rather badly dislocated and delaminated.

Bird duck-burlap pads replaced the duck-felt pads in part of sections 4 and 5 of the 4 1/2-deg curve in 1948. The 5 ply pads are shown in Figs. 38 and 39 and the 7 ply pads in Figs. 40 and 41. While about 15 percent of the pads had become badly delaminated, many still held a seal and were protecting the tie. In 1949, section 30 was established with duck-burlap pads and 11 in. tie plates to determine if pads might permit shorter tie plates. The performance of these short pads was reasonably good, but they showed greater damage than those under the 13 in plates. Duck-burlap pads were in the south 1/2 of section 38 with tie plate lock spikes and gage lock spikes but this installation was only 5 years old and there was no progress to report except that it was in excellent condition.

Bird 5 ply jute pads were first installed on the south 24 ties of section 40, at East Bernstadt, in 1956. Some ply separation was noted under the outer rail after 6 years service. It is believed that the pad would continue to give good service for many years although its construction is somewhat less rugged than the duck-burlap pad with cotton duck outer plies. The north 1/2 of section 38, built in 1958, has similar pads with tie plate lock spikes and gage lock spikes. These pads were in excellent condition but being only 5 years in service, an appraisal cannot be made.

The Johns-Manville laminated rubber asbestos pads in section 25 wore well, but they had no seal and were so hard that they wore into the tie in a manner similar to a tie plate.

The Taylor Fibre Company's rubber-vulcanized fiber laminated pads in the north 1/2 of section 40, started to fail in the first year of service through delamination and splitting of the fiber plies. They had no seal with the tie and the hard surface created wear of the wood so the pad served no purpose.

Miscellaneous Pads

Konvex tire carcass pads were installed in the south 1/2 of section 28 in 1958 and in the north 1/2 of the section in 1959. Both installations were coated top and bottom, but in 1959 a polyethylene film was placed on top of the pad so it would not adhere to the tie plate. As indicated in Figs. 11 and 12, both installations were maintaining a seal and were giving good service. It appears that they would continue to perform well over a considerable period of time.

The Burkart pads, section 27, were a vegetable fiber pad impregnated with an organosol but without a coating. This pad had no seal and crushed rather badly. It held moisture and squeezed out from under the plate particularly the field end under the outer rail. The outer end of many of the pads was completely gone and the plate was cutting the tie. Section 47 was installed in 1952 using Burkart pads of the same formation as in section 27 but coated on the bottom side. These latter pads were stretching and tearing badly on the field end under the outer rail. It is apparent that good results cannot be obtained from this type of pad and in fact it is no longer on the market.

The Bird vinyl pads on the north 27 ties of section 4 of the 4 1/2-deg curve did show some deterioration due to stretching and dislocation but were still protecting the tie. It is believed that the manufacturer has discontinued the vinyl pad.

Dayton Rubber Company's cast steel plates with raised rubber insert pads, sections 44 and 45, are not suitable because they concentrate the tie plate load on about 1/3 the area of a conventional tie plate and are prohibitive from a cost standpoint.

The one-ply duck pads with asphalt coating in section 3 of the oak and pine tangents were an effort to determine if a sealant with duck fabric as a bond would serve to protect the tie at a nominal cost. These pads began working out after 4 years service and since that time had little value in protecting the wood.

Pads Removed from Service During the Test Period Due to Failure or Obsolescence

Section 3, 4 1/2-deg curve; one-ply duck with asphalt coating replaced in 1952 with Bird improved fiber rubber account of fabric badly dislocated and torn after five years service.

Section 4, 4 1/2-deg curve, south 20 ties; Bird 5 ply duck-felt pads removed after one year to permit placing an improved pad using burlap jute for inner plies rather than paper felt.

Section 5, 4 1/2-deg curve, north 20 ties; Bird 7 ply duck-felt pads removed after one year to permit placing an improved pad using burlap jute for inner plies rather than paper felt.

Section 28, 4 1/2-deg curve; Western Wool Works' wool felt pads worn, stretched and dislocated, were removed in 1958 and 1959 after 9 and 10 years service respectively, to provide test space for Konvex tire carcass pads.

Section 38, 5-deg curve, East Bernstadt; Achuff sisal fiber pads worn, stretched and torn were removed in 1958 after six years service to provide test space for Bird 5 ply duck-burlap and 5 ply jute pads with tie plate lock spikes and gage lock spikes.

Section 40, 5-deg curve, East Bernstadt, south 24 ties; Taylor Fibre Company's rubber-vulcanized pads with plies split and delaminated were removed in 1956 after six years service to provide test space for Bird 5 ply all jute pads.

Section 41, 5-deg curve, East Bernstadt; Fabco pads with Baker's K-2 cement on bottom side were removed at the end of one year at the request of the sponsor to permit installation of similar pads with a newly developed oxidized asphalt coating on the bottom.

Section 56, 5-deg curve, East Bernstadt; Fabco pads with bottom coated were changed out in 1959 after 4 years service to permit installation of similar pads having a new type coating called Super-Seal on the bottom.

Tie Renewals

As all ties were new at the time of installation in 1947, renewals had only become necessary in recent years except in the tangent with creosoted oak ties where a derailment occurred in 1955. The following tabulation covers the renewals of 1947 creosoted oak ties in the 4 1/2-deg curve and 1947 creosoted pine ties in tangent track. Of the ties renewed, 24 percent of the oak and 19 percent of the pine were joint ties.

	Total Ties	Ties Renewed	Percent Renewed
4 1/2-Deg Curve-Creosoted Oak			
Control Sections	142	11	7.8
Special Fastenings	592	21	3.5
Tie Pads	120	11	9.2
Coatings	46	6	13.0
Total	900	49	5.5
Tangent-Creosoted Pine			
Control Sections	119	5	4.2
Special Fastenings	454	53	11.7
Tie Pads	143	4	2.8
Coatings	42	1	2.4
Total	758	63	8.3

The foregoing table is given as a matter of information as 16 years service is hardly sufficient to permit any definite conclusions. It appears, however, that the special fastenings have not been helpful in increasing the service life of the creosoted pine ties.

LABORATORY TESTS - RESEARCH CENTER

Foreword

The engineering laboratory at the AAR Research Center was built in 1957, and in 1958 was equipped with the first of two tie wear machines, Fig. 46, designed by staff members. The second machine was built and installed in 1959. These machines were for the purpose of evaluating tie plate fastenings and tie pads for both wood and concrete ties.

The tie wear machines were so designed that they provide loading on the rail comparable to that on the outer rail of sharp curves as determined from field investigations. The loading by two struts is accomplished through the vertical motion of the loading beam through a block to which the struts are attached. The vertical component of each strut is kept at an average of 20,000 lb on the tie plate with horizontal components of 7500 lb outward and 3750 lb inward of the track. Tests are operated at 129 cycles per minute for 2,500,000 cycles or 5,000,000 loads with full release between loads. After a seating period of 2500 cycles, sand and water are added to accelerate the plate cutting.

The first year of operation of the pilot machine was devoted chiefly to removing the "bugs" by redesign of various parts which failed in service or did not produce the desired results. Except for minor changes the second machine was built as a duplicate of the first machine including all revisions.

INVESTIGATIONS WITH TIE WEAR MACHINES

About the time the machines were placed in service, concrete ties were under investigation and one machine was assigned to the study of fastenings, pads and insulating bushings for use with such ties. The other machine was assigned to investigation of fastenings and pads for wood ties. Presently, both machines are used mainly for studies with wood ties or for special investigations. This report deals only with wood ties.

Hold-Down Fastenings

The basic control test, established for evaluating subsequent tests, was a 7 3/4-in by 14-in tie plate, AREA Plan 12 on a creosoted red oak tie with two 5/8-in cut spikes each for line and anchor. This is the spiking pattern in common use where anchor spikes are employed. To date, three of the control tests have been made and the average is being used as a basis of evaluating special hold-downs. The average of the three tests of 2.5 million cycles each, give tie plate penetration comparable to that obtained with 14-in plates in section 23 on the long 4 1/2-deg curve at London, Kentucky, after 190 million gross tons of traffic.

Table 7 shows a correlation on a percentage basis, between results obtained on certain special fastenings in the service tests on the L&N at London, Kentucky, and the tie wear machines in the laboratory. Except for the test with AAR clips, the results are not considered to be too far out of line. The laboratory results with Racor studs and with tie plate lock spikes are somewhat low, but possibly one test is not sufficient to develop a desirable comparison because of variations in the wood structure. The AAR clips did not develop an equivalent amount of plate cutting probably because the machines were not built to simulate the uplift of the rail that occurs in track between the two trucks of each passing car.

Tie Pads

Numerous tests of tie pads have been conducted as specimens have been made available by the suppliers. Table 8 shows the results of these tests together with pertinent data from control tests with creosoted oak and fir ties.

It will be noted that the Bird 5 ply SD duck-burlap pad with the outside plies of cotton duck gave superior performance to the 5 ply LD all jute (burlap) pads in the matter of seal with the tie and pad condition at the end of the tests. The tie wear of the SD pad on oak ties was also less than the LD due primarily to a better seal. The figure shown for tie wear on the fir ties was chiefly wood compression and is not significant. It is apparent that the LD pad will not withstand heavy duty service as well as the SD pad but for moderately heavy traffic on tangent track, should be satisfactory.

Of the 1/8-in Racor pads, the one in test M2-10A performed fairly well, but the other three gave a rather poor performance in that they offered little or no protection for the wood at the end of the tests. The thicker 3/16-in pads in tests M1-67 and M2-46 held up much better although they did lose their seal. It appears that the additional thickness is important in heavy duty service although the thinner pad would no doubt protect the tie under light traffic conditions.

The Fabco pads performed reasonably well except for broken spikes which also occurred in most other pads of rubber composition due to heavy lateral movement. As with the 1/8-in Racor pad, the Fabco pad of 1/8-in thickness appears too light for heavy service but should protect the tie under less severe conditions.

The Konvex tire carcass pad came out of the short test in good condition. The test was stopped because the lateral movement became excessive. While these pads have done well in the 4 1/2-deg curve of the L&N tests after 5 years service, some difficulty might be expected on the high rail of extremely sharp curves. This pad appears to have a good seal and the tie wear or wood compression are relatively light.

The Railroad Rubber Products pad was weak in resistance to lateral movement and the tie wear or wood compression were greater than in the control tests by about 30 percent. The pad was badly worn when the test was stopped and of course had no coating to seal off the tie surface from moisture.

Tests with Various Size Tie Plates

Table 9 provides a comparison between 12-in, 14-in and 16-in tie plates on creosoted oak ties and the smaller sizes on creosoted fir ties. The 12-in and 14-in plates had 3/8-in eccentricity and were AREA Plans 9 and 12 respectively, whereas the 16-in plate had 1 1/4-in eccentricity and was AREA Plan 21, designed for curves only. These tests permit comparison with results of some of the control tests on the L&N. The tie wear ratio of field over gage 1:1.75 for 14-in tie plates compares favorably with the average of 1:1.74 for sections 23 and 37 on the high rail of curves of the London, Kentucky, tests. The laboratory tests show the tie wear for 14-in plates on pine ties to be 138 percent of the wear for similar plates on oak ties, whereas the wear in sections 9 and 23 of the pine ties was 144 percent of the wear of similar sections of the oak ties also in tangent track. From these comparisons, it appears that the tie wear machines are providing data that is reasonably representative of service performance.

Epoxy Resin Adhesives

Investigations were conducted with epoxy resins as a means of fastening tie plates to ties and applying hardwood wearing surfaces to softwood ties. The results are given in Table 10.

From the several tests with tie plates glued to oak and fir ties, it is quite apparent the addition of water softens and weakens the wood fibers thereby causing a progressive loss of bond. On the basis of these test findings, the use of epoxy resin adhesives to prevent tie plate movement does not show any promise for ordinary track conditions where exposure to moisture may be expected. However, such adhesives have some promise if their use is confined to subways, dry tunnels or other locations which are free from moisture. It should also be kept in mind that water is one of the chief elements contributing to tie plate wear, hence, there is doubt as to the need for adhesives or hold-down fastenings under dry conditions except to maintain gage.

It has been thought that the life of softwood ties and their general performance might be improved by providing a hardwood bearing surface to better resist tie plate penetration. Test specimens of three-ply untreated and Penta treated hickory plywood were attached to the bearing area of untreated fir bridge ties using epoxy formulation as noted in Table 10. The specimens were then treated with a mixture of creosote and coal tar before being placed in the machine. As near as could be determined, there were no harmful effects from the creosote treatment. The results of tests M1-54 and M2-33 show that the adhesive failed in bond in a manner similar to the tests with plates glued to the ties. There was also heavy erosion on both the fir timber and the plywood.

CONCLUSIONS

1. Hold-down fastenings with the best performance relative to tie wear are superior in holding gage.

2. Special fastenings involving the use of bolts, washers and clips require more maintenance to keep them effective than more simple fastenings such as lock spikes or studs.

3. Tie plates with diamond bottoms have some usefulness in holding gage on curves, but have no such benefit on tangent and do not materially decrease plate cutting.

4. It is difficult to establish a superiority of 14-in plates over 13-in plates insofar as plate cutting is concerned but the 14-in plates have done a slightly better job in holding gage.

5. Tie pads have protected the ties from plate cutting, but only in the pine ties have they shown any results to indicate than an increase in tie life might be expected from their use.

6. Tie pads appear to have little effect on gage in tangent track, but have a tendency to contribute to gage widening on curves.

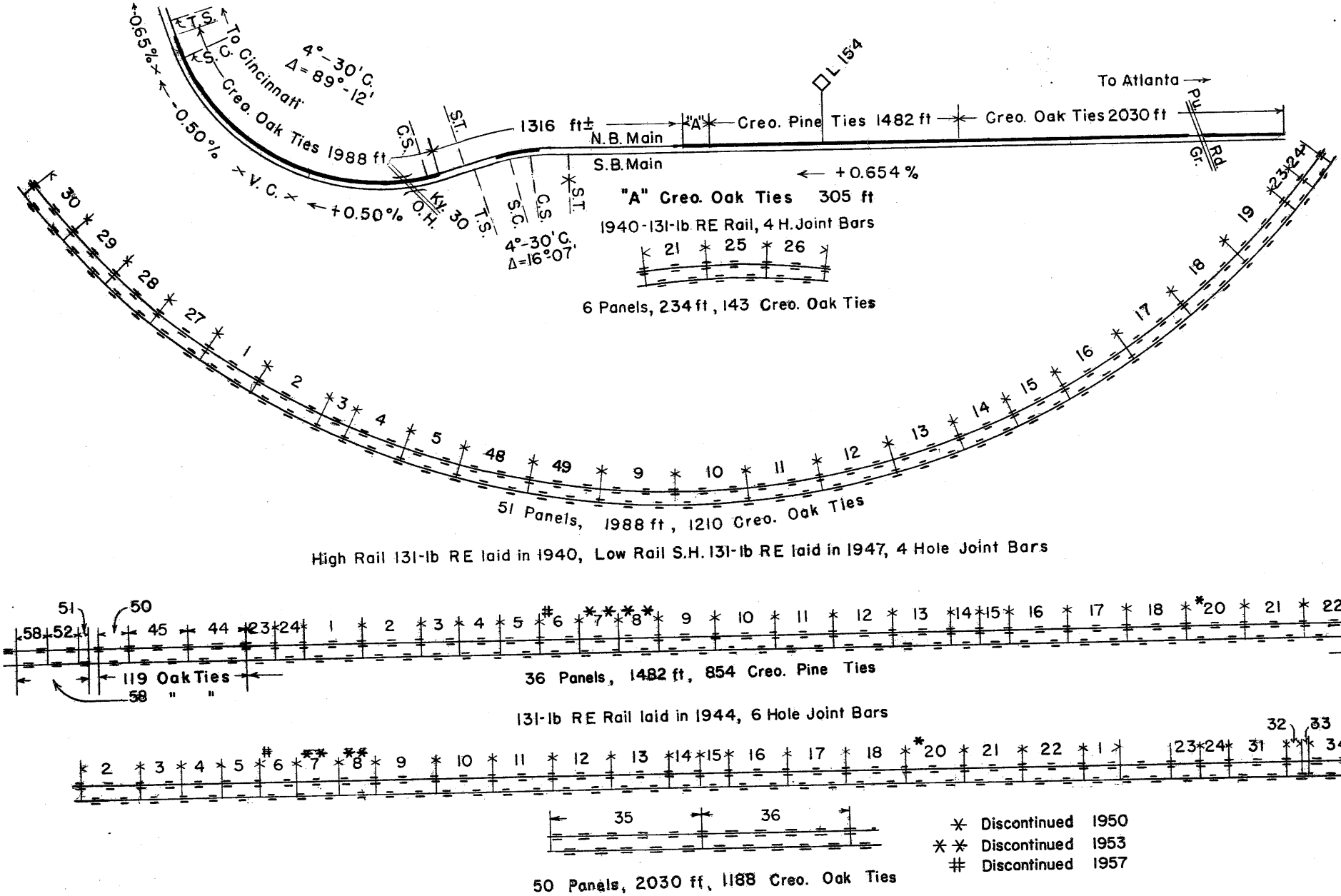
7. To be most effective, tie pads should be coated on the bottom with a coating which will also adhere to the wood and provide a seal against water and sand or other abrasive material for a substantial period of time.

8. A tie pad should be not less than 3/16-in thick and of such material that it will withstand a static tensile test of 1250 lb longitudinally and 500 lb transversely.

9. The tie wear testing machines in the AAR Engineering Laboratory provide results comparable to service testing and will permit evaluation of hold-down fastenings and tie pads on an accelerated basis.

References to progress reports in American Railway Engineering Association Proceedings

Vol. 49, p 357; Vol. 50, p 595; Vol. 51, p 675; Vol. 52, p 563; Vol. 53, p 65; Vol. 53, p 785; Vol. 54, p 1047; Vol. 55, p 721; Vol. 56, p 836; Vol. 57, p 707; Vol. 58, p 852; Vol. 59, p 1035; Vol. 60, p 800; Vol. 61, p 948; Vol. 62, p 668; Vol. 63, p 494; Vol. 64, p 440; Vol. 65, p 515.



High Rail 131-lb RE laid in 1940, Low Rail S.H. 131-lb RE laid in 1947, 4 Hole Joint Bars

131-lb RE Rail laid in 1944, 6 Hole Joint Bars

Fig. 1.- Plan of Test Track

TABLE 1. DESCRIPTION OF TEST SECTIONS SHOWN IN FIG. 1

Section No.	No. of Test Ties: Creo. Oak Curve	Creo. Oak Tang.	Pine Tang.	Total	Tie Plate Length in.	Date Built	Number and Type of Hold-Down Fastenings per Tie Plate, Tie Pads and Coatings (131-lb RE Rail)
1							Coatings and adhesives - no anchor spikes - subdivided as follows:
1.1	11	6	12	29	13	9-47	Beckosol No. 40. Hot paddle coat applied to bottom of tie plate
1.2	9	9	9	27	13	9-47	AREA Specification Waterproofing Asphalt applied as in subsection 1.1
1.3	0	4	6	10	13	9-47	CASCO Flexible Cement NT-442 applied to tie plate and tie in the field
1.4	3	3	6	12	13	9-47	NT-442 Cement applied to tie plate as a primer and CASCOPHEN RS-216 applied to tie plate and tie in the field
1.5	9	9	9	27	13	9-47	Same as subsection 1.4 except the tie plates were cemented to the ties before creosoting
1.6	2	0	0	2	13	9-47	Premolded sheet of asphalt, 1/8 in thick, made of regular Bird tie pad coating, designated No. 52
1.7	2	0	0	2	13	9-47	Premolded sheet of asphalt, 1/8 in thick, made of regular Bird tie pad coating modified to further reduce flow, designated No. 53
1.8	2	0	0	2	13	9-47	Same as subsection 1.7, except the asphalt was formed around brass screening, designated No. 54
1.9	2	0	0	2	13	9-47	Same as subsection 1.7, except the asphalt was formed around 1/4 in mesh galvanized screening, designated No. 55
1.10	6	0	0	6	13	8-48	Solvated Sealz Coating. Heavy brush coat applied to tie and tie plate
2	59	47	48	154	13	8-47	No anchor spikes (Rubber line spike cushions were applied to the north 24 ties of each tangent section 12-49)
3	0	31	32	63	13	8-47	1-ply duck pad with asphalt coating (Made by Bird & Son), no anchor spikes
3	(b)24	0	0	24	13	6-52	Bird improved fiber-rubber pads (1-ply duck pads were in service on the same ties from 8-47 to 6-52)
4	(b)27	0	0	27	13	6-52	Bird vinyl pads on N. 27 ties (5-ply duck-felt pads were in service on the same ties from 8-47 to 6-52)
4	0	32	32	64	13	8-47	5-ply Bird duck-felt pads, no anchor spikes
4	20	0	0	20	13	8-48	5-ply Bird duck-burlap pads on the south 20 ties of curve test section (Duck-felt pads in test 8-47 to 8-48), no anchor spikes
4							7-ply Bird duck-burlap pads on the north 20 ties of curve test section (Duck-felt pads in test 8-47 to 8-48), no anchor spikes
5	20	0	0	20	13	8-48	7-ply Bird duck-burlap pads, no anchor spikes
5	29	31	32	92	13	8-47	7-ply Bird duck-felt pads, no anchor spikes
6*	0	32	32	64	13	8-47	2 each of cut spikes for line and Racor Studs for anchors, (Changed from 2 Racor Drive Tight line spikes 12-49)
7*	0	32	32	64	13	8-47	2 each of Racor Drive Tight (Sandberg) line and anchor spikes. (Anchor spikes replaced 11-48)
8*	0	31	32	63	13	8-47	2 each of Racor Drive Tight (Sandberg) for anchors. (Anchor spikes replaced 11-48)
9	59	48	48	155	13	8-47	2 each of cut spikes for line and Racor Drive Tight (Sandberg) for anchors (Rubber anchor spike cushions were applied to the north 10 pine ties 12-49)
10	59	47	49	155	13	8-47	2 each of cut spikes for line and anchors. (Rubber anchor spike cushions were applied to the north 10 pine ties 12-49)
11	59	47	47	153	13	8-47	2 cut spikes for line and 2 round head cut spikes with single coil spring washers for anchors
12	57	48	48	153	13	8-47	2 cut spikes for line and 2 round head Dowel Studs with double coil helical spring washers for anchors
12	2	0	0	2	13	8-47	2 cut spikes for line and 2 Oliver Hold-Down Drive Spikes with double coil helical spring washers for anchors
13	47	47	47	141	13	8-47	2 cut spikes for line and 2 cone neck Oliver Hold-Down Drive Spikes without spring washers for anchors
13	12	0	0	12	13	8-47	2 cut spikes for line and 2 Elastic Spikes of design No. 93 for anchors
14	47	24	24	95	13	8-47	2 cut spikes for line and 2 Tie Plate Lock Spikes for anchors (North 12 ties)
15	48	24	24	96	13	9-47	2 cut spikes for line and 2 - 3/4 in thru bolts with single coil washers for anchors — Applied in the field / Applied in shop under load
16(a)	60	47	48	155	13	8-47	2 cut spikes for line and 2 screw spikes with double coil washers for anchors
17	60	47	47	154	13	8-47	2 cut spikes for line and 2 screw spikes for line and anchor spikes on tangent plus 2 cut spikes for line on the curve
							2 AAR spring rail clips and screw spikes for line and anchor spikes (PRR standard 14-3/4 in tie plates cut to a 13-in. length with 1/4 in eccentricity)
18	58	48	48	154	13	8-47	No anchor spikes. Erie single shoulder tie plate with diamond bottom and zero eccentricity
19(a)	59	0	0	59	13	8-47	2 cut spikes for line and 2 screw spikes with double coil washers and above Erie RR tie plate
21	0	47	47	94	13	8-47	Fabco tie pads, 1/4 in thick, uncoated, no anchor spikes
21	47	0	0	47	13	8-48	Fabco tie pads, 1/4 in. thick, uncoated, no anchor spikes

(Continued on next page)

TABLE 1. (CONCL.) DESCRIPTION OF TEST SECTIONS SHOWN IN FIG. 1

Section No.	No. of Test Ties				Tie Plate Length in	Date Built	Number and Type of Hold-Down Fastenings per Tie Plate, Tie Pads and Coatings (131-lb RE Rail)
	Creo. Oak		Pine	Total			
	Curve	Tang.	Tang.				
22	0	48	48	96	13	8-47	2 cut spikes for line and 2 Oliver Tie Plate Drive Spikes with single coil spring washers for anchors
23	24	24	23	71	14	9-47	L.& N. standard construction with 2 each of cut spikes for line and anchors
24	24	24	24	72	14	9-47	Same as section 23, except a Rails Co. compression clip was applied to alternate tie plates
25	47	0	0	47	13	8-48	Johns-Manville, uncoated, laminated rubber-asbestos tie pads; 1/8 in thick in north panel, 1/4 in thick in south panel, no anchor spikes
26	49	0	0	49	13	8-48	DL&W D.S. diamond bottom tie plate with 1/2 in eccentricity, 2 cut spikes for line and 1 anchor only
27	48	0	0	48	SH 13	10-48	Burkart fiber pads, no anchor spikes
28	24	0	0	24	SH 13	9-49	Western Felt Works wool felt pads, 1/4 in thick, no anchor spikes (North 24 ties)
28	24	0	0	24	14	8-58	Konvex Tie Pad Co. 3/16 in tire carcass pads coated top and bottom, 2 cut spikes each line and anchor (South 24 ties)
29	48	0	0	48	SH 13	9-49	Bird fiber-rubber pads, 1/4 in thick, coated, no anchor spikes
30	48	0	0	48	SH 11	9-49	Bird 5-ply duck-burlap pads. SH 11 in plates were cut from 13 in Plan 5B plates, no anchor spikes
31	0	48	0	48	14	8-49	G&H Controls No-Creep rail anchors on alternate tie plates. 2 cut line spikes on unanchored ties, 1 cut line spike and 2 Oliver Tie Plate Drive Spikes for anchors on anchored ties
32	0	12	0	12	14	9-49	Farbertite. Paddle coat applied to adzed surface and bottom of tie plate, no anchor spikes
33	0	5	0	5	14	9-49	Tie plates cemented to ties as in section 1.5 but under ideal conditions, no anchor spikes
34	0	48	0	48	14	9-49	2 cut spikes for line and 2 Tie Plate Lock Spikes for anchors. Asphalt roofing paint brushed on adzed surfaces of south 24 ties
35	0	120	0	120	SH 13	7-50	Coating of Koppers No. 16 Sealing Compound with covering of 1/4 in washed gravel on alternate new ties, 2 each of cut line and anchor spikes
36	0	118	0	118	SH 13	7-50	Coating of Koppers No. 16 Sealing Compound with covering of 1/4 in washed gravel on existing ties, 2 each of cut line and anchor spikes
44	0	48	0	48	12 7/16	11-50	Dayton Rubber Co's. cast steel tie plates with raised rubber insert pads on new ties, 2 each of cut line and anchor spikes
45	0	47	0	47	12 7/16	11-50	Same as section 44 except that existing ties in track were used
48	58	0	0	58	14	8-52	Racor coated tie pads with 2 cut line spikes and 2 Racor studs for anchors
49	60	0	0	60	14	8-52	2 cut spikes for line. 3 Racor studs as anchors on N. 30 ties and 4 on S. 30 ties
50	0	24	0	24	14	7-53	Paddle coat of "Anker Seel" applied to adzed surfaces, 2 each of cut line and anchor spikes
51	0	10	0	10	14	7-53	2 cut spikes for line and 2 creo. hardwood Nordberg pegs for anchors
52	0	24	0	24	14	8-53	Paddle coat of Protek-Tie applied to adzed surfaces, 2 each of cut line and anchor spikes
58	0	24	0	24	9	8-58	Railroad Rubber Products double shoulder 7 in x 9 in rubber tie plates, 4 cut spikes for line
	1,353	1,365	854	3,572			Totals

Notes: All of the new 13-in tie plates, except as noted above, were of the AREA Plan 5B (Modified) design with flat rail seat. Second hand (SH) 13-in tie plates were of the Plan 5B Design with rolled circular crown. All of the 14-in tie plates placed prior to 1949 were of the AREA Plan 6B design and subsequent installations were of the current design, AREA Plan 12.
All tie plates have flat bottom except as noted above.
In the sections on the two 4-deg 30 min curves where no anchor spikes were provided, 4 cut spikes were used.
(a). In the north half of each portion of the test sections the double coil Helical (experimental) spring washer was used and in the south half the double coil Thackery washer was used.
Prior to 1952, all of the above tie pads were placed without anchor spikes, except in sections 44 and 45. (b). These pads have 2 each of cut line and anchor spikes.
Section 20 with 2 Thompson rail and tie plate clamps has been excluded from this table and discontinued upon request by the sponsor.
Each portion of each test section has an oval tag on the north tie showing the section number, and every tenth tie from the north has a smaller tag showing the tie number.
*The supplier of the special hold-down fastenings in sections 7 and 8 requested discontinuance of these installations in 1953.
**The supplier of the special hold-down fastenings in section 6 requested discontinuance of these installations in 1957 because the Racor Studs are of obsolete design.
Konvex pads on the south 24 ties of section 28 installed Aug. 27, 1958 replaced Western Felt Works Wool Felt pads installed Sept. 1949.
North 30 alternate new ties section 35 recoated with Koppers Tie Sealing Compound with covering of 1/4 in stone chips Aug. 27, 1958.

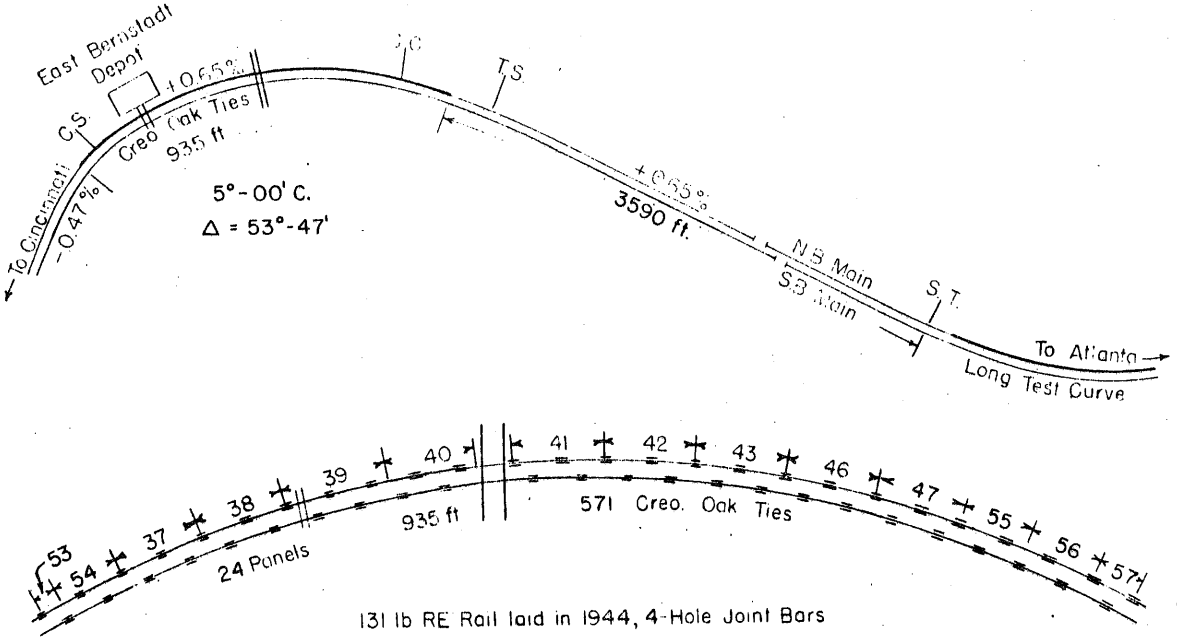


Fig. 2.– Plan of Test Track

TABLE 2. DESCRIPTION OF TEST SECTIONS SHOWN IN FIG. 2.

Section No.	No. of Creo. Oak Ties	Date Built	Number and Type of Hold-Down Fastenings per Tie Plate and Tie Pad AREA Flat Bottom 14-in Tie Plates, 131-lb RE Rail
37	48	7-50	2 each of cut spikes for line and anchors
38	48	8-58	Bird 5-ply coated pads (on new ties) with 2 Bernuth, Lembcke Gage Lock Spikes for line and 2 Bernuth, Lembcke Tie Plate Lock Spikes for anchor (North 24 ties LD jute pads) (South 24 ties SD duck and burlap pads)
39	22	7-50	Johns-Manville rubber-vegetable and asbestos fiber pads, uncoated (North 22 ties)
39	22	11-51	Johns-Manville rubber-comp. pads with coating on the bottom side, replacing original J. M. pads placed 7-50
40	24	7-50	Taylor Fibre Company's rubber-vulcanized fiber laminated pads (North 24 ties)
40	24	5-56	Bird 5-ply LD pads (Jute), coated (on 1950 ties)
41	23	7-50	Fabco pads, uncoated (North 23 ties)
41	12	7-51	Fabco pads with an oxidized asphalt coating compound on the bottom side. (These pads replaced pads placed in 7-50 with Baker's K-2 cement on the bottom side)
41	12	7-50	Fabco pads coated on both sides with Baker's S-72 cement (South 12 ties)
42	48	7-50	Dunne Rubber Company's molded rubber pad, 1/8-in thick uncoated
43	47	7-50	2 each of cut spikes for line and Racor Studs for anchors
46	24	11-51	Racor rubber-fiber pad, uncoated
46	25	11-51	Racor rubber-fiber pad with asphaltic coating on both sides
47	48	6-52	Burkart fiber pads, coated on bottom side
53	13	6-55	Nox-Rust tie seals under tie plates (solid sheet of Protek-Tie, approximately 1/8-in thick)
54	36	6-55	Railroad Rubber Products natural rubber pads 1/4-in thick, uncoated. The adzed surfaces of the south 10 ties were coated with Super Seal, a liquid rubber sealant
55	35	6-55	Johns-Manville fiber-rubber pads, 1/4-in thick, bottom coated
56	36	6-55	Fabco pads, bottom coated, 1/4-in thick on north 18 ties and 1/8-in thick on south 18 ties
57	24	6-56	2 each of cut spikes for line and Spring Lags for anchors
	571		Total

Notes: All pad sections have 2 each of cut line and anchor spikes. All sections, except Nos. 46 and 47, were installed with new AREA Plan 12 tie plates. Sections 46 and 47 have SH 14-in AREA Plan 6B tie plates. Plan 6B was withdrawn from the Manual in 1948.

Each test section has an oval tag on the north tie showing the section number, and every tenth tie from the north has a smaller tag showing the tie number.

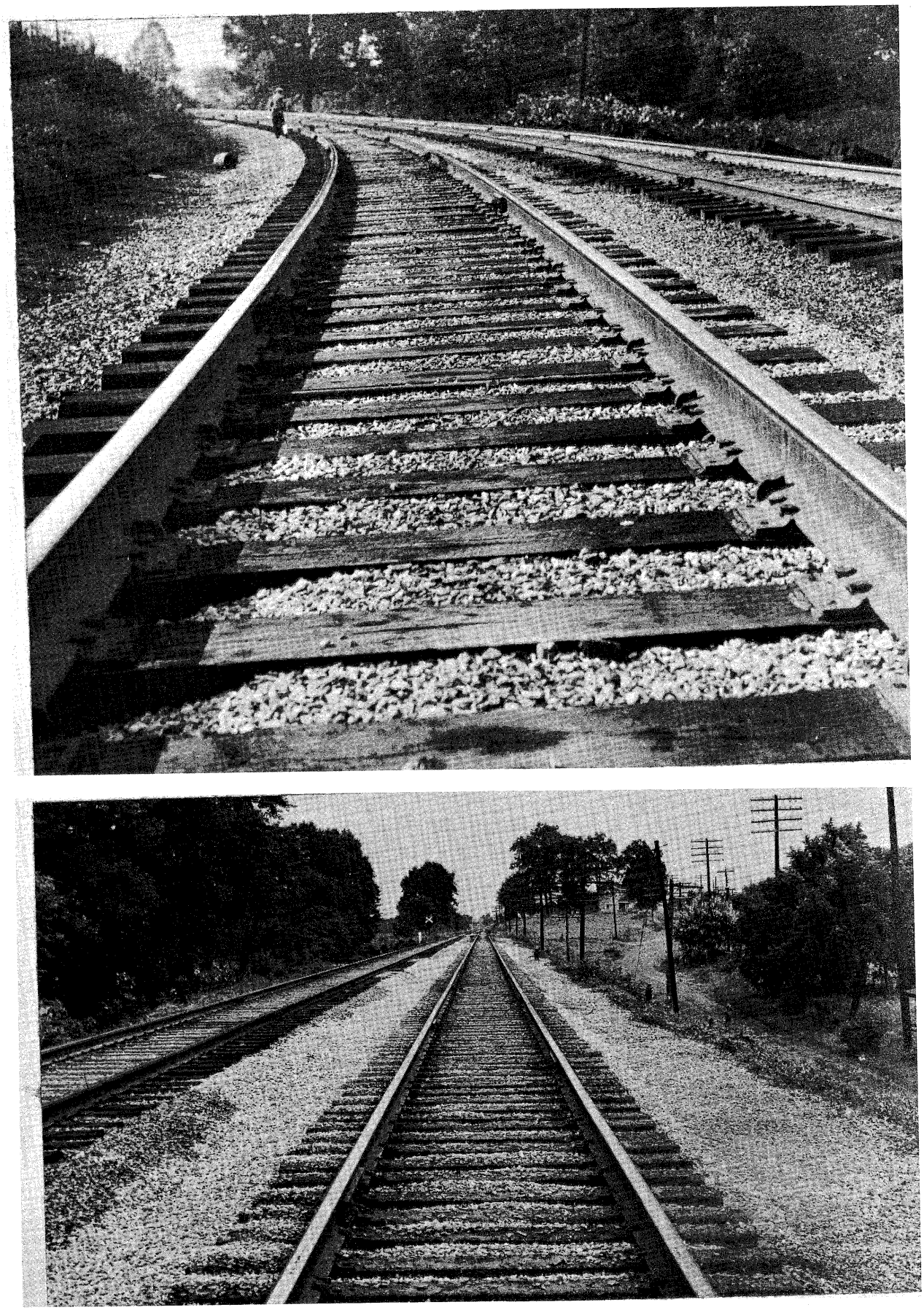
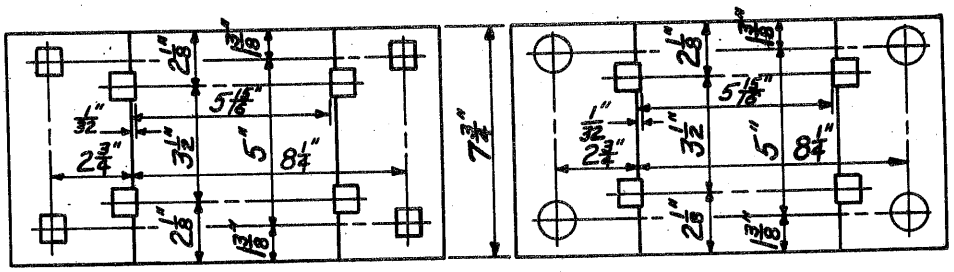


Fig. 3--Top - Southward View of Long 4 1/2-deg. Test Cur
Bottom - Northward View of Tangent Test Track.



Punching A

4-¾" sq. line spike holes and 4-11/16" sq. hold-down spike holes for section Nos. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 13, 21, and 22.

Punching B

4-¾" sq. line spike holes and 4 round hold-down spike holes as follows:

(1) 4-1" dia. holes for section No. 16.
(2) 4-15/16" dia. holes for section Nos. 11 and 12.
(3) 4-13/16" dia. holes for section Nos. 14 and 15.

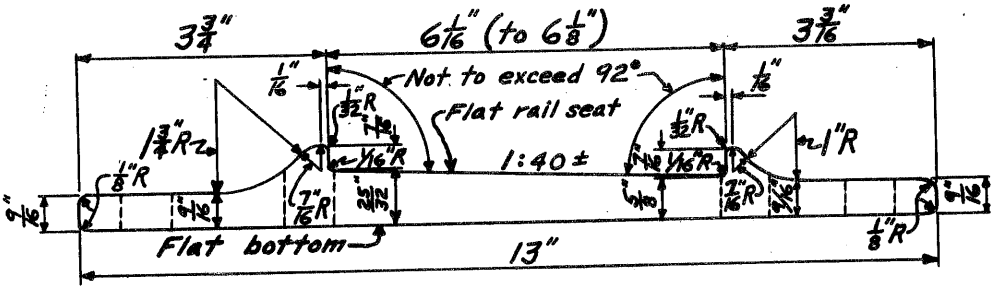
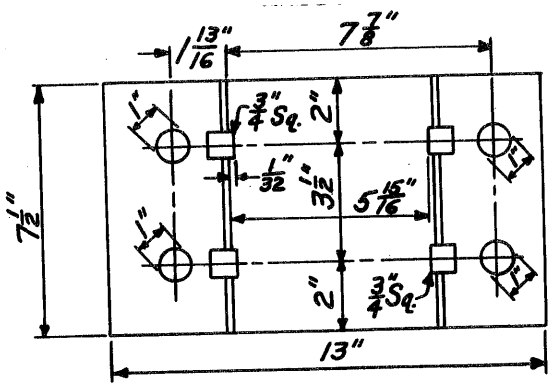


Fig. 4--AREA Plan No. 5B (Modified) Tie Plate for 131 lb RE Rail.



Punching

4-¾" sq. line spike holes and 4-1" dia. hold-down spike holes for section 17.

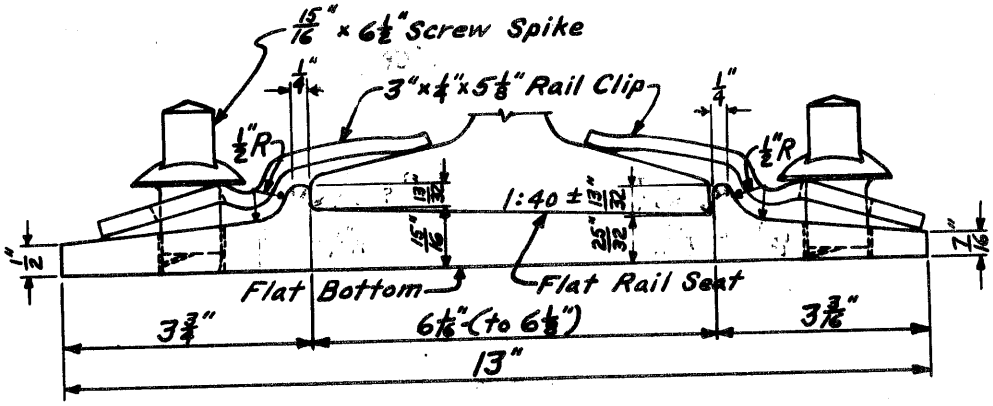


Fig. 5--Penn. R.R. Standard 14 3/4-in Tie Plate for 131 lb RE Rail Sheared to a 13-in Length and 1/4-in Eccentricity for Use with AAR Spring Rail Clip.

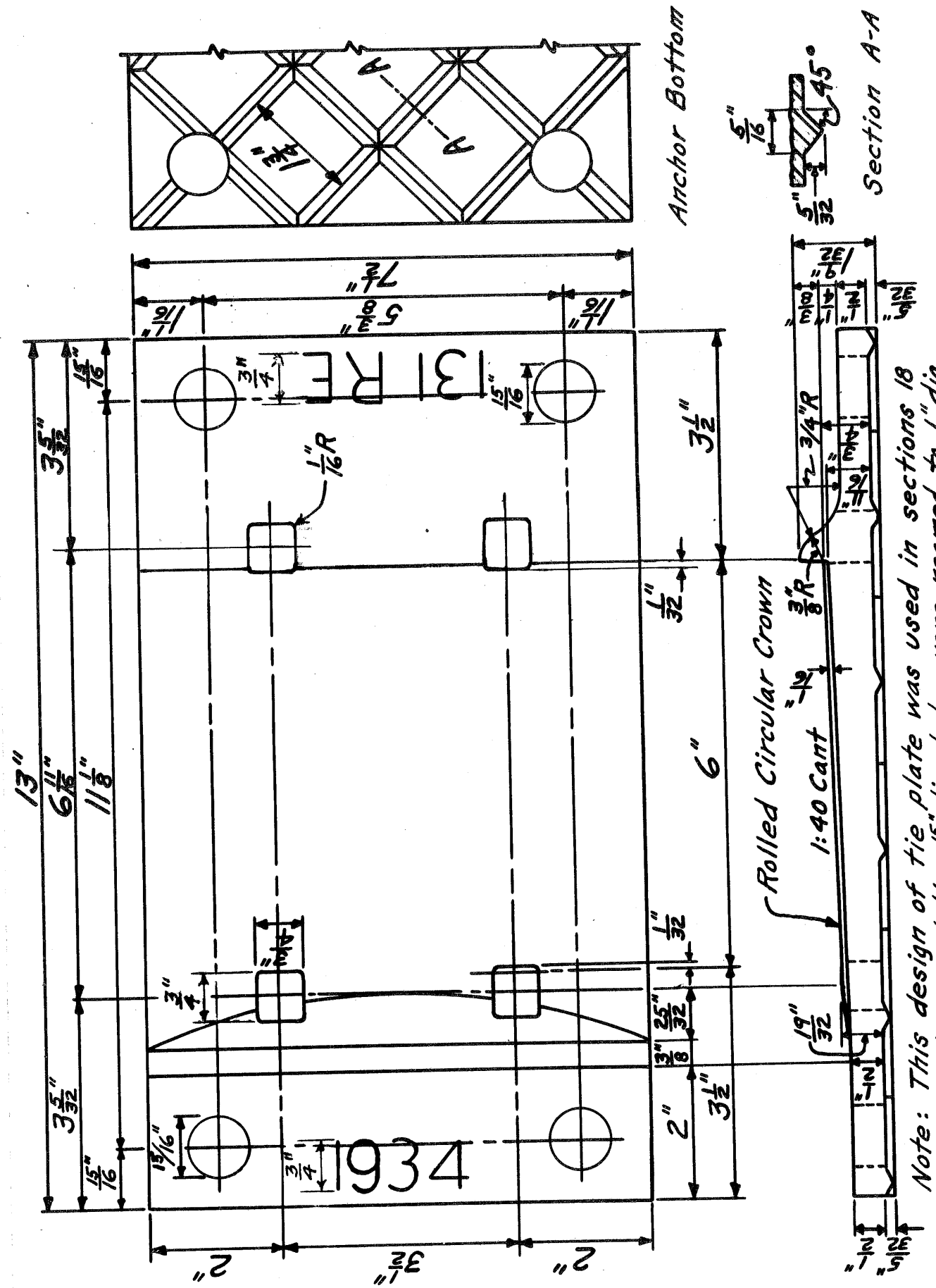


Fig. 6--Erie Railroad Standard 13-in Outside Joint Tie Plate for 131 lb RE Rail.

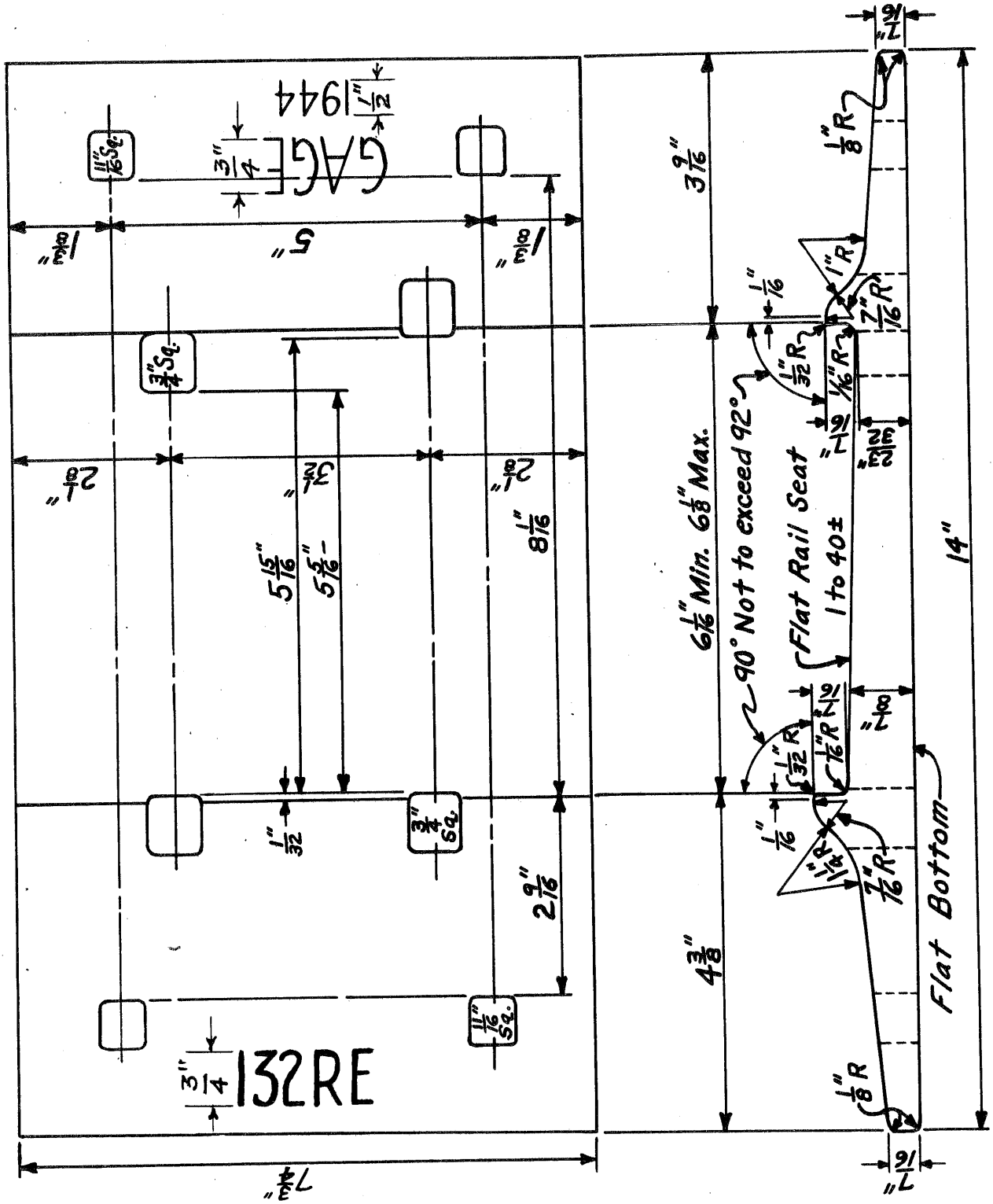


Fig. 7--L&N R. R. Standard 14-in Tie Plate for 131 lb and 100 lb RE Rails.

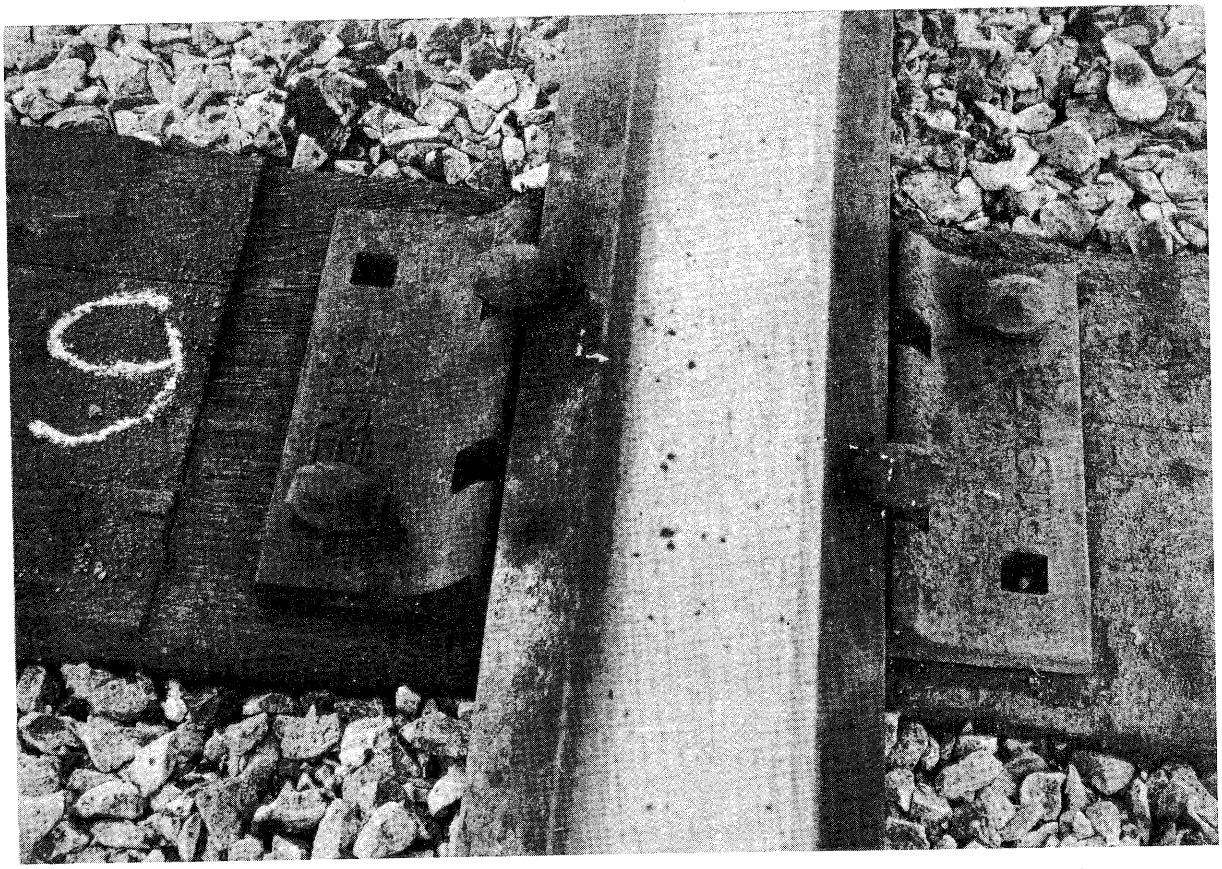


Fig. 8--Section 9, 2 each of Standard Cut Spikes for Line and Anchor

Fig. 9--Section 9, 2 Rubber Anchor Spike Cushions on North 10 Ties.

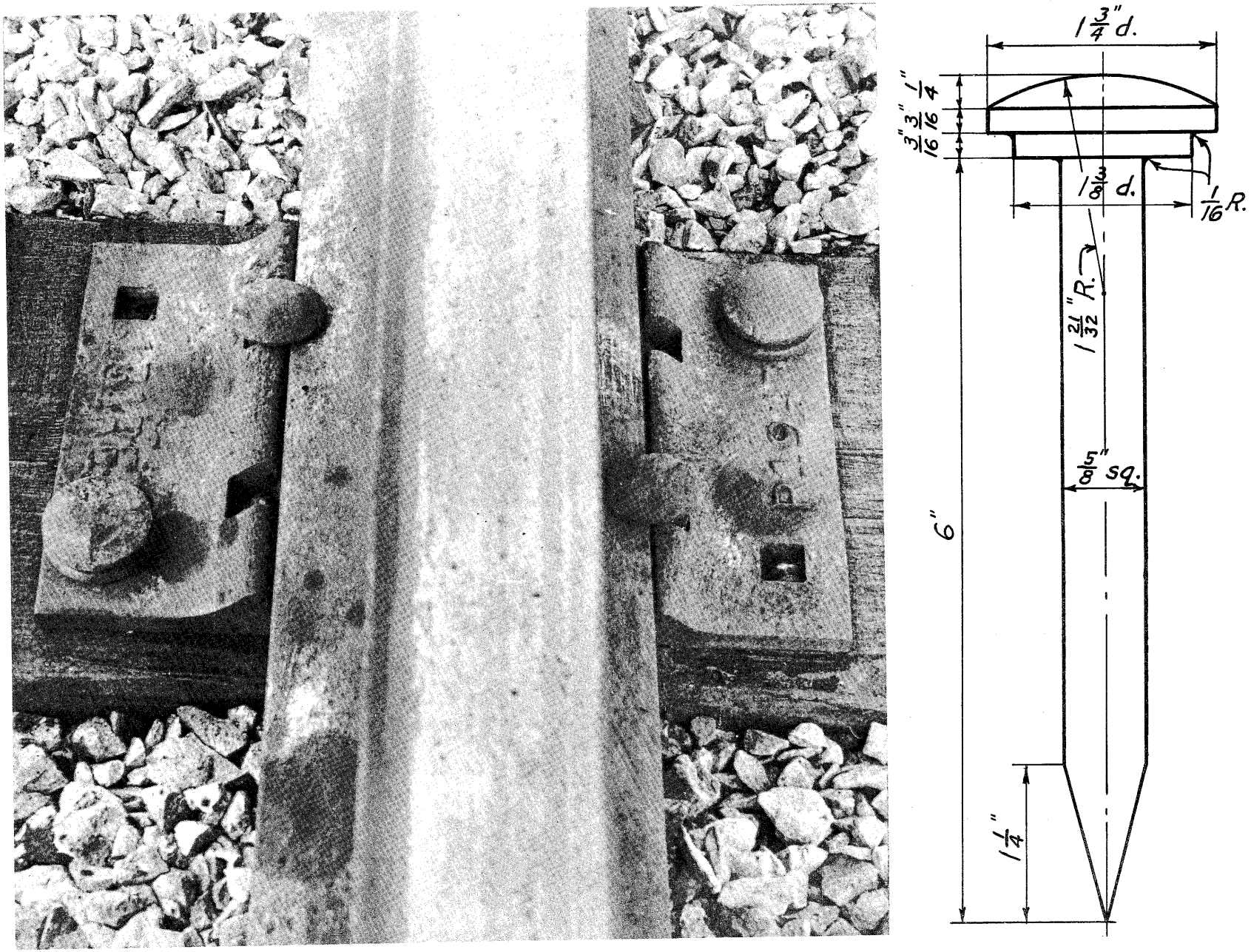
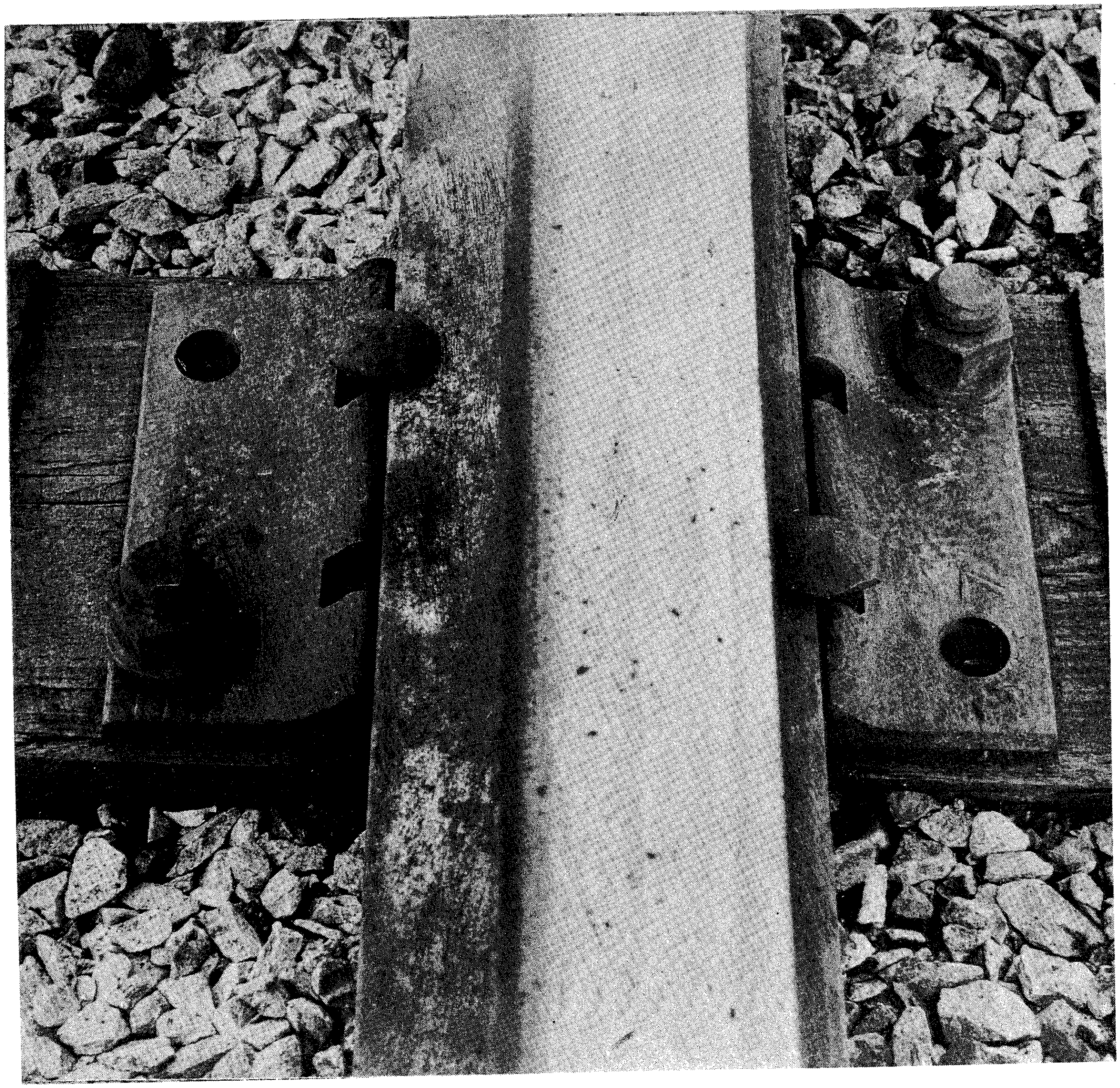


Fig. 10--Section 10, 2 - 5/8 in x 6 in Round Head Cut Spikes with Single Coil Alloy Spring Washers.



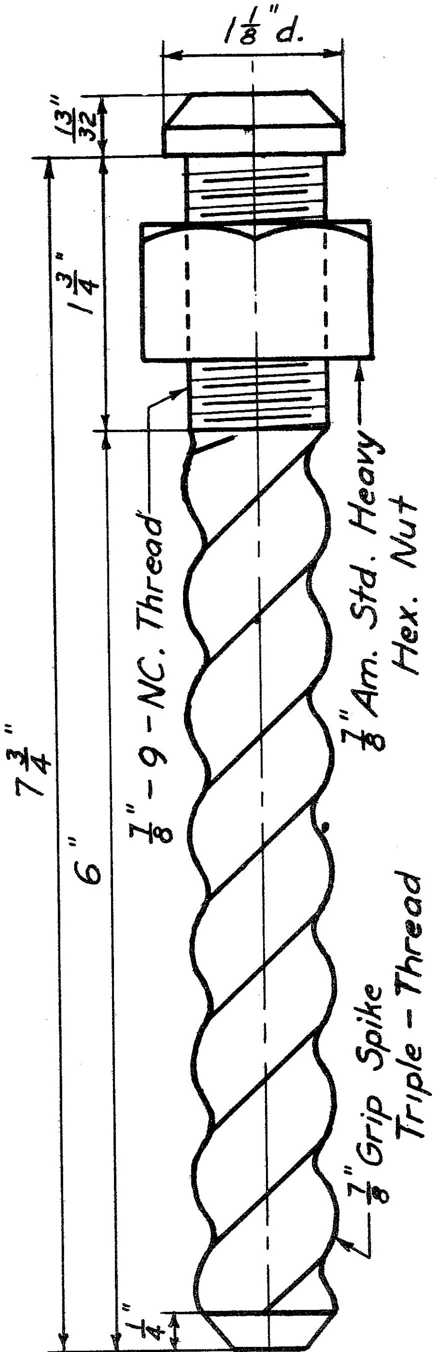
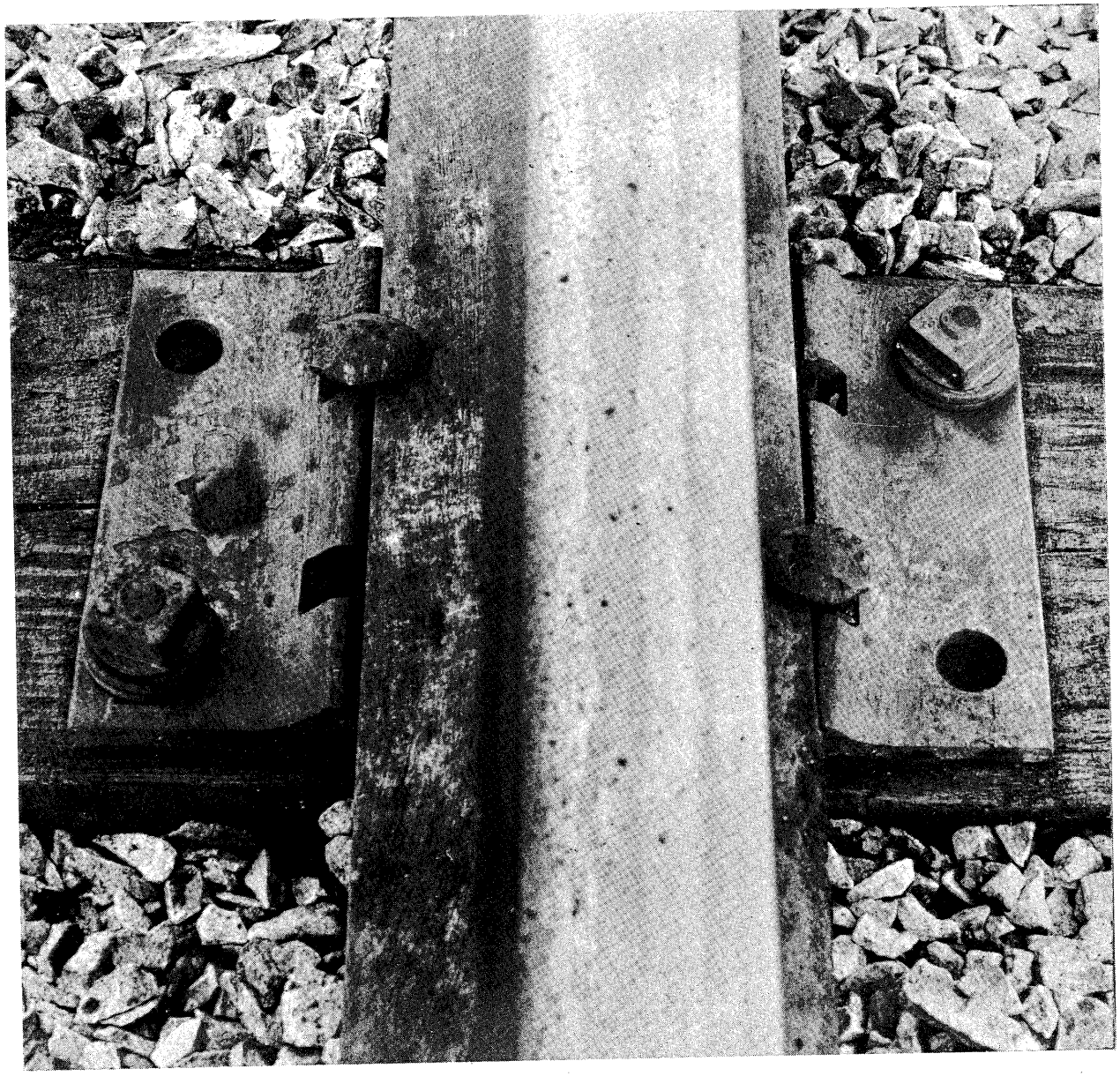


Fig. 11--Section 11, 2 - 7/8 in x 7 3/4 in Dowel Studs with Double Coil Helical (Experimental) Spring Washers



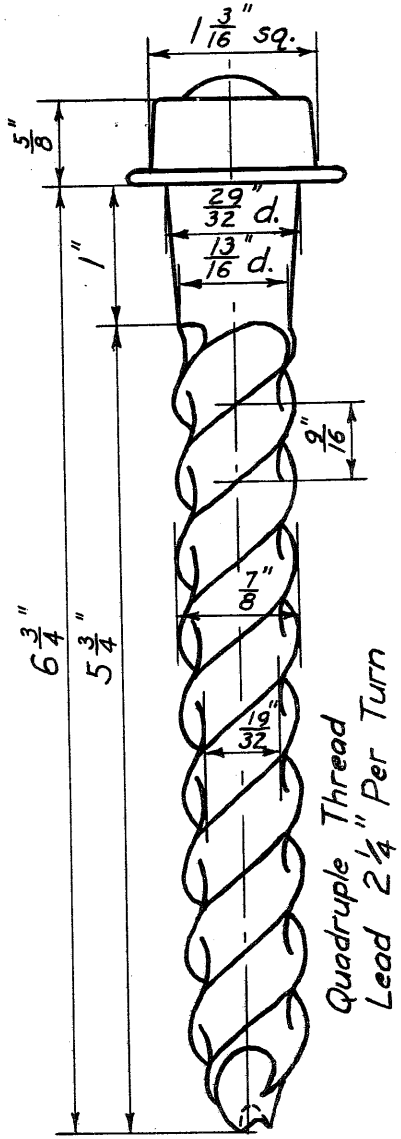


Fig. 12--Section 12, 2 - 7/8 in x 6 3/4 in Oliver Hold-down Drive Spikes with Double Coil Helical (Experimental) Spring Washers.

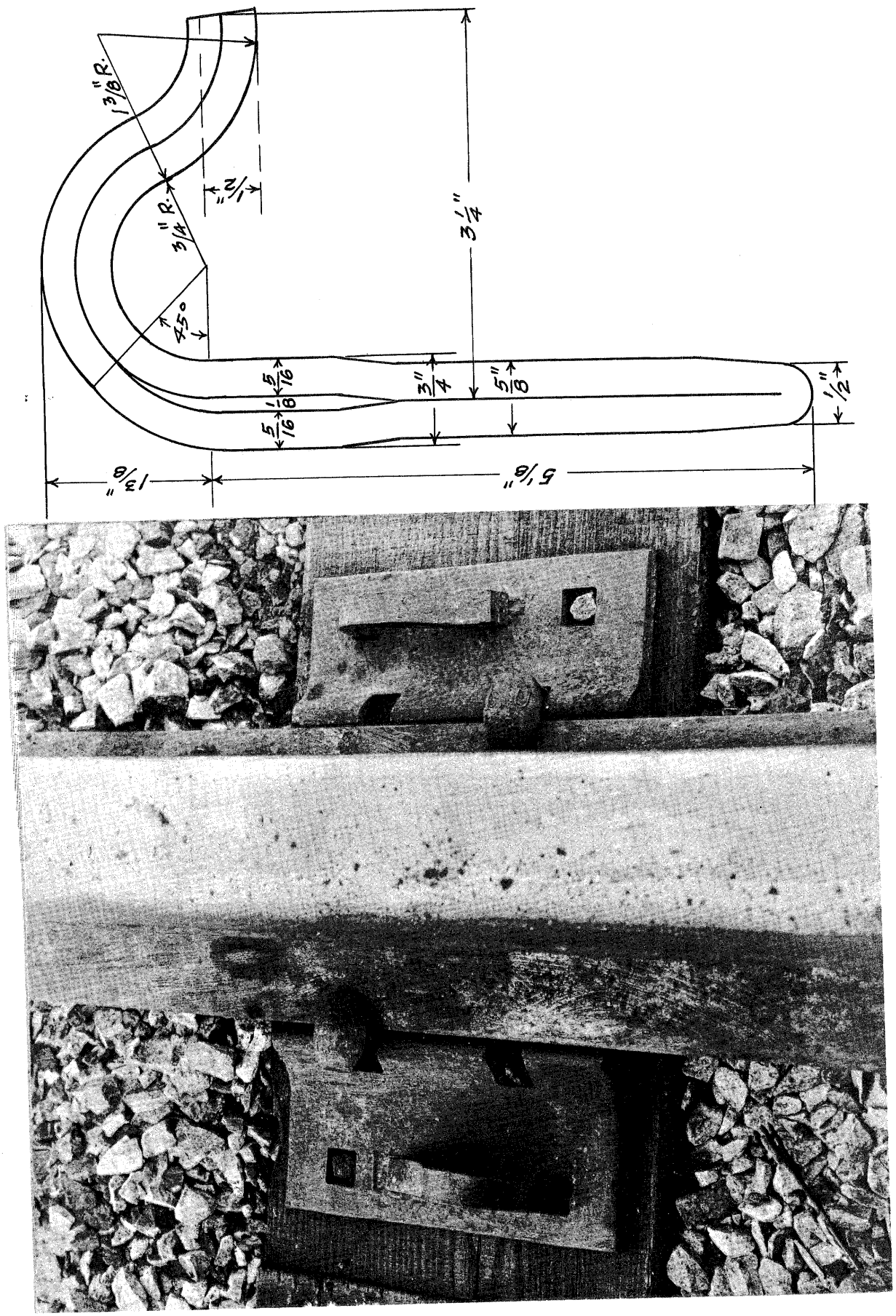


Fig. 13--Section 13, 2 Elastic Spikes of Design No. 93.

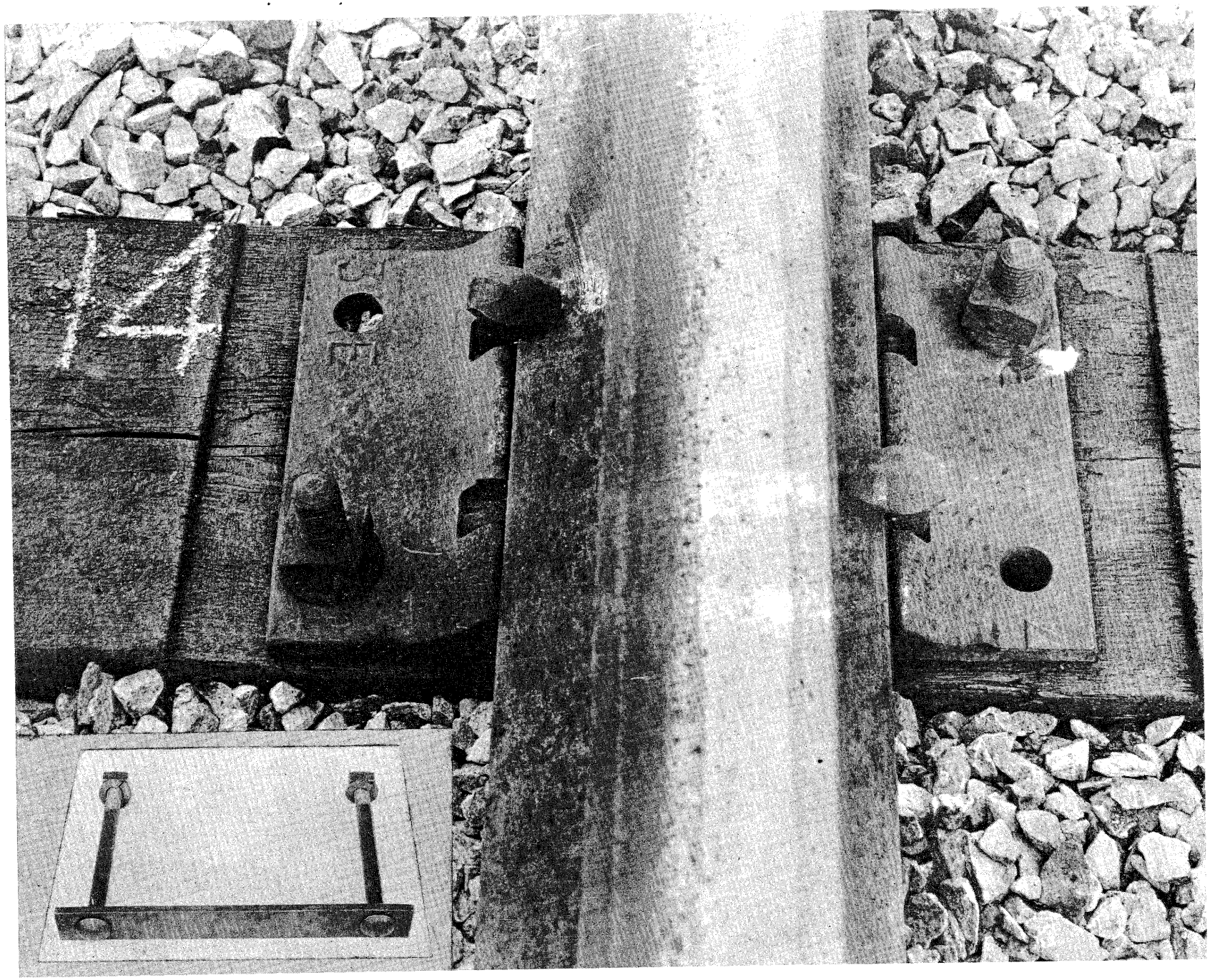


Fig. 15--Section 14, 2 - 3/4 in x 9 1/2 in Thru Bolts with Single Coil Allow Spring Washers - Also Inset of Bolts and Headlocks.

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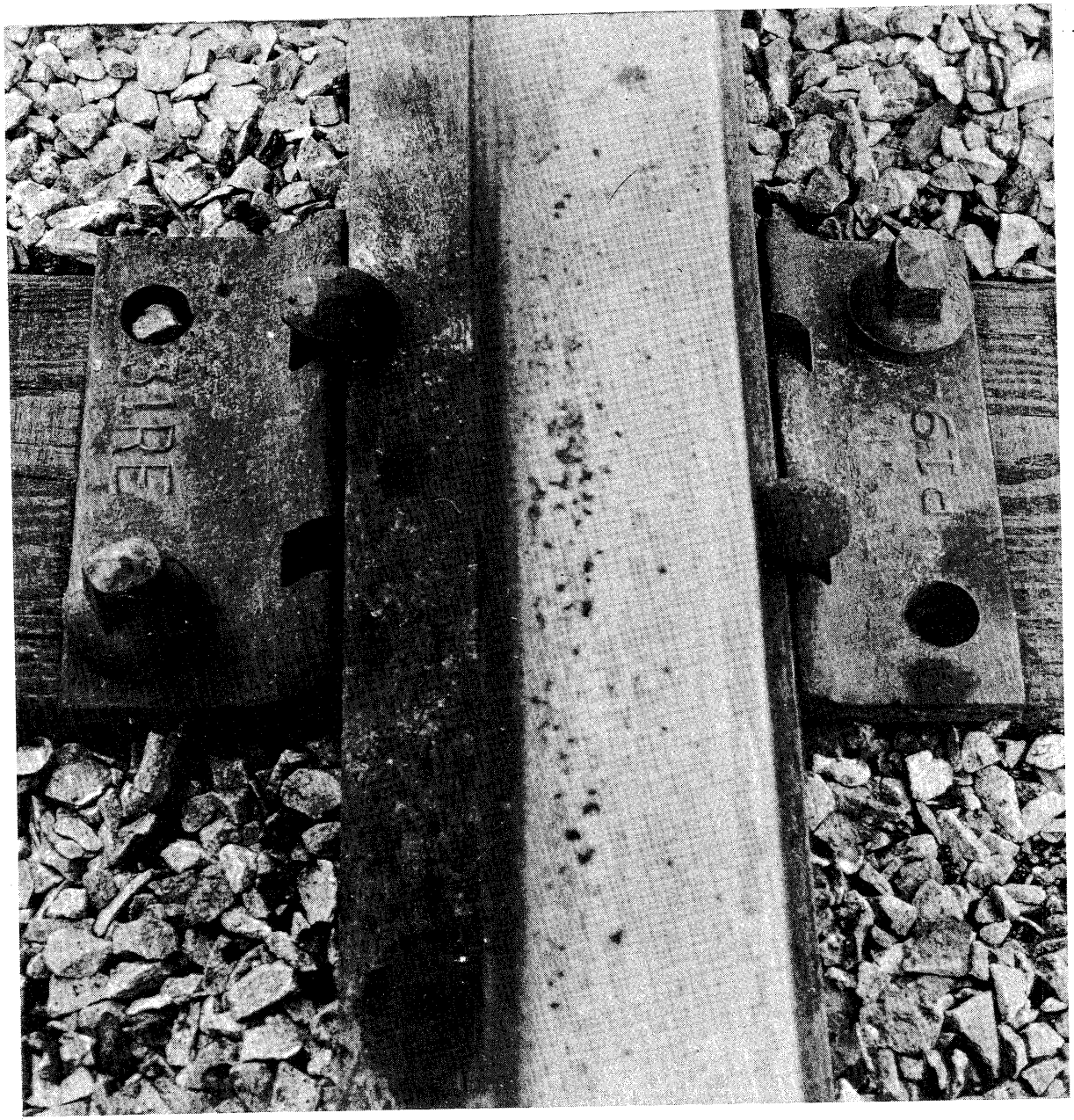
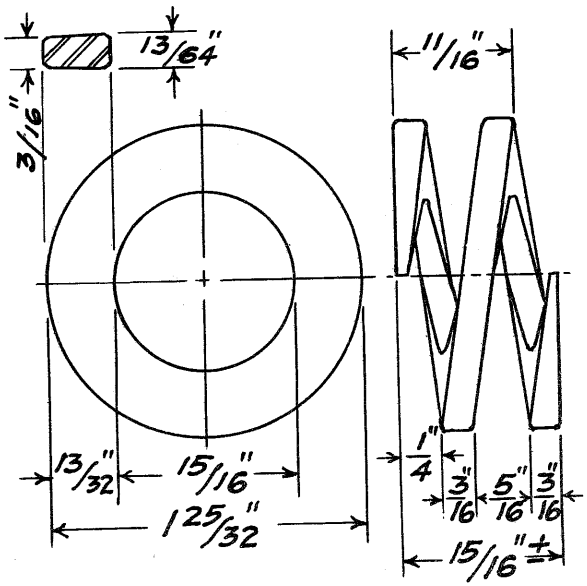
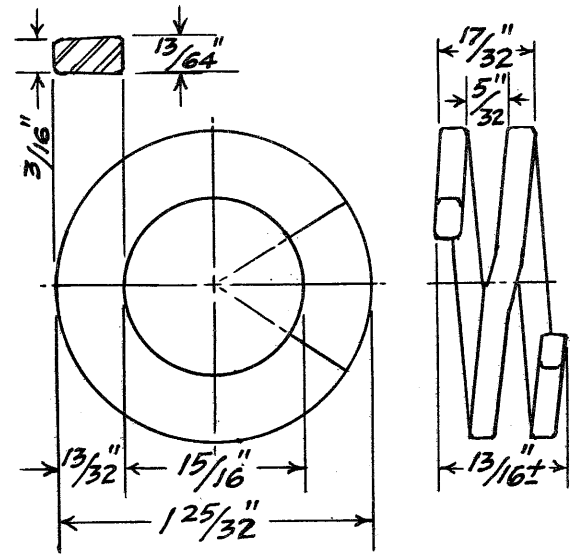




7/8"Double Coil Helical Spring Washers



7/8"Double Coil Thackery Spring Washers

Fig. 16--Section 16, 2 - 15/16 in x 6 1/2 in Screw Spikes with Double Coil Spring Washers as Shown.

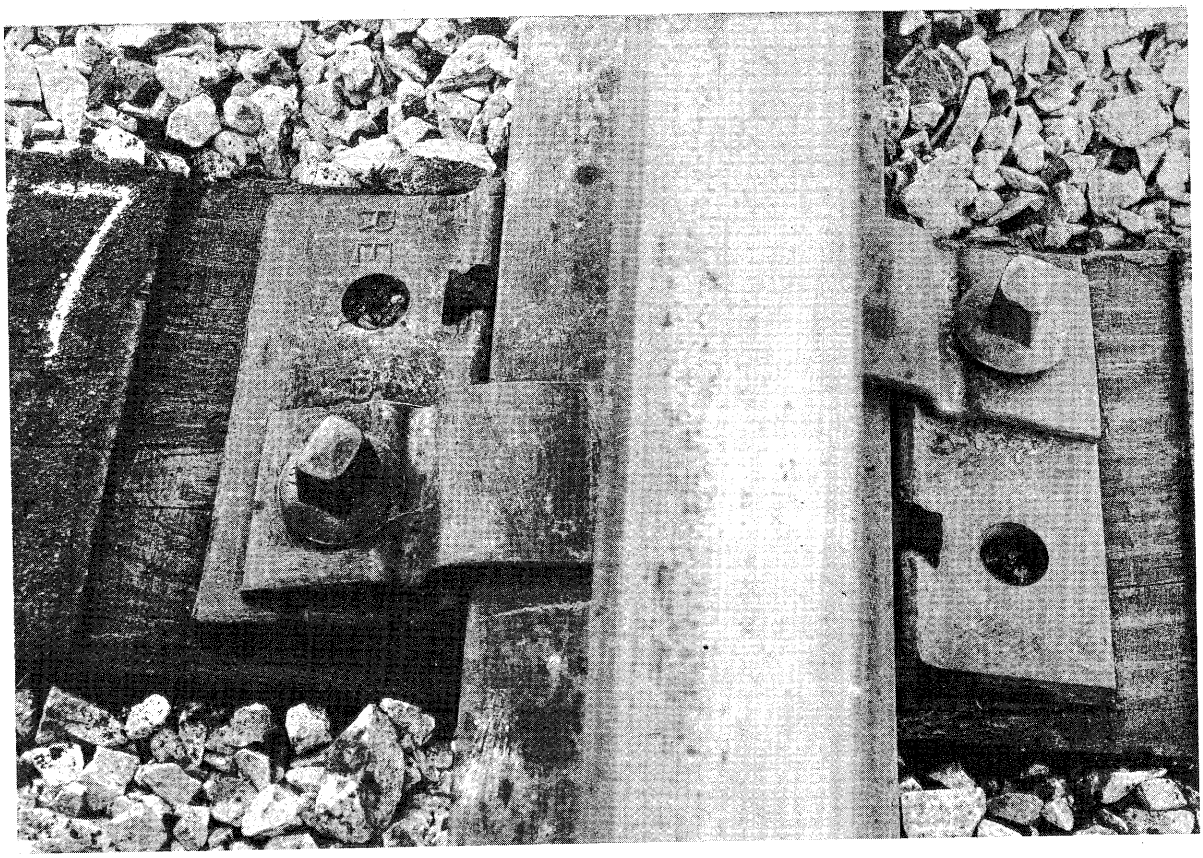


Fig. 17--Section 17, 2 AAR Spring Rail Clips with Screw Spikes - Tangent Track Creosoted Pine Ties.

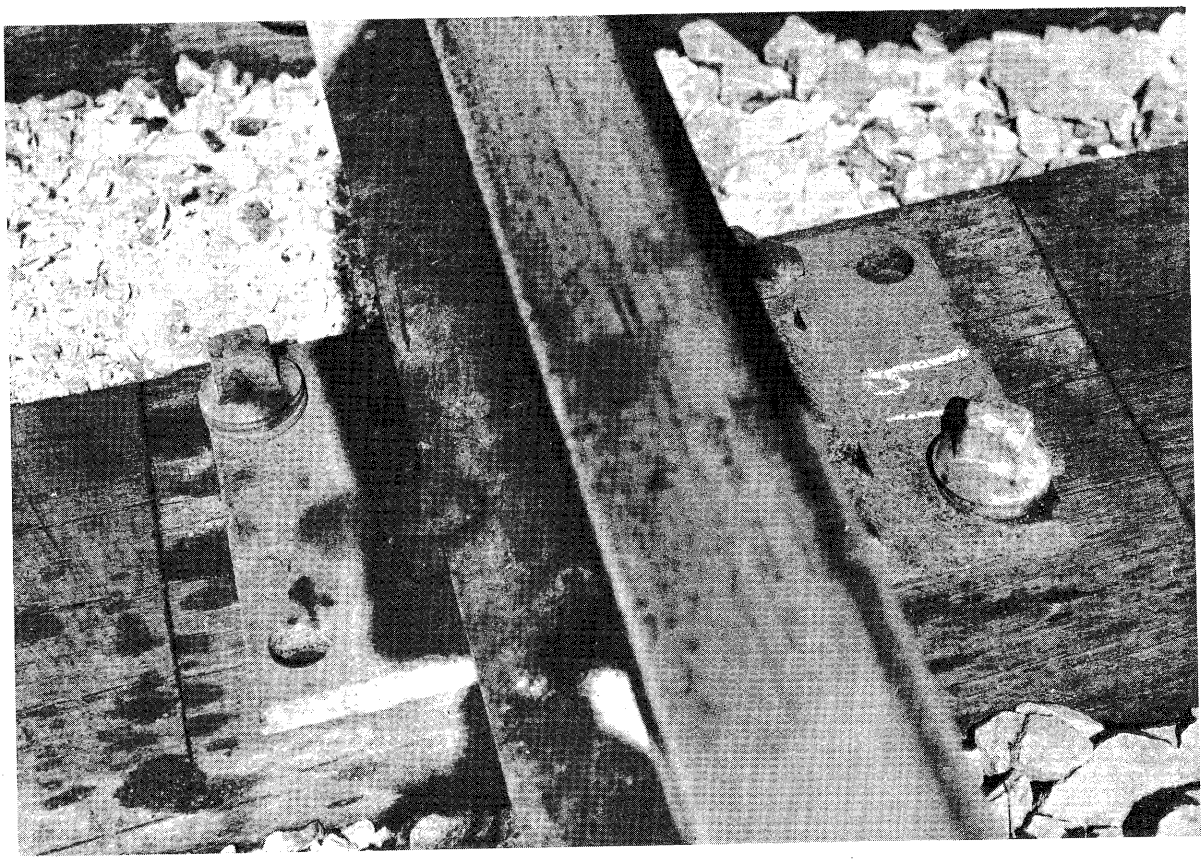


Fig. 18--Section 19, Erie Single Shoulder, Diamond Bottom Tie Plate with 2 - 15/16 in x 6 1/2 in Screw Spikes and Double Coil Spring Washers.

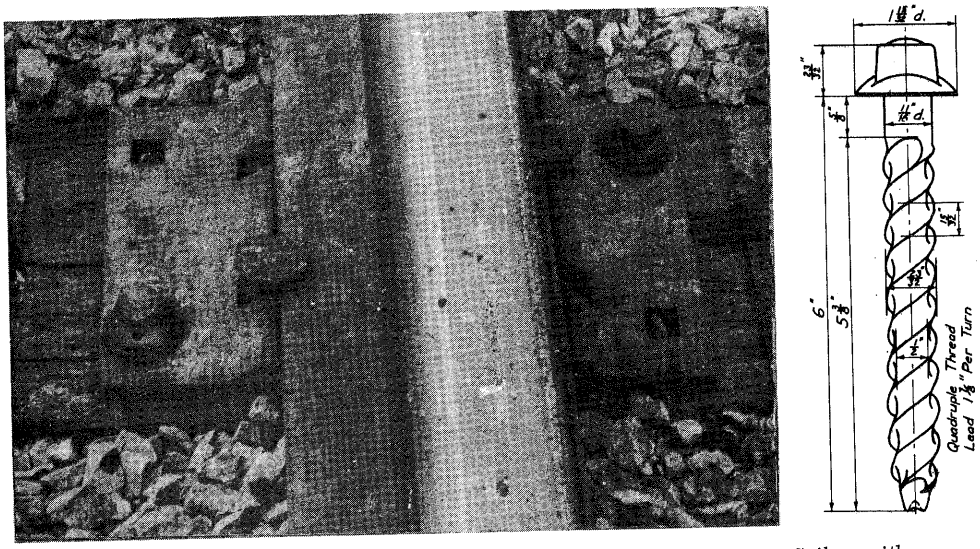


Fig. 19--Section 22, 2 - 11/16 in x 6 in Oliver Tie Plate Drive Spikes with Single Coil Alloy Spring Washers.

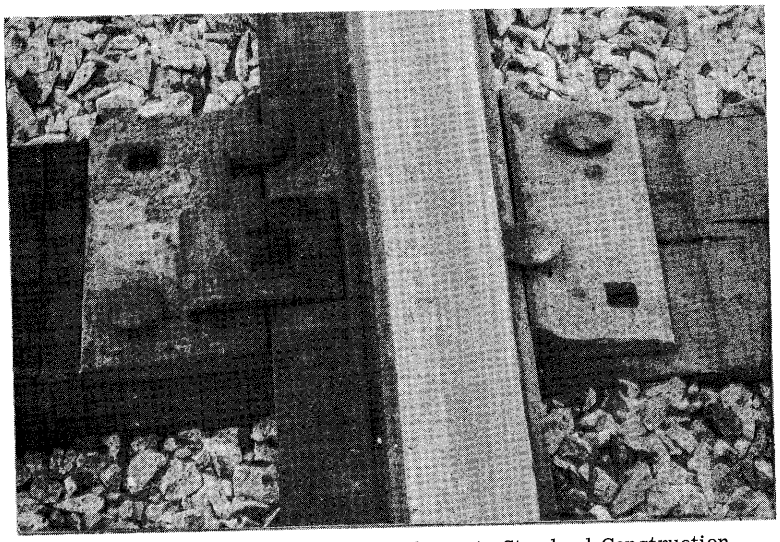


Fig. 20--Section 24, L&N R.R. Alternate Standard Construction with a 14 in Tie Plate and a Rails Company Clip on Alternate Tie Plates.

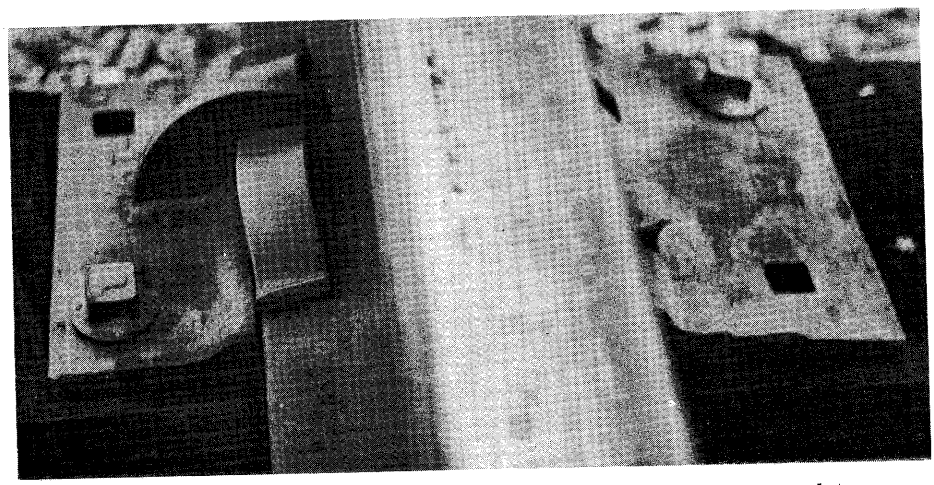


Fig. 21--Section 31, G&H No-Creep Rail Anchor and 2 Oliver Tie Plate Drive Spikes on Alternate Ties.

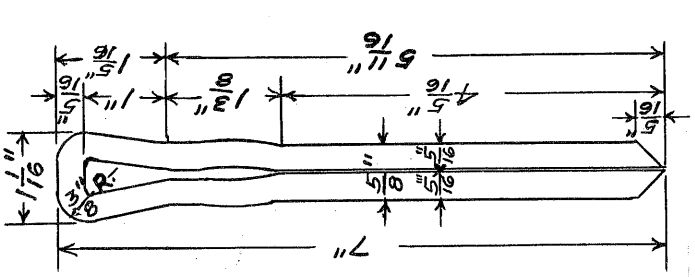


Fig. 22--Section 34, 2 Tie Plate Lock Spikes.

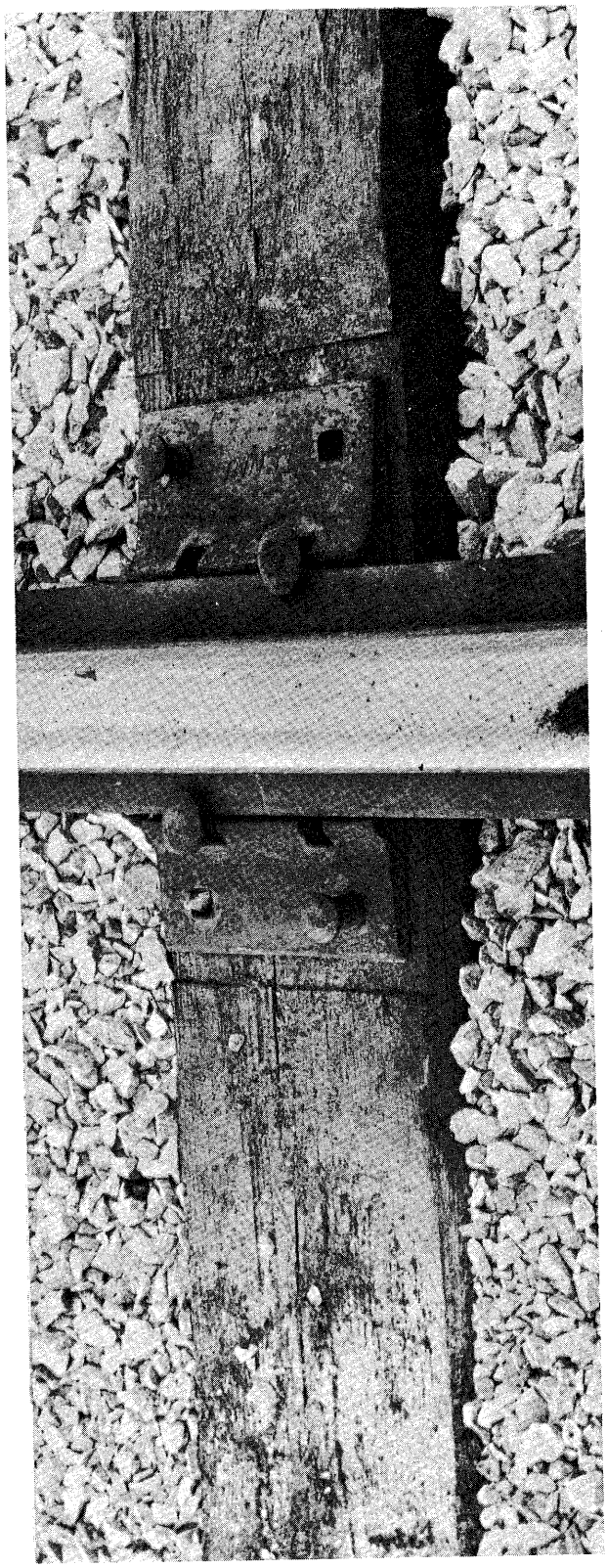
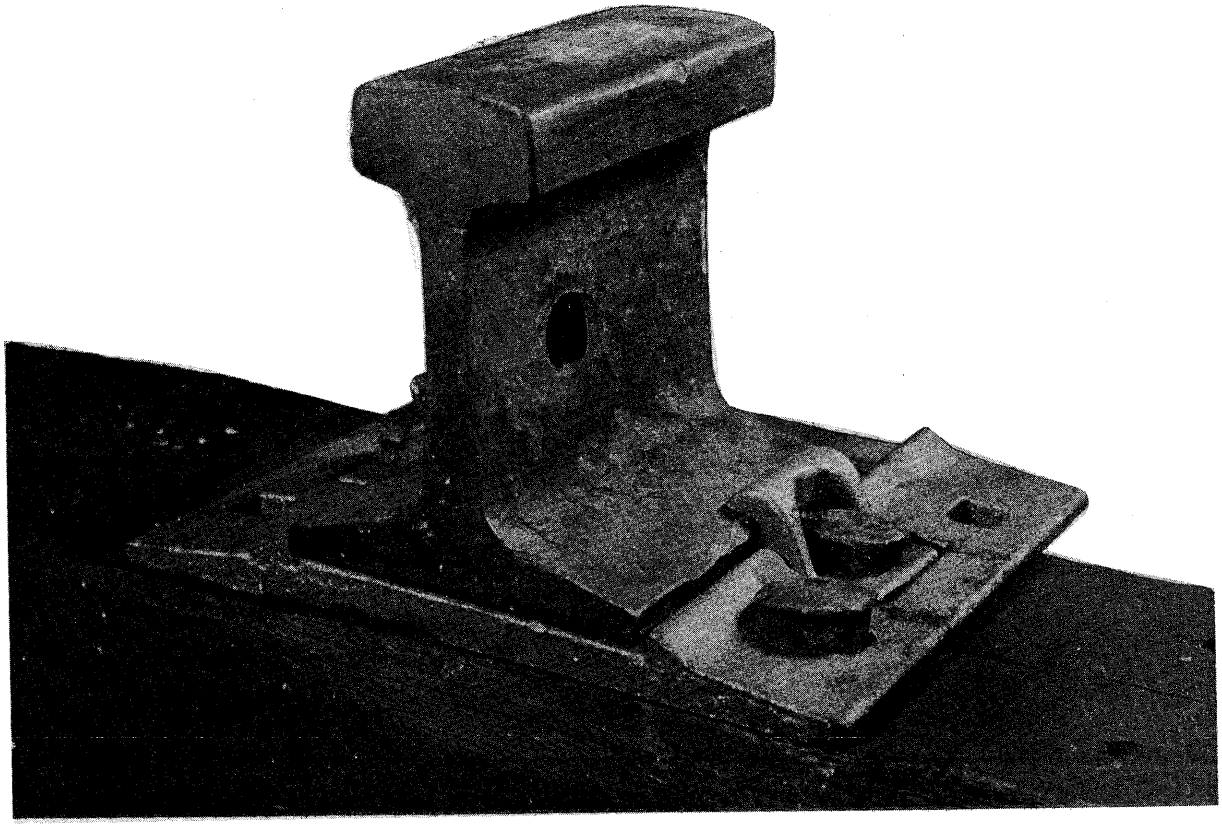


Fig. 23--Section 43, 2 Racor Studs.



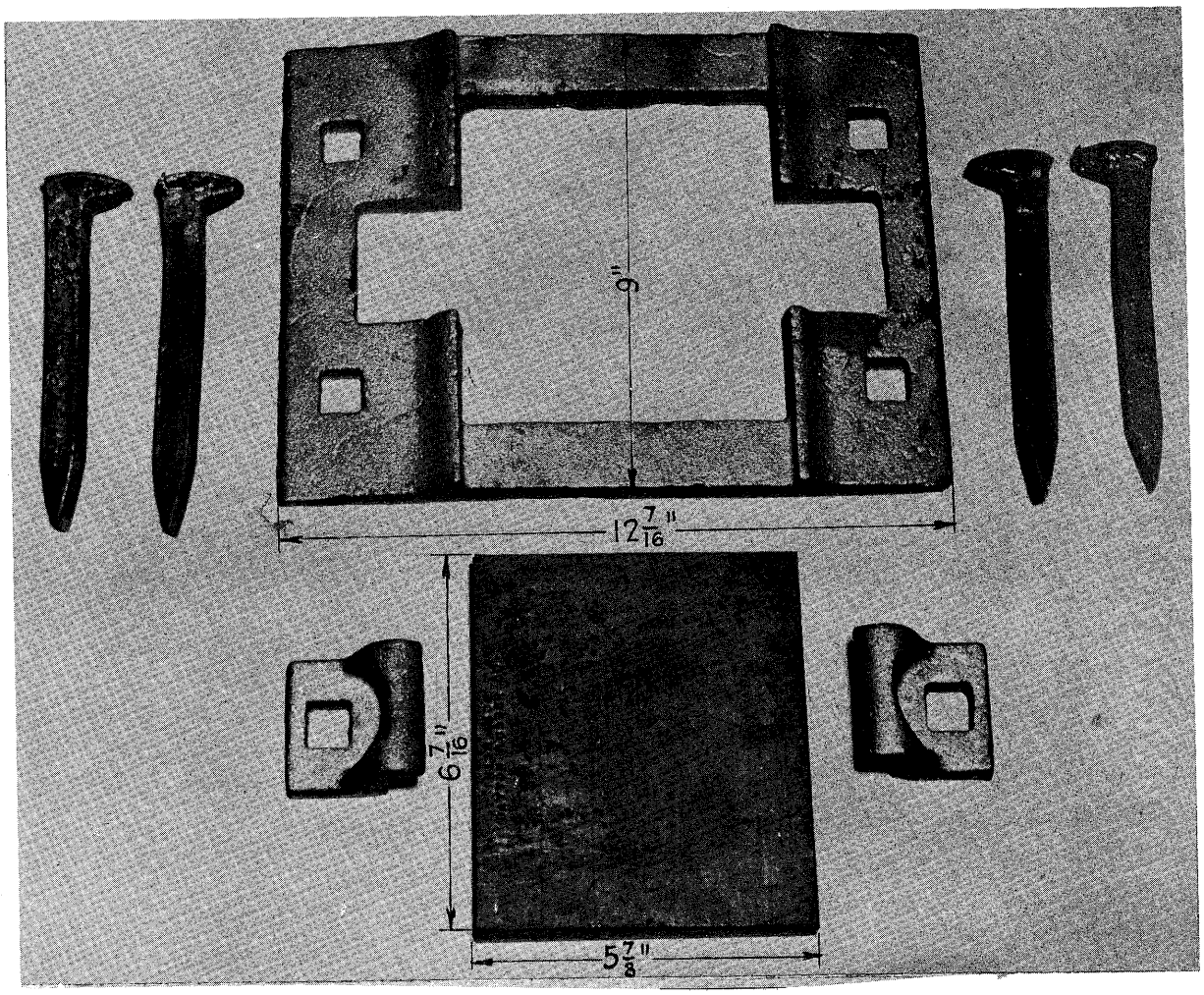


Fig. 24--Sections 44 and 45, Dayton Rubber Co.'s Tie Plate and Pad.

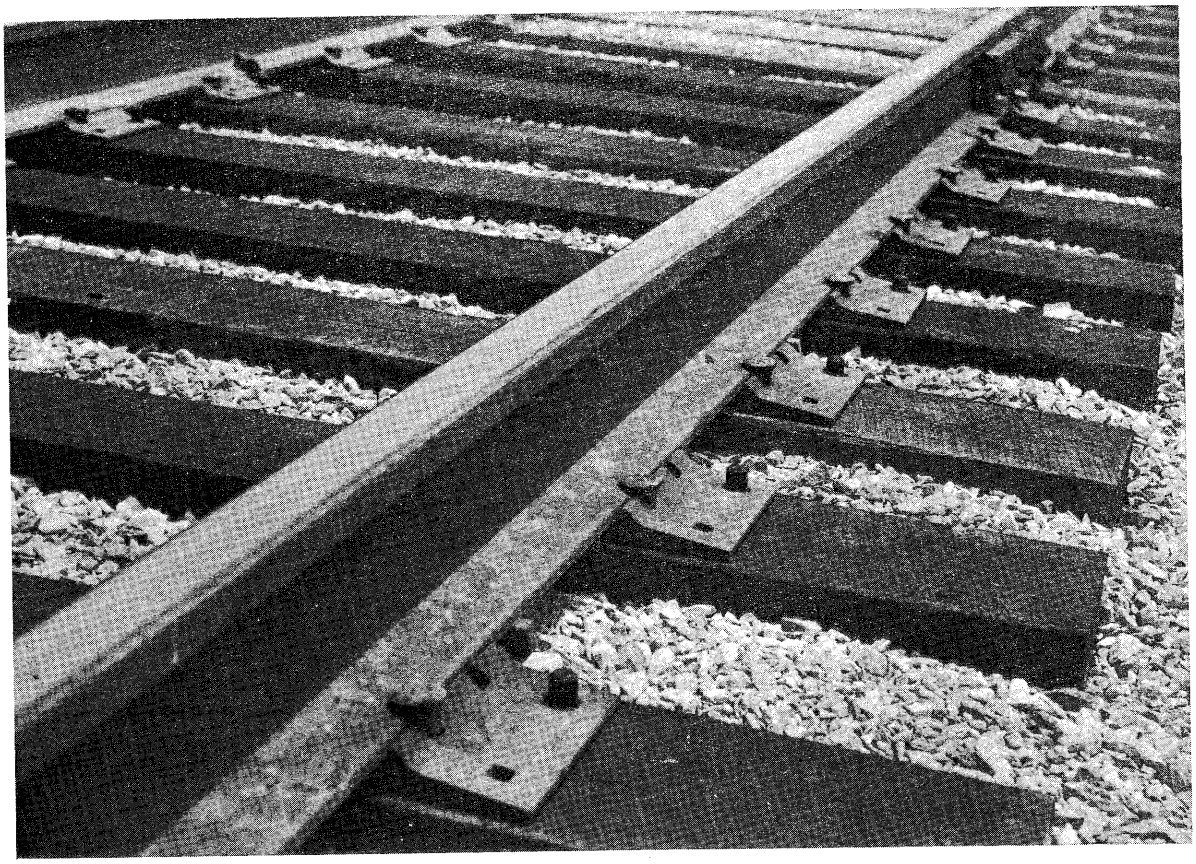
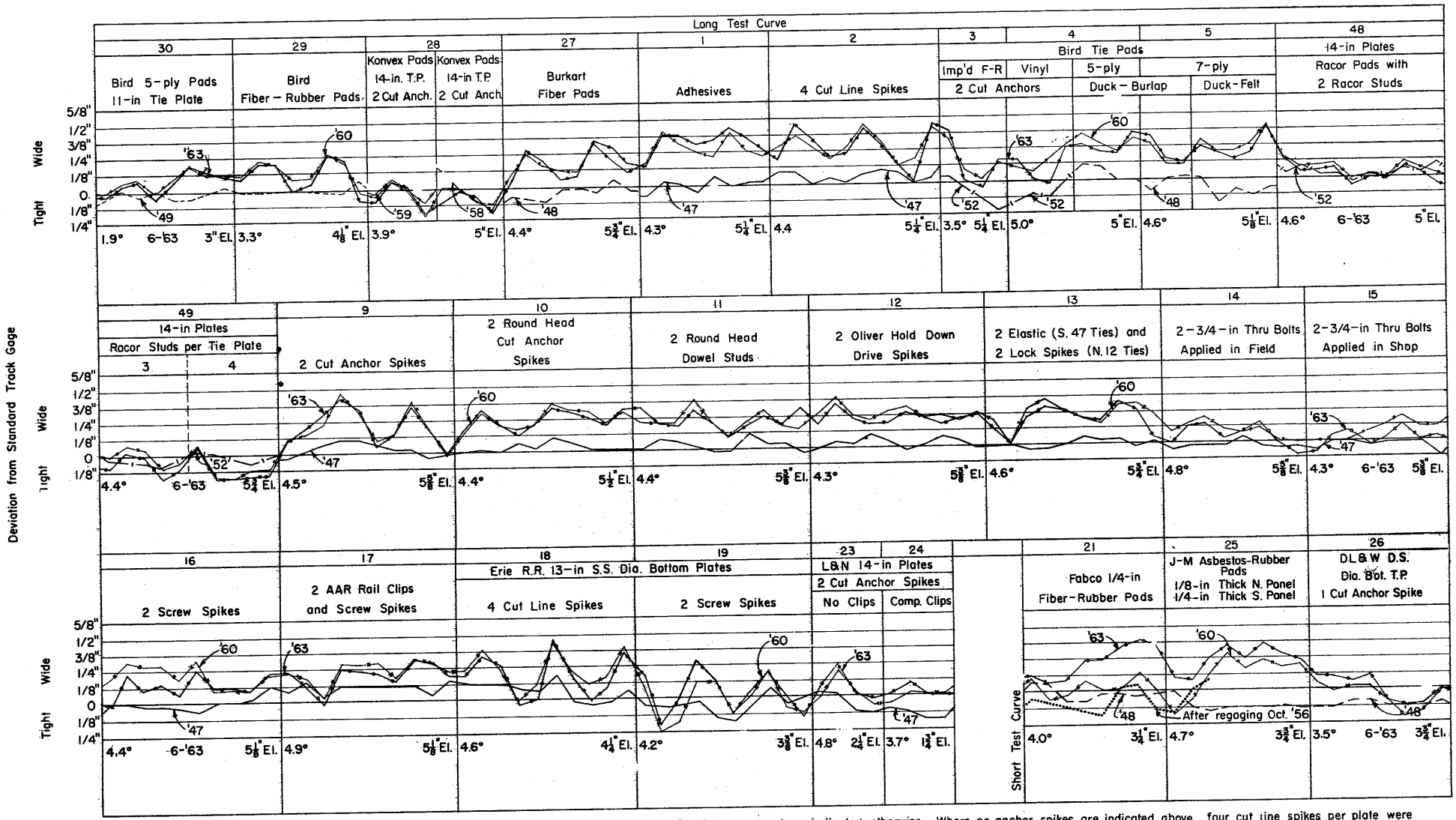


Fig. 25--Section 51, Nordberg Creosoted Hardwood Pegs.

Fig. 26--Section 57, Spring Lags.



Notes: All test sections have 13-in tie plates, except as noted above. All tie plates have a flat bottom, except as indicated otherwise. Where no anchor spikes are indicated above, four cut line spikes per plate were provided. Sections with anchor spikes have two cut line spikes. The oldest gage record shown for each section represents the condition at the beginning of the original test or when a section was revised by changing the tie pads or fastenings. The following sections were regaged: Sections 4 and 5, Aug. 1948; North portion Section 16 by relaying outer rail, Sept. 1953; Section 21, Sept. 1953 and Oct. 1956. Two cut anchor spikes were added to the South 24 plates in the outer rail of Section 21, Nov. 1953. All ties were installed as of the earliest date shown, except in Sections 3, 4, and 5, the 1947 ties were retained in service. Two cut anchor spikes were added to the north 23 plates in the outer rail of Section 21 after regaging, Oct. 1956.

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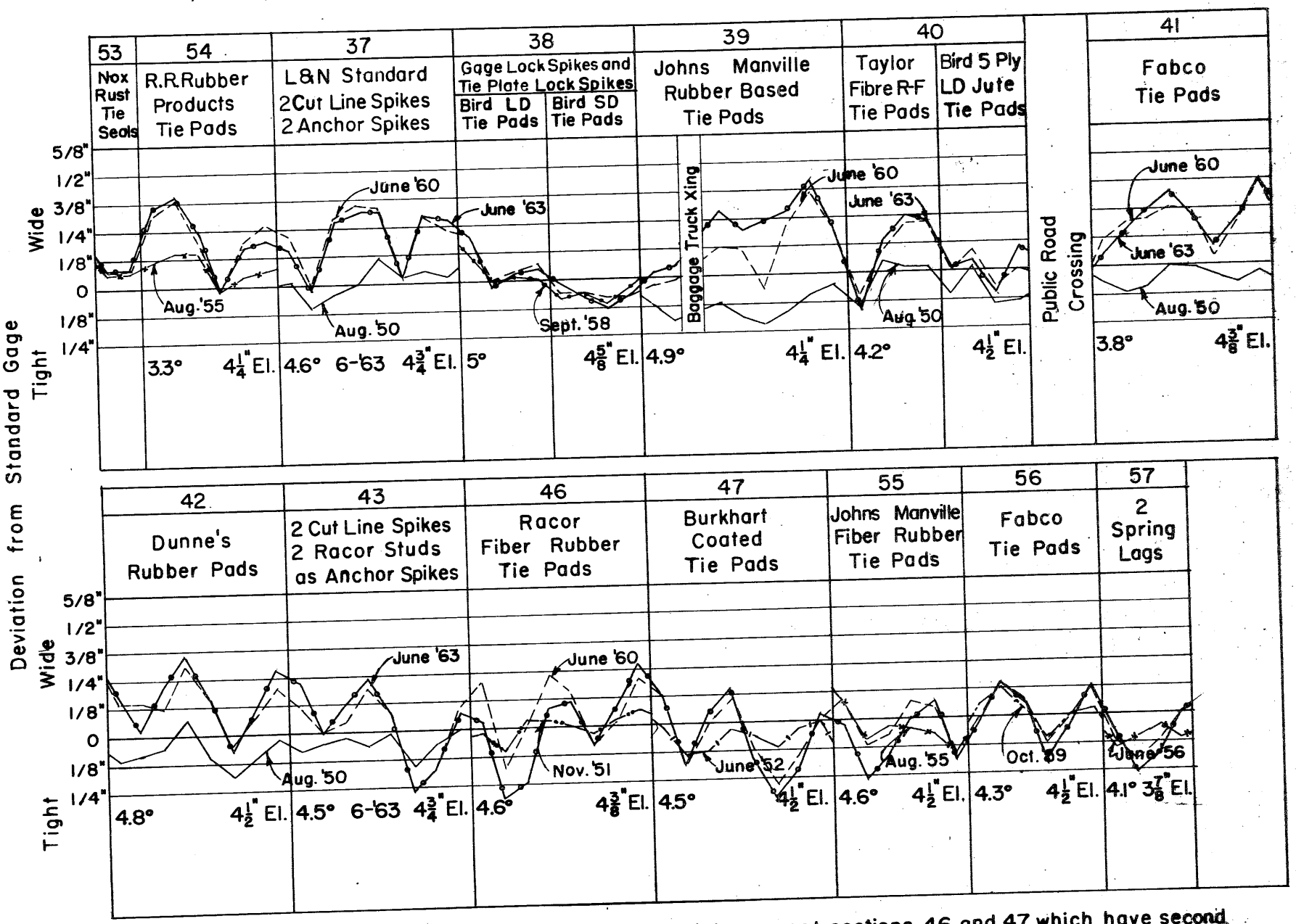
Fig. 27. Gage, Curvature and Elevation of Each Section of Test Track on the 4°-30' Curves, Mile L-154, L&N R R, near London, Ky.



All sections have new AREA 14-in Plan 12 flat bottom tie plates except sections 46 and 47 which have second hand AREA Plan 6B flat bottom tie plates. All sections have two each of cut spikes for line and anchor except as noted.

Fig. 28. Gage, Curvature and Elevation of Each Section of Test Track on the 5-deg Curve, Mile L-153, L.&N.R.R. East Bernstadt, Ky.

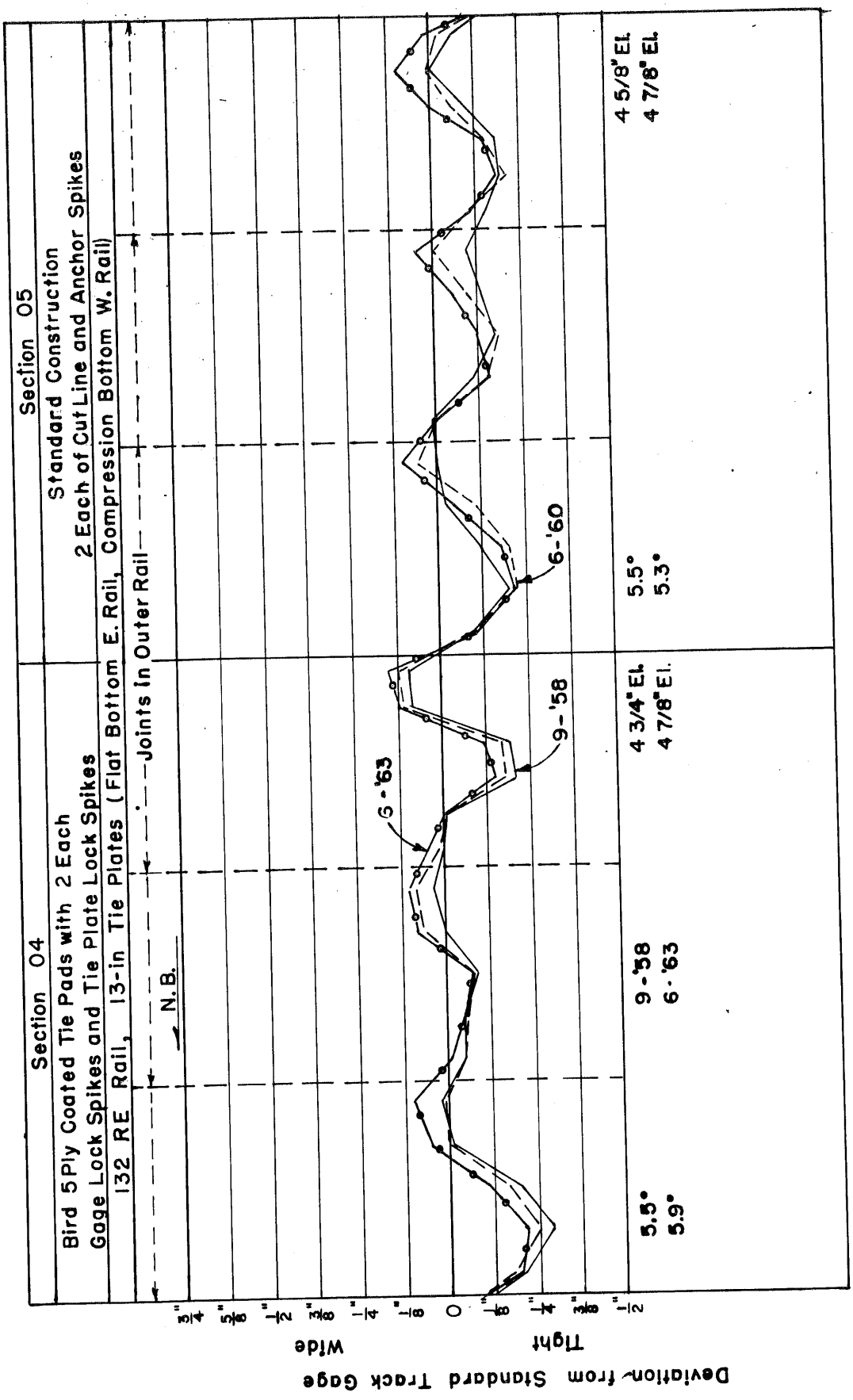


Fig.29. Gage, Curvature and Elevation of Sections 04 and 05 in 5°36' Curve, Mile L-152, L&N.R.R.

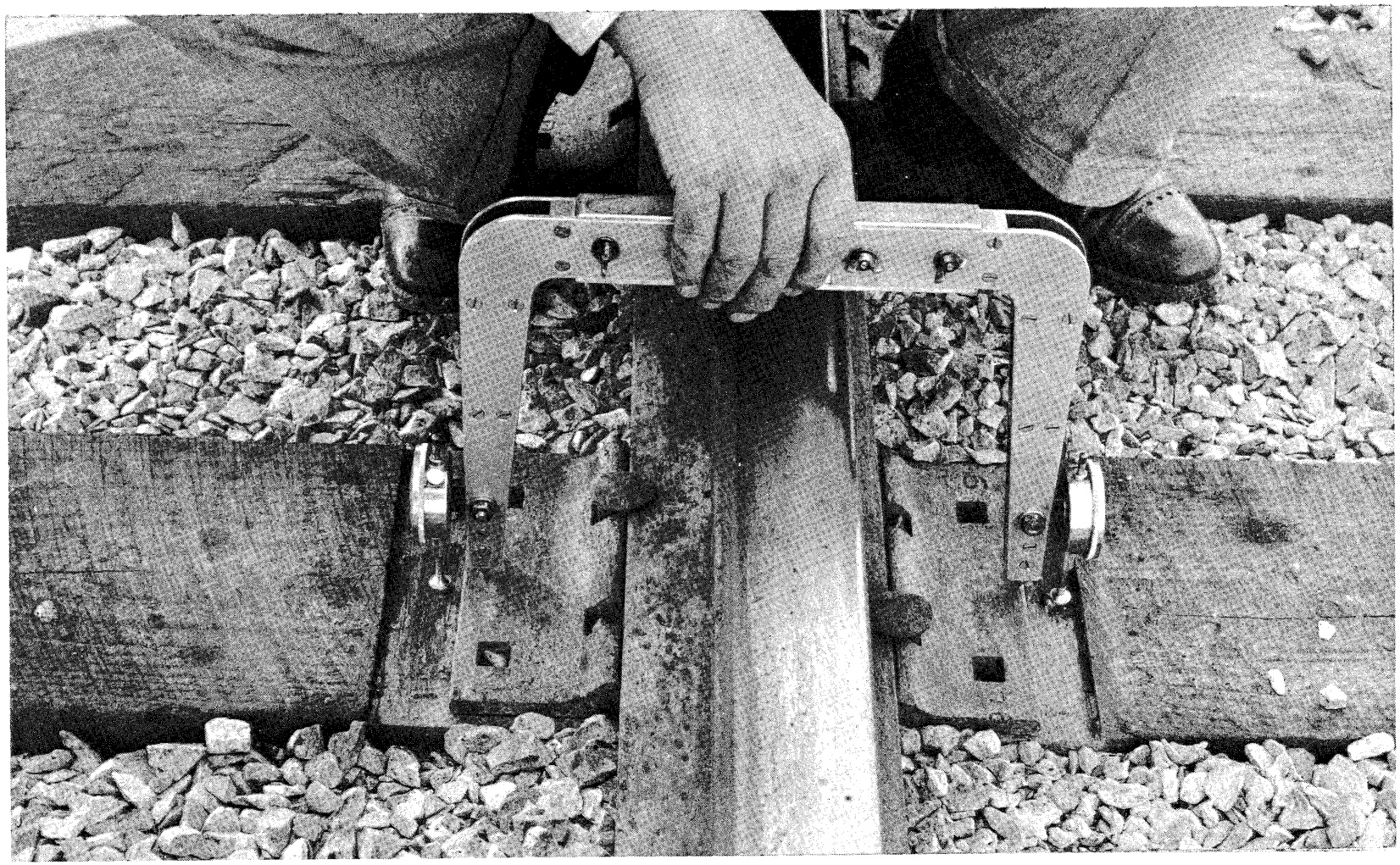


Fig. 30--Tie Plate Penetration Gage set for Taking Dial Readings on Heads of Brass Screws in Tie Chisel Marks Provide Gage Points on Tie Plate.

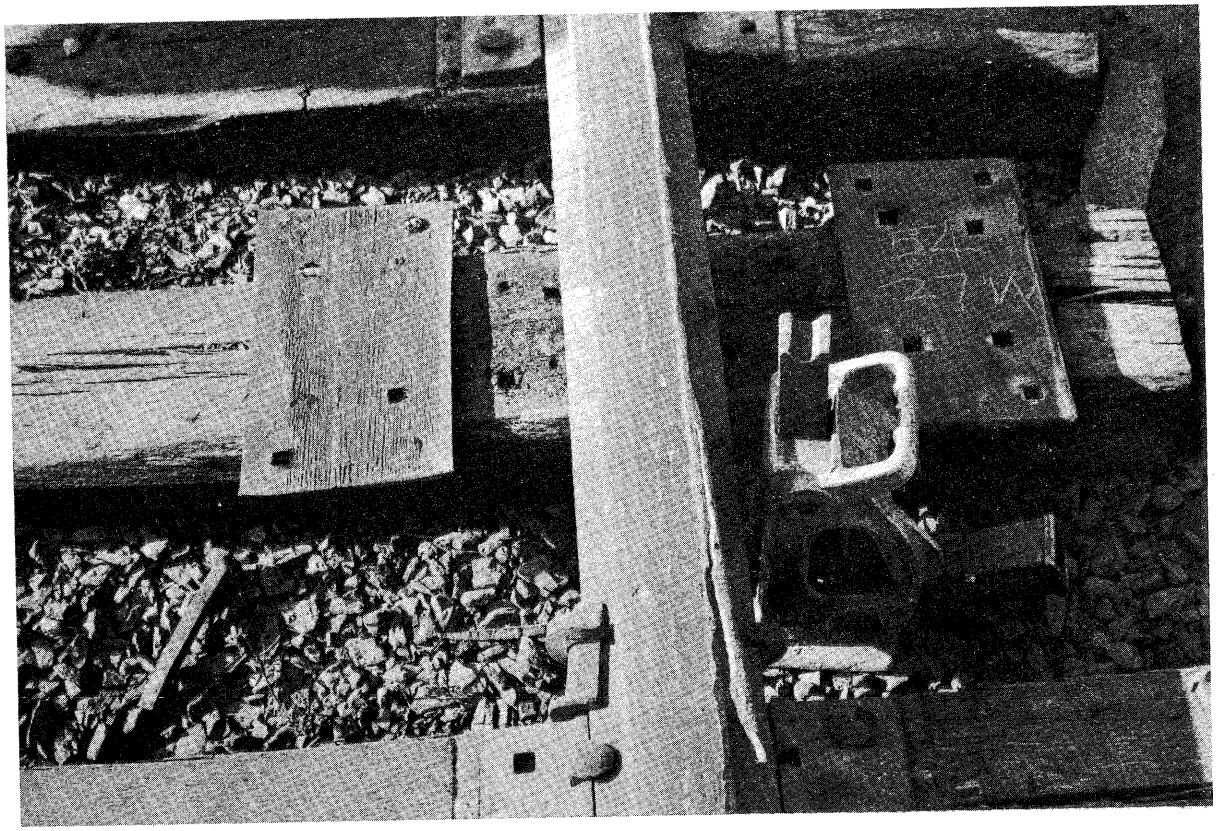


Fig. 31 -- Section 54, 14-in Railroad Rubber Products rubber pad, 1/4-in thick, uncoated, with adzed surface coated with liquid rubber sealant, 95 months of service, inner rail of 5-deg curve. Sand and moisture under pad, some wood compression, all sealant gone in the pad area. Pad slightly stretched but otherwise in good condition, sealant of little value.

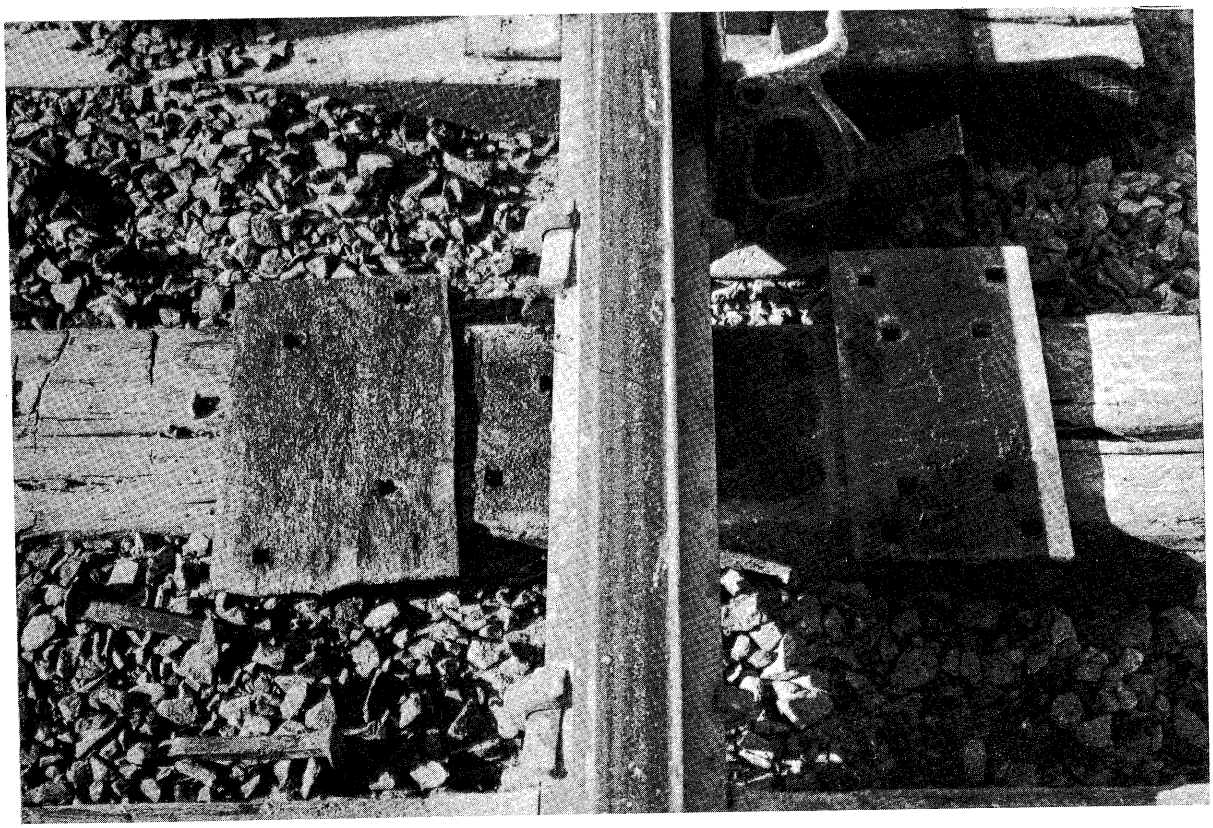


Fig. 32 -- Section 41, 14-in Fabco fiber-rubber pad with oxidized asphalt coating on the bottom side, 142 months of service, inner rail 5-deg curve. Much sand and moisture under pad together with considerable wood compression. Pad condition fair but stretched laterally on field end, sealant gone.

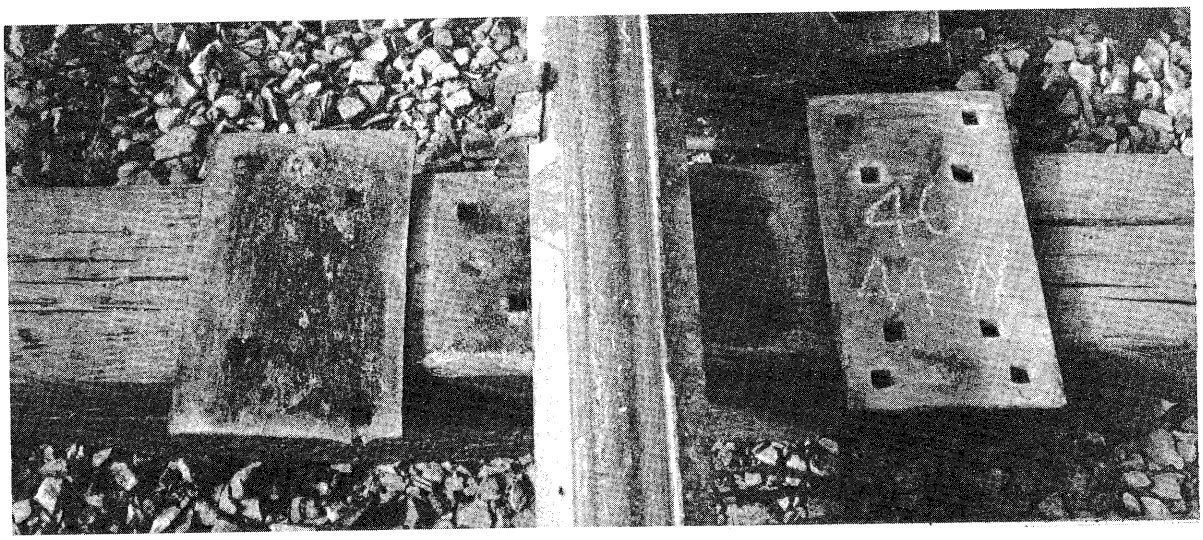


Fig. 33 -- Section 46, 14-in Racor fiber-rubber pad, coated, 138 months of service, inner rail 5-deg curve. Some sand and moisture under pad, wood compression slight. Pad condition fair. Stretched on field end split at gage anchor spike, not sealed to tie.

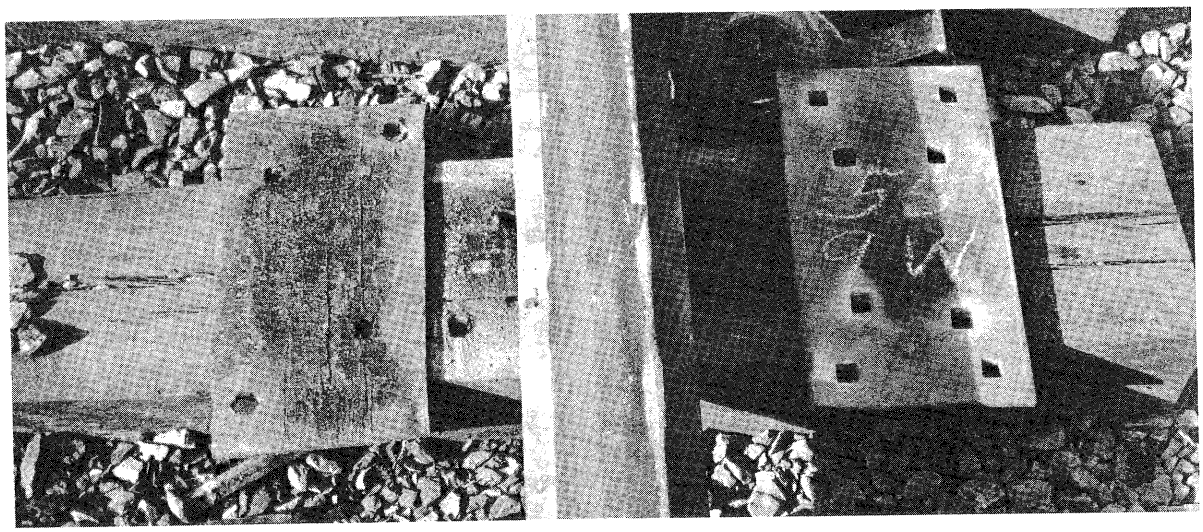


Fig. 34 -- Section 55, 14-in Johns-Manville fiber-rubber pad, 1/4-in thick, coated, 95 months of service, inner rail 5-deg curve. Pad had no seal with tie and there was some sand and moisture on the under side. There was some longitudinal stretching and pad was adhered to the plate. No wood compression.

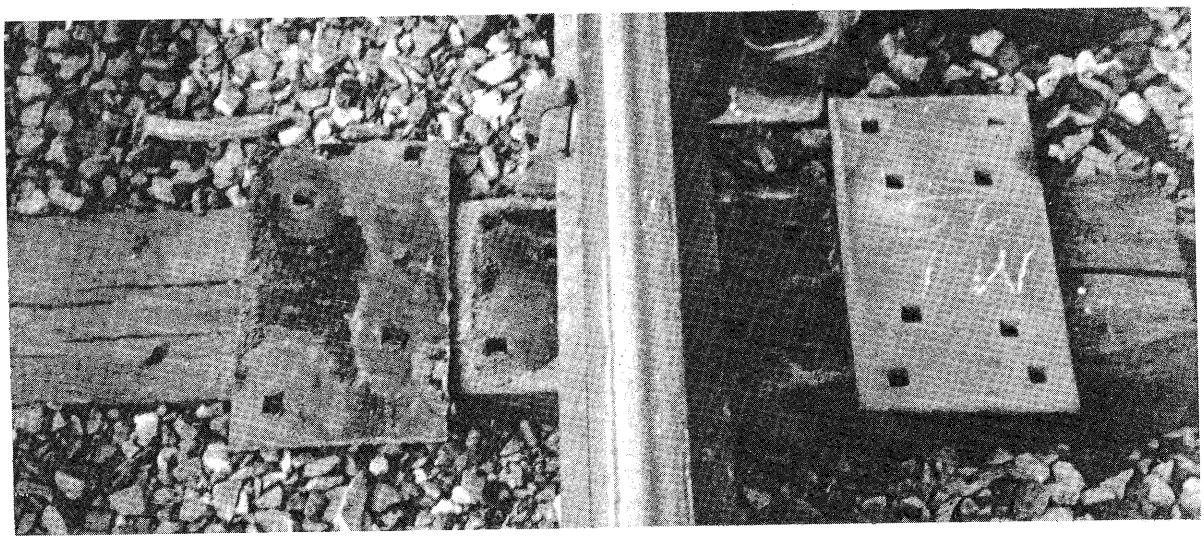


Fig. 35 -- Section 56, 14-in Fabco Super-Seal Pads, 1/4-in thick, bottom coated, 43 months of service, inner rail 5-deg curve. Pad had approximately 90 percent seal with no sand or moisture on under side.

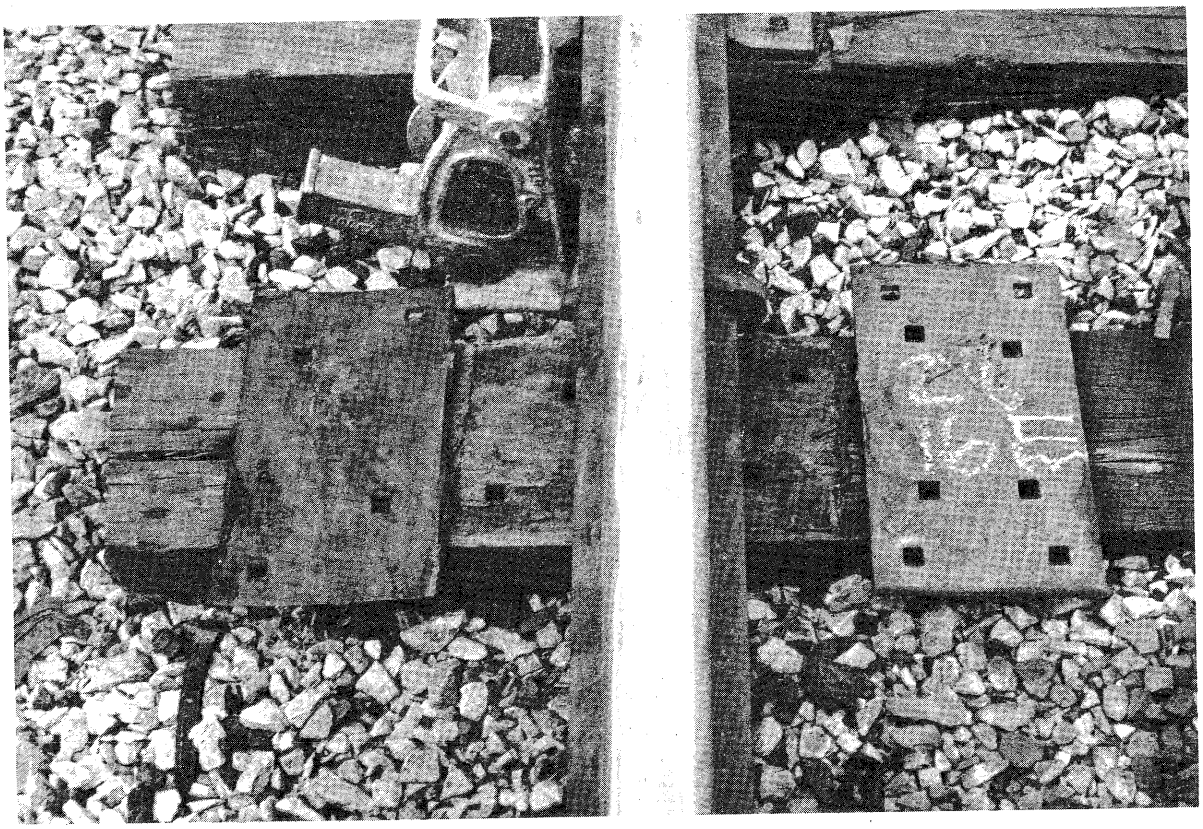


Fig. 36 -- North portion Section 28, 14-in Konvex tire carcass tie pad 3/16 in thick, coated both sides, 43 months of service, inner rail 4-1/2-deg curve. The pad had 70 percent seal with the tie and the polyethylene film on top effectively prevented a seal with the tie plate. Some coating adhered to the wood.

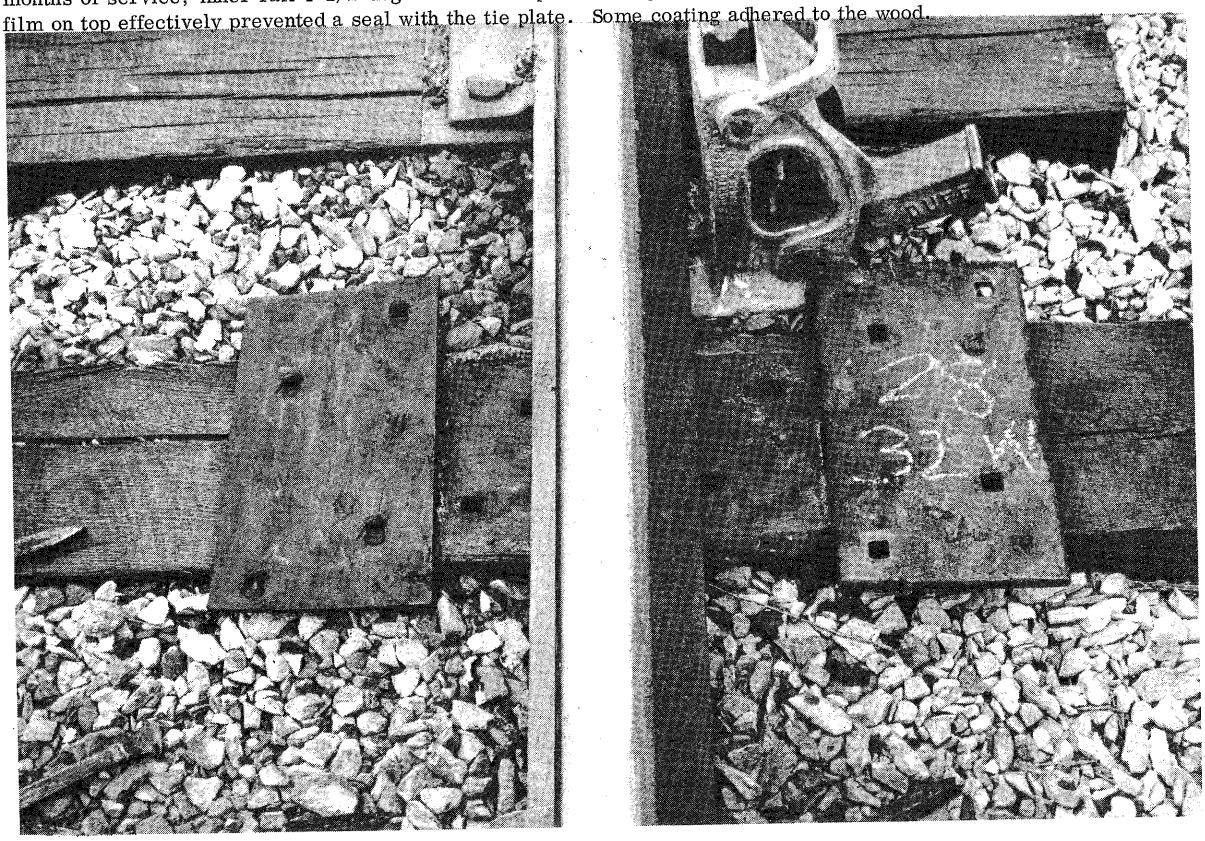


Fig. 37 -- South portion Section 28, 14-in Konvex tire carcass tie pad 3/16 in thick, coated both sides, 57 months of service, outer rail 4-1/2-deg curve. The pad had 60 percent seal with the tie. The coating on the bottom adhered to the tie and not to the pad. This pad was without polyethylene and some coating stuck to the plate. There was some sand around the anchor spike holes.

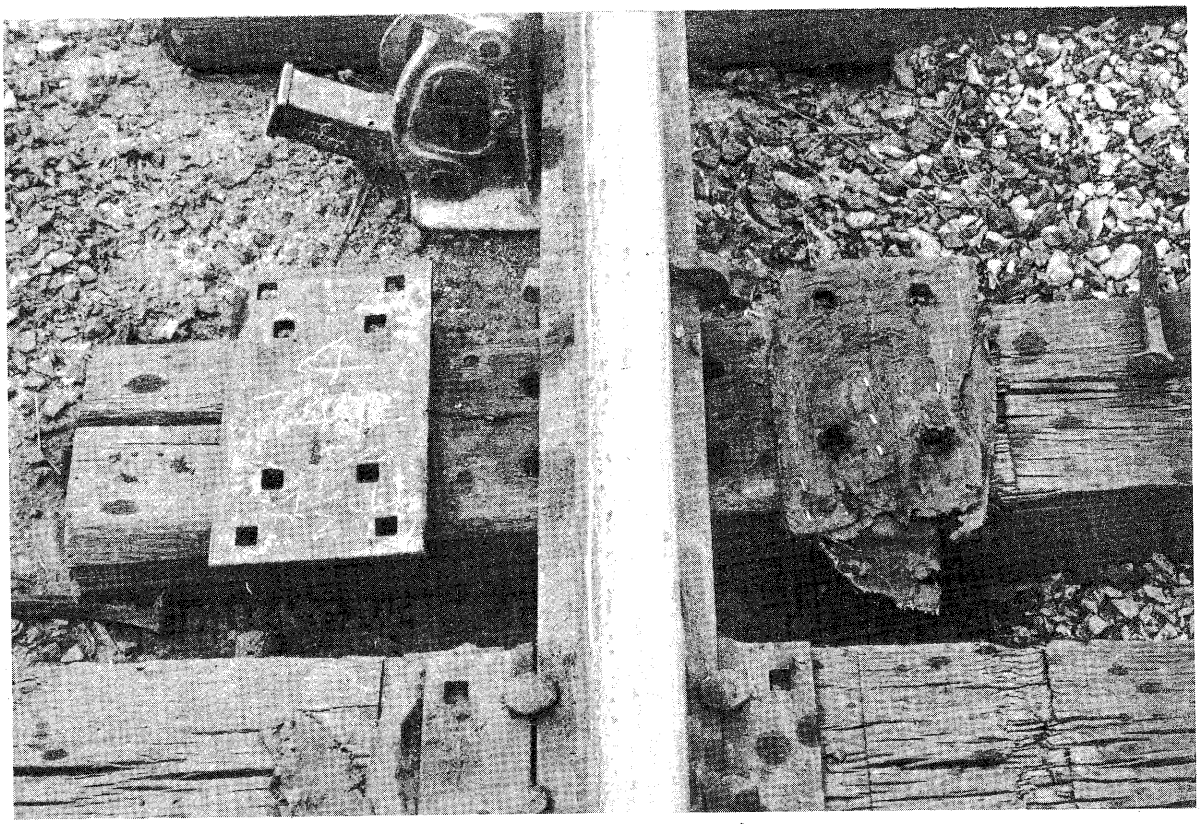


Fig. 38 -- South portion Section 4, 13-in Bird 5-ply duck burlap pad coated, 177 months of service, inner rail of 4-1/2-deg curve. Pad had lost its seal and there was small amount of sand and moisture on the tie surface. There was considerable delamination and stretching on the field end together with some wood compression.

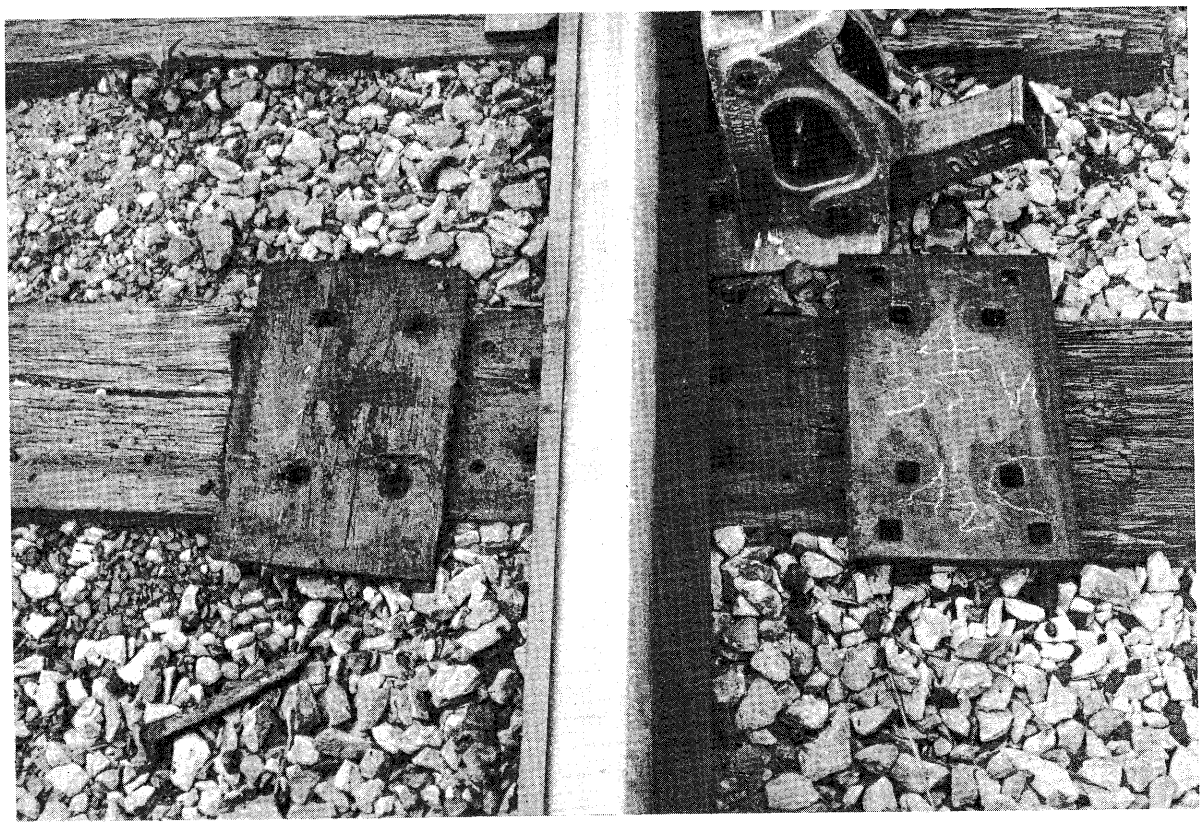


Fig. 39 -- South portion Section 4, 13-in Bird 5-ply duck burlap pad coated, 177 months of service, outer rail of 4-1/2-deg curve. Pad had 90 percent of its seal and tie surface was free from sand and moisture. The pad condition was good, and there was no wood compression.

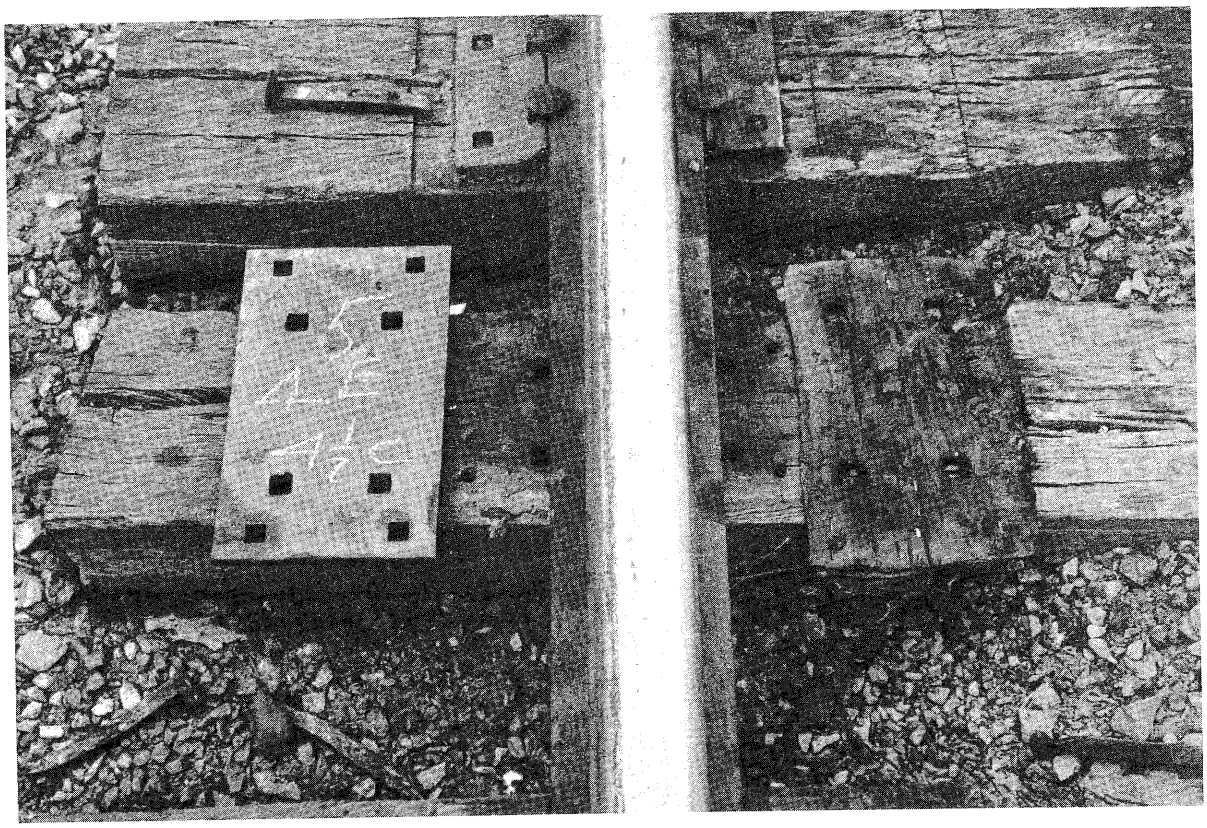


Fig. 40 -- North portion Section 5, 13-in Bird 7-ply duck burlap pad coated, 177 months of service, inner rail of 4-1/2-deg curve. The pad area was 60 percent sealed and free from moisture although there was some around the spikes. The pad condition was fair with some stretching and there was a little wood compression on the field end.

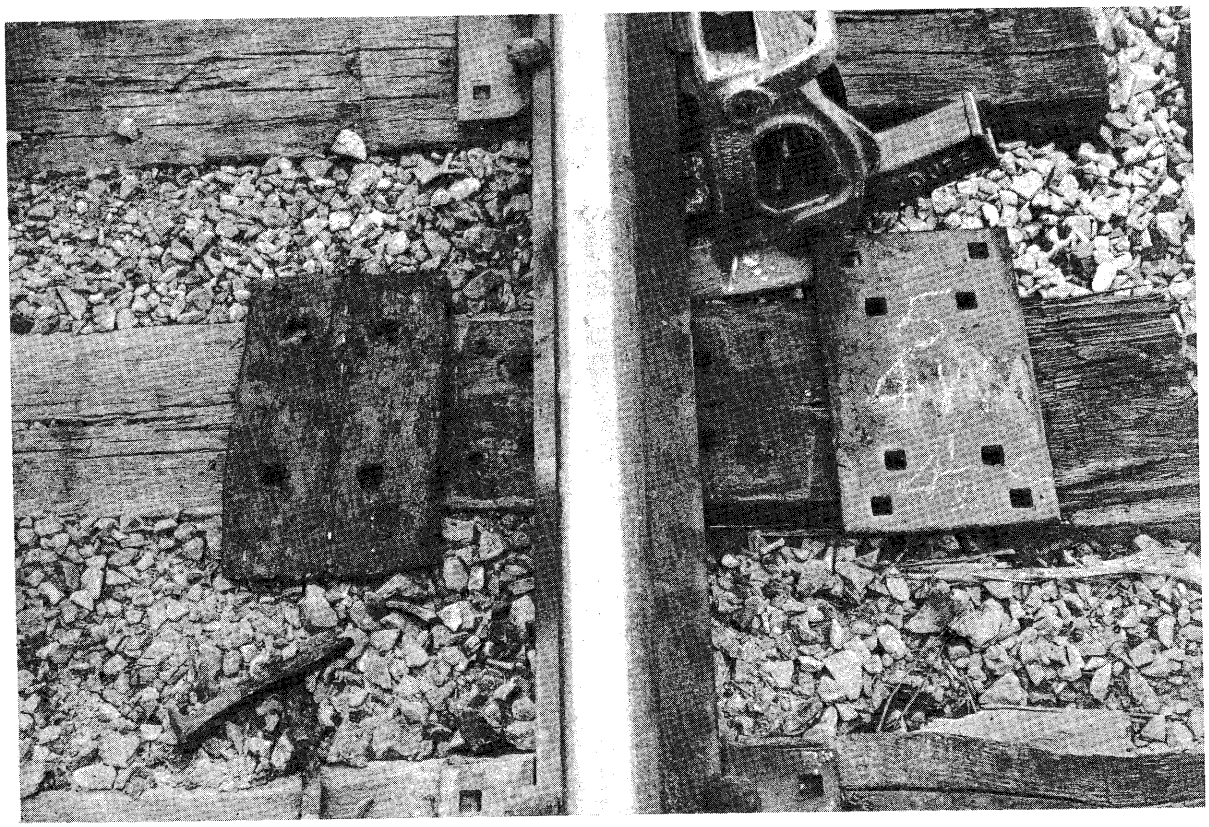


Fig. 41 -- North portion Section 5, 13-in Bird 7-ply duck burlap pad coated, 177 months of service, outer rail 4-1/2-deg curve. The pad was 80 percent sealed and the tie surface was without sand or moisture. The pad condition was good and there was only slight wood compression on the field end.

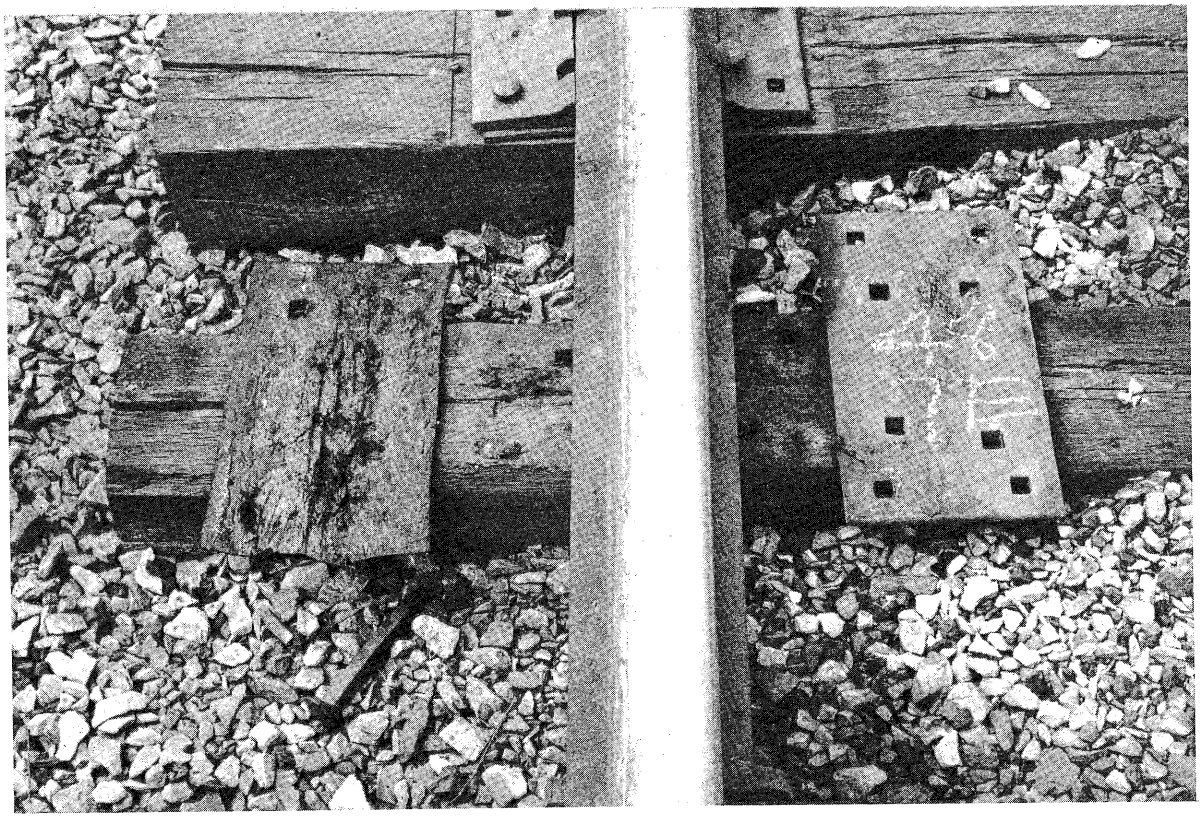


Fig. 42 -- Section 48, 14-in Racor fiber rubber tie pad, coated, 2 Racor studs, 129 months of service, inner rail of 4-1/2-deg curve. The under pad area was 60 percent sealed, had some sand around anchor but was free from moisture. Pad condition good except some stretching on field end, torn when prying from tie surface, no wood compression.

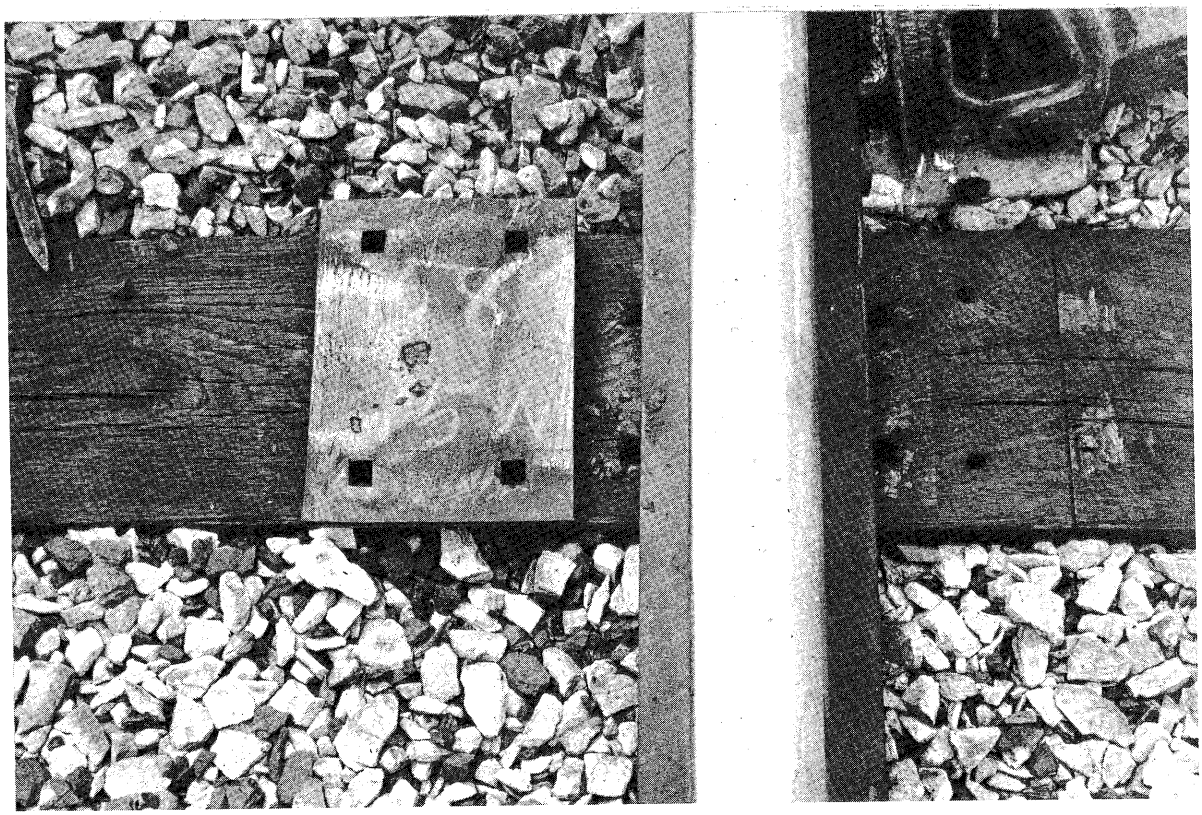


Fig. 43 -- Section 58, Railroad Rubber Products rubber tie plate, 57 months of service on oak tie tangent. Pad condition good except slight splits at spike holes. Some sand, moisture and wood compression on tie surface.

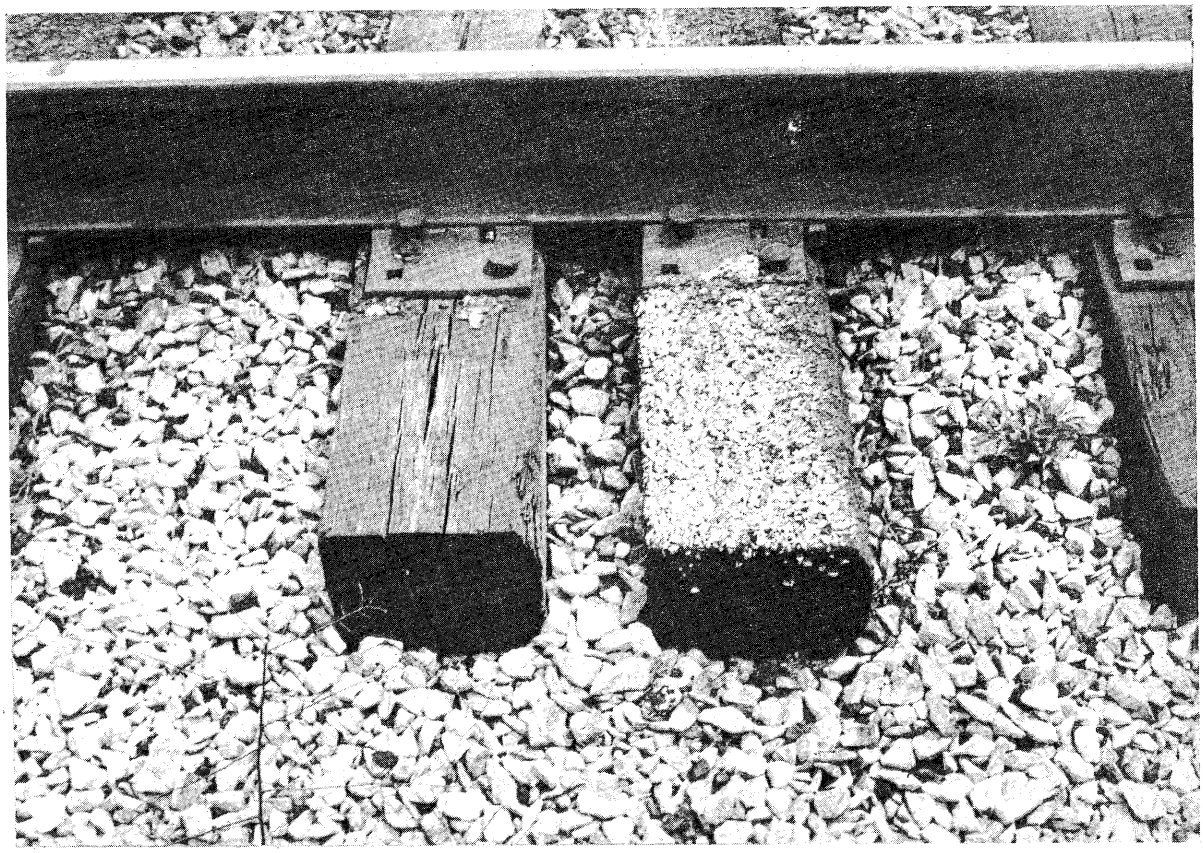


Fig. 44 -- North 1/2 Section 35, alternate new creosoted oak ties coated with Koppers No. 16 Sealing Compound, total service life 154 months with ties recoated after 97 months.

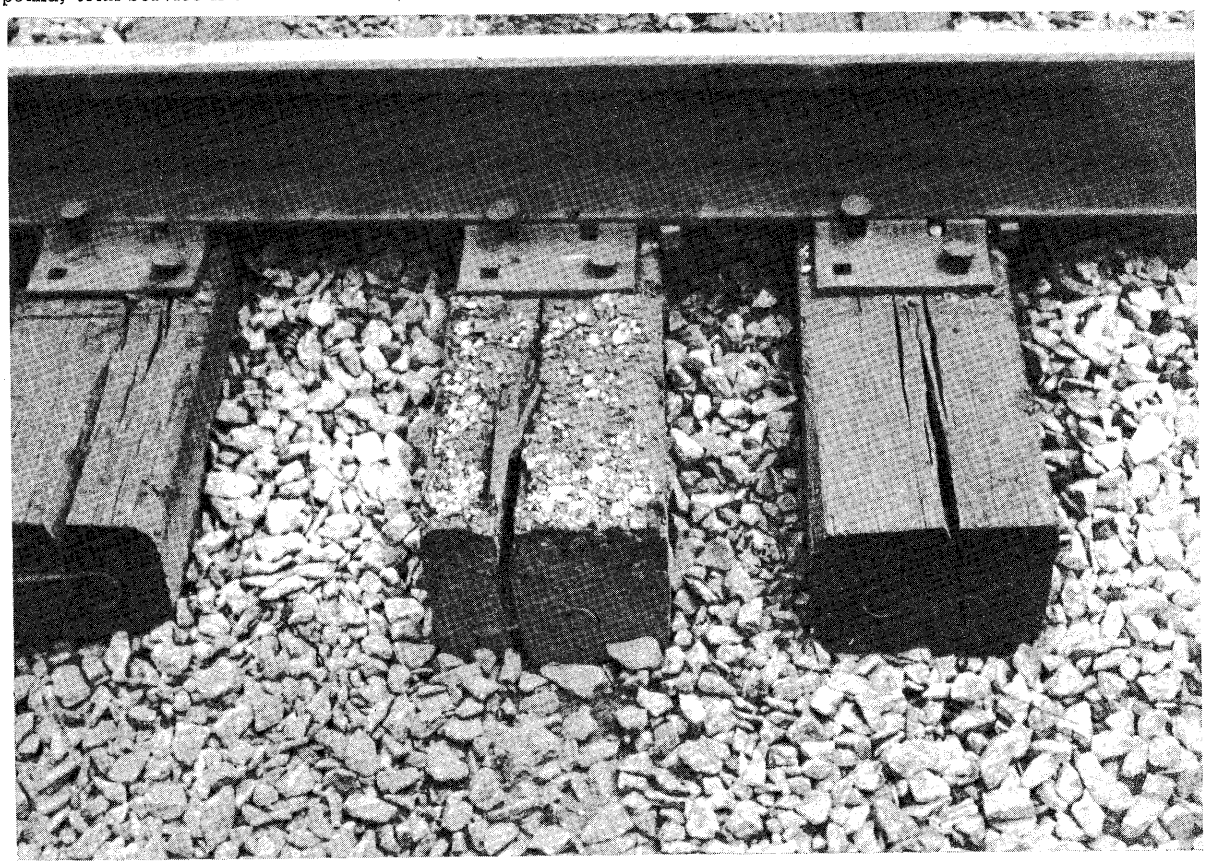
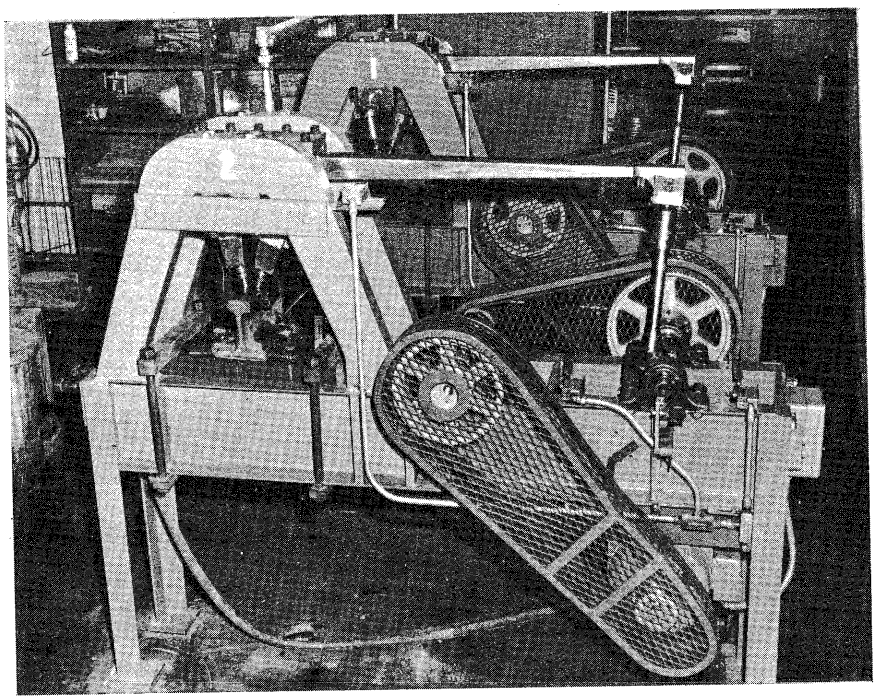
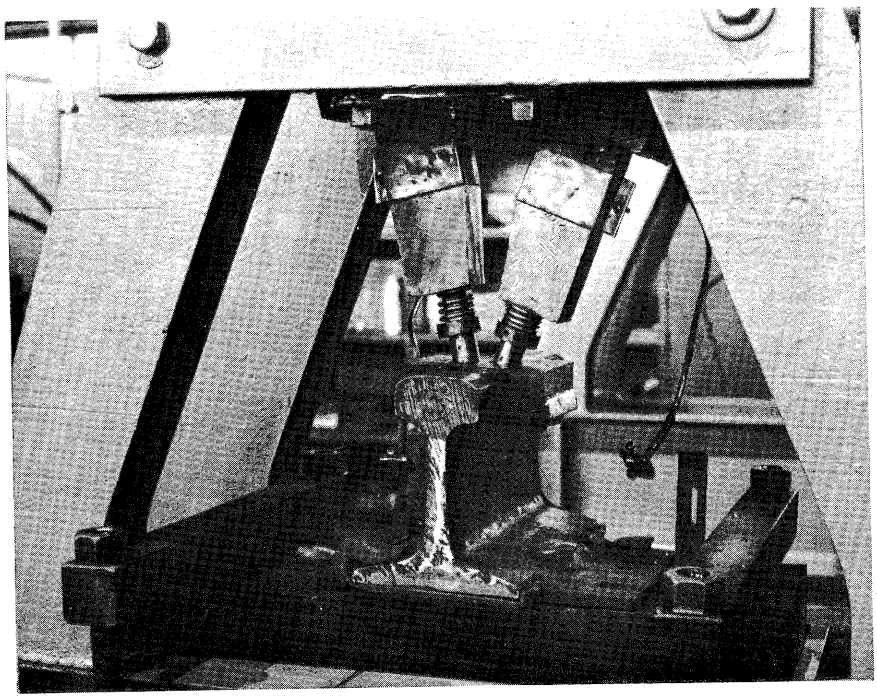


Fig. 45 -- South 1/2 Section 35, alternate new creosoted oak ties coated with Koppers No. 16 Sealing Compound, service life 154 months, ties not recoated. Coating does not appear to have retarded the splitting.



General View



Close-up Showing Struts and Water Tubes

Fig. 46 - AAR Tie Wear Machines

TABLE 3. -- TIE PLATE PENETRATION MEASUREMENTS OF SERVICE TESTS OF HOLD-DOWN FASTENINGS AND COATINGS ON THE L. & N. R. R., NEAR LONDON, KY.

Columns (1).-Million gross tons of traffic. Columns (2).-Average tie plate penetration to June 1963 in 0.001 in. Columns (3).-Years of service to 6-1963.

Section No.	Tie Plate Length in	Description of Fastenings, etc.	4°-30' Curves Creo. Oak Ties (1)	(2)	(3)	Tangent Creo. Oak Ties (1)	(2)	(3)	Tangent Creo. Pine Ties (1)	(2)	(3)	Section No.
		Fastenings and Coatings										
1		Adhesives - no anchor spikes - subdived as follows:										1
1.1	13	Solid Beckosol No. 40 - paddle coat on plate	256.4	*203	15.8	256.3	130	15.8	256.2	208	15.8	1.1
1.2	13	AREA Spec. Waterproofing Asphalt - paddle coat on plate	256.4	*225	15.8	256.3	141	15.8	256.2	201	15.8	1.2
1.3	13	Plates attached to ties in field with CASCO Cement NT-442	-	-	-	256.3	165	15.8	256.2	213	15.8	1.3
1.4	13	Plates attached in field with NT-442 and RS-216 Cements	256.4	*256	15.8	256.3	153	15.8	256.2	201	15.8	1.4
1.5	13	Same as section 1.4, except plates attached in shop before treatment	256.4	*208	15.8	256.3	128	15.8	256.2	163	15.8	1.5
1.6	13	1/8-in asphalt sheet made of Bird tie pad coating	256.4	*213	15.8	-	-	-	-	-	-	1.6
1.7	13	Same as section 1.6, except asphalt was modified to reduce flow	256.4	*233	15.8	-	-	-	-	-	-	1.7
1.8	13	Same as section 1.7, except formed around brass screening	256.4	*308	15.8	-	-	-	-	-	-	1.8
1.9	13	Same as section 1.7, except formed around 1/4-in galvanized mesh	256.4	*224	15.8	-	-	-	-	-	-	1.9
1.10	13	Solvated Sealz - heavy brush coat on plate and tie	240.5	*187	14.8	-	-	-	-	-	-	1.10
2	13	No anchor spikes	256.4	*249	15.8	256.5	*213	15.8	256.1	*239	15.8	2
9	13	2 each of cut spikes for line and anchors - rubber anchor spike cushions N. 10 ties	-	-	-	-	-	-	256.1	*214	-	9
9	13	2 each of cut spikes for line and anchors	256.4	266	15.8	256.3	195	15.8	256.1	249	15.8	9
10	13	2 round head cut spikes with single coil washers for anchors	256.4	136	15.8	256.3	151	15.8	256.1	172	15.8	10
11	13	2 Dowel studs with double coil washers for anchors	256.4	127	15.8	256.3	134	15.8	256.1	123	15.8	11
12	13	2 Oliver hold-down drive spikes with d.c. washers for anchors	256.4	152	15.8	256.4	140	15.8	256.1	161	15.8	12
13	13	2 Tie plate lock spikes for anchors (North 12 ties 4°30' curve only)	No readings - plates shifted			-	-	-	-	-	-	13
13	13	2 Elastic spikes of design No. 93 for anchors	256.4	140	15.8	256.4	126	15.8	256.1	180	15.8	13
14	13	2 thru bolts with single coil washers for anchors (field)	256.4	88	15.8	256.2	86	15.8	256.5	194	15.8	14
15	13	Same as section 14, except plates were applied under load in shop	256.5	74	15.8	256.2	92	15.8	256.5	179	15.8	15
16	13	2 screw spikes with double coil washers for anchors	256.4	92	15.8	256.2	105	15.8	256.5	180	15.8	16
17	13	2 AAR spring rail clips with screw spikes for anchors	256.4	*106	15.8	256.2	112	15.8	256.5	140	15.8	17
18	13	Erie single shoulder diamond bottom tie plate, no anchors	256.2	215	15.8	256.2	182	15.8	256.5	212	15.8	18
19	13	Erie tie plate, 2 screw spikes with d.c. washers for anchors	256.2	178	15.8	-	-	-	-	-	-	19
22	13	2 Oliver tie plate drive spikes with single coil washers for anchors	-	-	-	256.2	142	15.8	256.5	160	15.8	22

TABLE 3. (Continued)

Columns (1).-Million gross tons of traffic. Columns (2).-Average tie plate penetration to June 1963 in 0.001 in. Columns (3).-Years of Service to 6-1963.

Section No.	Tie Plate Length in.	Description of Fastenings, etc.		4°-30' Curves Creo. Oak Ties (1)	(2)	(3)	Tangent Creo. Oak Ties (1)	(2)	(3)	Tangent Creo. Pine Ties (1)	(2)	(3)	Section No.
		Fastenings and Coatings											
23	14	L&N standard with 2 each of cut spikes for line and anchors		256.1	184	15.7	255.7	154	15.7	256.7	246	15.7	23
24	14	L&N alternate standard, 2 each of cut line	Ties without clips	256.2	184	15.7	255.7	165	15.7	256.2	224	15.7	24
24	14	and anchor spikes with Rails Co. compression clips	Ties with clips	256.2	190	15.7	255.7	152	15.7	256.2	215	15.7	24
24	14	on alternate ties	All ties	256.2	188	15.7	255.7	160	15.7	256.2	224	15.7	24
26	13	DL&W D.S. diamond bottom tie plate, 2 cut spikes for line and 1 anchor		235.9	224	14.8	-	-	-	-	-	-	26
31	14	G&H Controls No-Creep rail anchors on alternate tie plates. 2 cut line	Anchored ties	-	-	-	215.9	138	13.8	-	-	-	31
31	14	spikes on unanchored ties, 1 cut line spike and 2 Oliver tie plate	Unanchored ties	-	-	-	215.9	128	13.8	-	-	-	31
31	14	drive spikes for anchors on anchored ties	All ties	-	-	-	215.9	134	13.8	-	-	-	31
32	14	Farbertite - paddle coat on adzed surface and plate		-	-	-	215.9	127	13.8	-	-	-	32
33	14	Tie plates cemented to ties as in section 1.5, except under laboratory conditions		-	-	-	215.9	83	13.8	-	-	-	33
34	14	2 Tie plate lock spikes for anchors. Asphalt roofing paint on S.24 ties		-	-	-	215.9	92	13.8	-	-	-	34
49	14	2 cut line spikes and 3 Racor studs for anchors		156.0	* 60	10.8	-	-	-	-	-	-	49
49	14	2 cut line spikes and 4 Racor studs for anchors		156.0	* 94	10.8	-	-	-	-	-	-	49
50	14	"Anker Seel" applied to adzed surfaces, 2 each of cut spikes line and anchor		-	-	-	136.8	61	9.9	-	-	-	50
51	14	2 cut spikes for line and 2 creo. hardwood Nordberg pegs for anchors		-	-	-	136.8	67	9.9	-	-	-	51
52	14	Protek-Tie applied to adzed surfaces, 2 each of cut spikes line and anchor		-	-	-	136.8	70	9.8	-	-	-	52
		5° Curve - Creo. Oak Ties - near East Bernstadt, Ky.											
		Fastenings and Coatings											
37	14	2 each of cut spikes for line and anchors		201.4	193	12.9	-	-	-	-	-	-	37
43	14	2 cut spikes for line and 2 Racor studs for anchors		201.4	*139	12.9	-	-	-	-	-	-	43
53	14	Nox-Rust tie seals under tie plates, 2 each of cut spikes line and anchor		112.0	114	8.0	-	-	-	-	-	-	53
57	14	2 cut spikes for line and 2 Spring Lags for anchors		109.0	71	7.0	-	-	-	-	-	-	57

Notes: Penetration measurements are the average of both rails in each subsection. The penetration data includes partial cutting of the ribs on diamond bottom plates in sections 18, 19 and 26. All other plates have flat bottom.

*The following notes apply only to the section numbers shown: (1 and 2) These sections on the long test curve were damaged by one derailed truck, July 3, 1952. (2) Rubber line spike cushions were added to the N. 24 ties of each portion on tangent 12-1-49. (43) Racor studs were driven down with a large size air hammer in 1951, principally because they were not driven down far enough when originally installed. (9) Rubber anchor spike cushions were added to the N. 10 pine ties 12-13-49. (17) 2 cut line spikes were used only on the curve. (49) Racor studs, originally driven down with a unit air hammer were redriven in 1960 with a dual air hammer at the request of the supplier.

TABLE 4. RELATIVE TIE WEAR OF THE 1947 TEST INSTALLATIONS WITH HOLD-DOWN FASTENINGS AND COATINGS ON THE L. & N. R.R., NEAR LONDON, KY.

(The average tie plate penetration for both rails in section 2 for each category has been used as controls, or 100 percent. All tie plates are 13 in. long with flat bottom, except as noted otherwise.)

Sect. No.	Description	4 1/2° C. Oak	Tan. Oak	Tan. Pine	Com-posite
	Hold-down Fastenings				
2	No anchor spikes (control section)	100	100	100	100
15	2 Thru bolts with s.c. spring washers (field)	30	43	75	49
14	2 Thru bolts with s.c. spring washers (shop)	35	40	81	52
17	2 AAR spring rail clips with screw spikes	43	53	59	52
16	2 Screw spikes with d.c. spring washers	37	49	75	54
11	2 Dowel studs with d.c. spring washers	52	63	51	55
13	2 Elastic spikes	56	59	75	63
12	2 Oliver hold-down drive spikes with d.c. spring washers	61	66	67	65
10	2 Round head cut spikes with s.c. spring washers	55	71	72	66
22	2 Oliver tie plate drive spikes with s.c. spring washers	-	67	67	-
(a) 19	Erie s.s. dia. bot. tie plates, 2 screw spikes, d.c. washers	72	-	-	-
24	L&N alt. std., 14" plates, Rails Co. clips on alternate ties	76	75	94	82
23	L&N std., 14" plates, 2 cut spikes for line and anchors	74	72	103	83
(a) 18	Erie single shoulder dia. bot. tie plates, no anchors	86	85	89	87
(b) 9	2 Cut spikes with rubber cushions N. 10 pine ties	-	-	90	-
9	2 Cut spikes (N. 10 pine ties excluded)	105	91	104	100
	Tie Coatings and Adhesives				
1.5	N.T. 422 and R.S. 216 cements attached in shop	84	60	68	71
1.1	Beckosol No. 40	82	61	87	77
1.2	AREA waterproofing asphalt	90	66	84	80
1.3	N.T. 422 cement applied in field	-	77	89	-
1.4	N.T. 422 and R.S. 216 cements applied in field	103	72	84	86

(a) The penetration data include partial cutting of the ribs on diamond bottom plates in sections 18 and 19.

(b) Rubber anchor spike cushions were added to N. 10 pine ties 12-13-49.

TABLE 5. RELATIVE TIE WEAR OF INSTALLATIONS MADE SUBSEQUENT TO 1947 WITH HOLD-DOWN FASTENINGS, COATINGS AND ADHESIVES ON THE L.&N. R.R. NEAR LONDON, KENTUCKY

Section No.	Description	Size Plate (b)	No. of Ties	Location	Kind of Tie	Test Period From	Test Period To	Test Period Years	Million Gr. T.	Avg. Tie Wear in (a)	Percent of Control Sec.
	Tie Coatings and Adhesives										
1.10	Solvated Sealz	13"	6	4°30'C.	Oak	8-48	6-63	14.8	240.5	0.187	80
2	No anchors (Control)	13"	59	4°30'C.	Oak	11-47	-	-	240.5	0.234	100
32	Farberite	14"	12	Tang.	Oak	11-49	6-63	13.6	215.9	0.127	91
33	NT-442 and RS 216 Cements Lab. Cond.	14"	5	Tang.	Oak	11-49	6-63	13.6	215.9	0.083	60
23	L&N std. 2 cut spike anchors (Control)	14"	24	Tang.	Oak	11-47	-	-	215.9	0.139	100
50	Anker Seel Coating	14"	24	Tang.	Oak	8-53	6-63	9.8	136.8	0.061	63
52	Protek Tie Coating	14"	24	Tang.	Oak	8-53	6-63	9.8	136.8	0.070	72
23	L&N std. 2 cut spike anchors (Control)	14"	24	Tang.	Oak	11-47	-	-	136.8	0.097	100
53	Nox-Rust tie seal under tie plates	14"	13	5°C.	Oak	8-55	6-63	7.8	112.0	0.114	108
37	2 Cut spike anchors (Control)	14"	48	5°C.	Oak	8-50	-	-	112.0	0.105	100
	Hold-Down Fastenings										
31	G&H controls anchors	14"	48	Tang.	Oak	11-49	6-63	13.6	215.9	0.134	96
34	2 lock spikes anchors	14"	48	Tang.	Oak	11-49	6-63	13.6	215.9	0.092	66
23	L&N std. 2 cut spike anchors (Control)	14"	24	Tang.	Oak	11-47	-	-	215.9	0.139	100
51	2 creo. hardwood Nordberg pegs	14"	10	Tang.	Oak	8-53	6-63	9.8	136.8	0.067	69
23	L&N std. 2 cut spike anchors (Control)	14"	24	Tang.	Oak	11-47	-	-	136.8	0.097	100
43	2 Racor stud anchors	14"	47	5°C.	Oak	8-50	6-63	12.8	201.4	0.139	72
37	2 Cut spike anchors (Control)	14"	48	5°C.	Oak	8-50	6-63	12.8	201.4	0.193	100
49	N-29 Ties, 3 Racor stud anchors	14"	29	4°30'C.	Oak	10-52	6-63	10.7	156.0	0.060	52
49	S-31 Ties, 4 Racor stud anchors	14"	31	4°30'C.	Oak	10-52	6-63	10.7	156.0	0.094	82
23	L&N std. 2 cut spike anchors (Control)	14"	24	4°30'C.	Oak	11-47	-	-	156.0	0.115	100
57	2 Spring Lag anchors	14"	24	5°C.	Oak	10-56	6-63	6.7	109.0	0.071	70
37	2 Cut spike anchors (Control)	14"	48	5°C.	Oak	8-50	-	-	109.0	0.102	100

(a) Tie wear of control sections was obtained by interpolation based on equivalent tonnage.
(b) All tie plates have flat bottoms.

TABLE 6. SUMMARY OF SPECIAL HOLD-DOWN FASTENINGS TAPPED DOWN OR RETIGHTENED FROM THE DATE OF INSTALLATION THROUGH MAY 1963 ON THE L&N RR., NEAR LONDON, KY.

Sec. No.	Hold-Down Fastenings	Date Built	Long 4°-30' Curve (1)	Long 4°-30' Curve (2)	Tangent Creo. Oak Ties (1)	Tangent Creo. Oak Ties (2)	Tangent Creo. Pine Ties (1)	Tangent Creo. Pine Ties (2)	Total For Each Construction (1)	Total For Each Construction (2)
10	2-Round Head cut spikes with single-coil spring washers	8-47	404	180	234	139	588	300	1226	206
11	2-Round Head Dowel studs with double-coil helical spring washers	8-47	95	40	2	1	230	122	327	54
12	2-Oliver hold-down drive spikes with double-coil helical spring washers	8-47	46	20	6	3	134	70	183	30
13	2-Elastic spikes, design No. 93	8-47	2	1	0	0	238	129	240	65
13	2-Tie plate lock spikes (North 12 Ties)	8-47	0	0	-	-	-	-	0	0
14	2-Thru bolts with single-coil spring washers (field)	8-47	188	100	96	100	183	211	467	126
15	2-Thru bolts with single-coil spring washers (shop)	8-47	192	100	96	100	86	110	374	102
16	2-Screw spikes with double-coil spring washers	8-47	248	103	4	2	220	115	472	76
17	2-AAR spring rail clips and screw spikes	8-47	480	216	480	333	408	237	1368	252
19	2-Screw spikes and double-coil spring washers with 13 in Erie RR. diamond bottom tie plates	8-47	254	108	-	-	-	-	254	108
22	2-Oliver tie plate drive spikes with single-coil spring washers	8-47	-	-	264	138	438	230	702	184
31	G&H Controls No-Creep rail anchors and 2-Oliver tie plate drive spikes without spring washers on anchored ties only, 14-in tie plates	8-49	-	-	96	100	-	-	96	100
34	Tie plate lock spikes - Asphalt coating, 14 in tie plates	9-49	-	-	0	0	-	-	0	0
48	2-Racor studs - Racor tie pads, 14 in tie plates	8-52	0	0	-	-	-	-	0	0
49	2-Cut line spikes, 3 Racor studs, 14 in tie plates	8-52	174	(b)100	-	-	-	-	174	100
49	2-Cut line spikes, 4 Racor studs, 14 in tie plates	8-52	248	(b)100	-	-	-	-	248	100
			5° Curve							
43	2-Racor studs, 14 in tie plates	7-50	188	(a)100	-	-	-	-	188	100
57	2-Cut line spikes, 2 spring lags, 14 in tie plates	6-56	0	0	-	-	-	-	0	0

Notes: Col. (1) Number of hold-down fastenings retightened or tapped down. Col. (2) Percentage of hold-down fastenings retightened or tapped down. All tie plates have a flat bottom and 13-in length, except as indicated above. (a) Racor studs in section 43 were tapped down with an air hammer in July 1951, because they were not driven home when originally applied with a maul. (b) Racor studs in section 49 were originally driven with a unit air hammer and redriven in 1960 with a dual hammer driver at the request of the supplier. All maintenance work on the special hold-down fastenings, except the Racor studs, was performed manually. The work of retightening the special hold-down fastenings has required 169 man-hours. In addition, 35 man-hours were required for applying No-Ox-Id "A" Special twice to the dowel studs in section 11 and the thru bolts in sections 14 and 15 to protect the exposed threads from corrosion. For more details of this work, see AREA Proceedings Vol. 53, 1952, page 792; Vol. 54, 1953, page 1057; Vol. 55, 1954, page 728; Vol. 56, 1955, page 842; Vol. 57, 1956, pages 713-715; Vol. 59, 1958, page 1035 and Vol. 60, 1959, page 801

TABLE 7. CORRELATION TESTS, HOLD-DOWN FASTENINGS

AAR TIE WEAR MACHINES VS SERVICE TEST ON L & N, LONDON, KY.

London Tests			*Laboratory Tests		
Section No. and Hold-down Fastening	Avg. Wear Inches	Per-cent	Test No. and Hold-down Fastening	Avg. Wear Inches	Per-cent
13 in. Plates-4 1/2 deg. Cv., Outer Rail			All 14 in. Plates and Oak Ties		
Sec. 9, Control-2 Cut Spikes for Anchor	0.267	100	3 Tests, Control-2 Cut Spikes for Anchor	0.138	100
Sec. 12, 2 Twisted Drive Spikes	0.159	60	M1-53, 2 Twisted Drive Spikes	0.090	65
Sec. 15, 2 Thru Bolts	0.077	29	M2-36, 2 Thru Bolts	0.047	34
Sec. 16, 2 Screw Spikes	0.076	28	M1-47, 2 Screw Spikes	0.039	28
Sec. 17, AAR Clips, 2 Screw Spikes	0.116	43	M2-38, AAR Clips, 2 Screw Spikes	0.017	12
14 in. Plates-5 deg. Cv., Outer Rail					
Sec. 37, Control-2 Cut Spikes for Anchor	0.198	100			
Sec. 43, 2 Racor Studs	0.140	71	M1-41, 2 Racor Studs	0.060	43
14 in. Plates Tang. Oak					
Sec. 23, Control-2 Cut Spikes for Anchor	0.139	100			
Sec. 34, 2 Tie Plate Lock Spikes	0.092	66	M2-16, 2 Tie Plate Lock Spikes	0.057	42

*All laboratory tests were 2,500,000 cycles, 129 cycles per min. with strut loads; 20K vertical, 7.5K horizontal outward and 3.75K horizontal inward. Water and sand were added after a scating period of 2,500 cycles to simulate track conditions and accelerate tests.

TABLE 8, TIE WEAR MACHINE DATA--TIE PADS ON CREOSOTED WOOD TIES

Test No.	Description	Date of Specimen	Cycles Operation	(1) Avg. Tie Wear Inches	Avg. Lateral Inches	Seal Percent	Pad Condition	Remarks
Avg. 3 Tests	Control Tests-Oak Ties-No Pads	-	2,500,000	0.127	0.007	-	-	
Avg. 3 Tests	Control Tests-Fir Ties-No Pads	-	2,500,000	0.180	0.006	-	-	
	Bird Pads-Coated							
M2- 9	5 Ply SD, Duck-Burlap-Oak Tie	1960	2,500,000	0.004	0.021	60	Good	Slight stretching, no delamination.
M1-42	5 Ply LD, All Jute-Oak Tie	1960	2,500,000	0.012	0.024	0	Poor	96 percent abraded and worked out.
M1-43	5 Ply LD, All Jute-Oak Tie	1956	2,500,000	0.025	0.023	13	Poor	35 percent on gage end abraded away.-Broke one spike.
M2-35	5 Ply SD, Duck-Burlap-Fir Track Tie	1962	2,500,000	0.039	0.035	22	Fair	Some stretching-3 top plies abraded away.
M1-63	5 Ply SD, Duck-Burlap-Fir Bridge Tie	1962	2,500,000	0.086	0.031	39	Fair	Worn on edges-most of top ply abraded away.
	Racor Pads-Coated							
M2-10A	1/8 in. Fiber-Rubber-Oak Tie	1960	2,378,200	0.027	0.062	10	Fair	Heavy wear but tie surface protected.-Broke 4 spikes.
M1-48	1/8 in. Fiber-Rubber-Oak Tie	1961	2,500,000	0.076	0.031	1	Poor	Very little pad left at end of test.
M2-31	1/8 in. Fiber-Rubber-Oak Tie	1962	2,500,000	0.068	0.033	0	Poor	45 percent abraded and worked out.-Broke one spike.
M2-32	1/8 in. Fiber-Rubber-Oak Tie	1962	2,500,000	0.090	0.045	0	Poor	Badly worked out-very little left under plate.-Broke 3 spikes.
M1-67	3/16 in. Laminated Fiber-Rubber-Oak Tie	1963	2,500,000	0.089	0.022	0	Fair	Worn thin on gage end, some splitting.
M2-46	3/16 in. Single Ply Fiber-Rubber-Oak Tie	1963	2,500,000	0.032	0.040	0	Good	Some wear at field end, two small splits.
	Fabco Pads-Coated							
M2-28	1/8 in. Fiber-Rubber, Coated-Oak Tie	1961	2,500,000	0.029	0.053	8	Fair	Worn very thin.-Broke 2 spikes.
M1-49	1/4 in. Fiber-Rubber, Coated-Oak Tie	1961	2,500,000	0.029	0.044	23	Good	Very slight wear.-Broke 7 spikes.
	Miscellaneous Pads							
M2-13	Konvex Tire Carcass, Coated-Oak Tie	1959	1,190,500	0.021	0.097	20	Good	Very slight wear-excessive lateral.-Broke 2 spikes
M2-15	R.R. Rubber Products, Uncoated-Oak Tie	1959	1,494,000	0.166	0.126	0	Poor	Pad badly worn and torn-excessive lateral.-Broke 3 spikes.

(1) Tie wear is average at 15 readings throughout the bearing area.
All tests operated 129 cycles per min. with 7 3/4 in. x 14 in. tie plates (Plan 12) with 2 cut spikes each, line and anchor.
Water and sand added after seating period of 2500 cycles to simulate track conditions and accelerate tests.

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TABLE 9. AAR TIE WEAR MACHINE TEST RESULTS WITH 12 IN., 14 IN. AND 16 IN. TIE PLATES, ALSO OAK AND FIR TIES, 2 CUT SPIKES EACH, LINE AND ANCHOR

Tests	*Description	Tie Wear-Inches Avg. at Ends of Plate			Lateral Inches		Ratio Field to Gage	Tie Wear Percent of Control
		Field	Gage	Avg.	Max.	Avg.		
	Creosoted Oak Ties							
Avg. 3 Tests	7 3/4 in. x 14 in. Tie Plates 3/8 in. Eccentricity (Control)	0.175	0.100	0.138	0.012	0.007	1:1.75	100
Avg. 2 Tests	7 3/4 in. x 12 in. Tie Plates 3/8 in. Eccentricity	0.272	0.130	0.201	0.012	0.008	1:2.09	146
Avg. 2 Tests	7 3/4 in. x 16 in. Tie Plates 1 1/4 in. Eccentricity	0.135	0.177	0.156	0.012	0.006	1:0.76	113
	Creosoted Fir Ties							
Avg. 3 Tests	7 3/4 in. x 14 in. Tie Plates 3/8 in. Eccentricity	0.212	0.169	0.190	0.009	0.006	1:1.25	138
Avg. 2 Tests	7 3/4 in. x 12 in. Tie Plates 3/8 in. Eccentricity	0.312	0.118	0.215	0.007	0.005	1:2.65	156

*All tests were 2,500,000 cycles, 129 cycles per min. Strut loads; 20K vertical, 7.5K horizontal-outward and 3.75K horizontal-inward. Water and sand added after a seating period of 2500 cycles.

TABLE 10. TESTS USING EPOXY RESIN ADHESIVES TO FASTEN TIE PLATES TO TIES OR GLUING HARDWOOD WEARING SURFACES TO SOFTWOOD TIES

Test No. 1	Description	Cycles Operation at 129 cpm	Results
M1-40	7 3/4 in. x 14 in. Tie Plate glued to planed surface of Creosoted Oak Tie, 2 line spikes only. Sand and water added after 1,607,700 cycles.	2,500,000	Cracking at the edges was noted soon after the test started, but plate movement held steady until 1,448,500 cycles. At end of test only 1.5 percent of area was in bond.
M1-47	7 3/4 in. x 14 in. Tie Plate glued to planed surface of Creosoted Oak Tie, 2 line spikes only. Sand and water added after 2,500 cycles.	2,500,000	Cracking at the edges started at 16,900 cycles. Bond was completely gone at 1,745,200 cycles as confirmed by temporarily stopping the test and lifting the tie plate.
M2-29	7 3/4 in. x 14 in. Tie Plate glued to planed surface of Untreated Fir Bridge Tie, 2 line spikes. Without sand and water Sand and water added after 2,500,000 cycles. Total Cycles	 2,500,000 869,400 3,369,400	Crack at the edges of the plate occurred early in the test and evidence of horizontal shear appeared in the wood below the top surface. Bond held well until water and sand were added. After 380,000 additional cycles the lateral movement began to increase. After 869,400 cycles operation with sand and water, the plate was pried off and the bond was gone from 71 percent of the surface.
M1-50	Same as M2-29 except sand and water were added after 2,500 cycles.	1,017,700	Cracking occurred at the tie plate edges soon after starting the test. Also a horizontal shear crack appeared in the wood about 1/2 in. below the top. Bond was completely gone when the test was stopped at 1,017,700 cycles.
M1-54	3 Ply Penta treated hickory plywood glued to a Fir Bridge Tie and then creosote treated, 7 3/4 in. x 14 in. Tie Plate, 2 each line and anchor spikes. Sand and water added after 2,500 cycles.	2,500,000	Failure of bond was first evident at 995,000 cycles and appeared to be entirely gone at 1,892,000. At the end of the test the glue was nearly all eroded away and the fir wood worn to an average depth of 0.119 in. at the ends of the plate.
M2-33	Same as M1-54 except untreated plywood used.	2,500,000	Failure by cracking at the glue line started at 271,000 cycles and bond appeared entirely gone at 1,169,000 cycles. Average wear of the Fir wood at the ends of the plate was 0.087 in.

Epoxy Formulation: AREA Proceedings, Vol. 64, Primer - P1, page 15; Adhesive - 991-67, pages 12 and 13.

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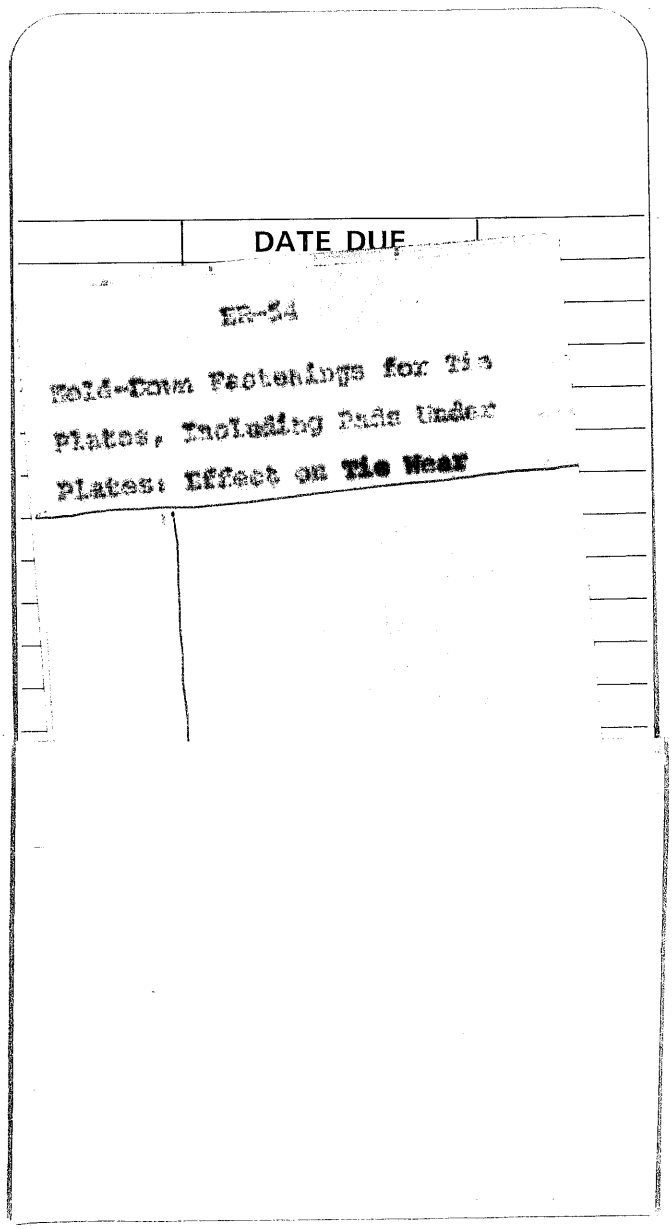
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