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Letter
Circular
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RAILWAY TRACK SCALE TESTING SERVICE

OF THE

NATIONAL BUREAU OF STANDARDS

FISCAL YEAR 1936 (JULY 1, 1935 to JUNE 30, 1936)

Letter
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RAILWAY TRACK SCALE TESTING SERVICE OF THE NATIONAL BUREAU OF STANDARDS FISCAL YEAR, 1936

INTRODUCTION

This report presents the results of the activities of the Railway Track Scale Testing Service of the National Bureau of Standards, for the fiscal year 1936 (July 1, 1935 to June 30, 1936). It is one of a series of reports which the Bureau is accustomed to issue annually to bring these results to the attention of agencies interested in the accuracy of railway track scales. This group includes the railroads of the United States, weighing and inspection bureaus, various railroad and industrial associations, industrial organizations using railway track scales in their transactions, State and local officials engaged in the enforcement of weights and measures laws, and others.

In former reports of this series the nature, purposes, and development of this service, and the activities undertaken to accomplish the desired results, have from time to time been discussed in considerable detail. The fundamental objects may be stated to be the maintenance and dissemination of a uniform standard for scales used in weighing commodities in carload lots, and the improvement of the accuracy of these weighing facilities and of their use. To this end various steps are taken which may be grouped under four general heads:

(a) Calibration of master track scales.

Master track scales are those employed in the standardization of railway track scale test weight cars which, in turn, are utilized by railroads, industries, and testing agencies, as standard test weights in the test and adjustment of railway track scales. Nineteen of these scales, owned by railroads and governmental agencies, are located in various parts of the United States. The National Bureau of Standards operates three railway track scale testing equipments, two of which are available for master scale tests. These equipments travel on itineraries laid out in advance in accordance with the terms of an agreement entered into with the Association of American Railroads. The itineraries must be so planned that one of the equipments will visit each of the master track scales at approximately yearly intervals. Thus each of the nineteen master scales is calibrated annually by the Bureau.

(b) Standardization and weighing of railway track scale test weight cars.

The National Bureau of Standards operates a master track scale located at its Master Scale Depot at Clearing, Illinois. This scale serves as the Federal standard for heavy weights and weighing. It is used in the standardization of railway track scale test weight cars and other heavy weights, which are submitted for this purpose by railroads, industries, and governmental

agencies. Test cars are also weighed in the field in connection with the tests of railway track scales.

(c) Testing of railway track scales.

The itineraries upon which the Bureau track scale testing equipments travel are so prepared that from time to time the equipments travel on the lines of all the important railroads of the country, and so that movements on recent itineraries will not be duplicated. The equipments test railway track scales owned by railroads, industries, and governmental agencies encountered on their routes, with the result that each year representative information is gained as to the general accuracy of railway track scales in commercial use in all sections of the country.

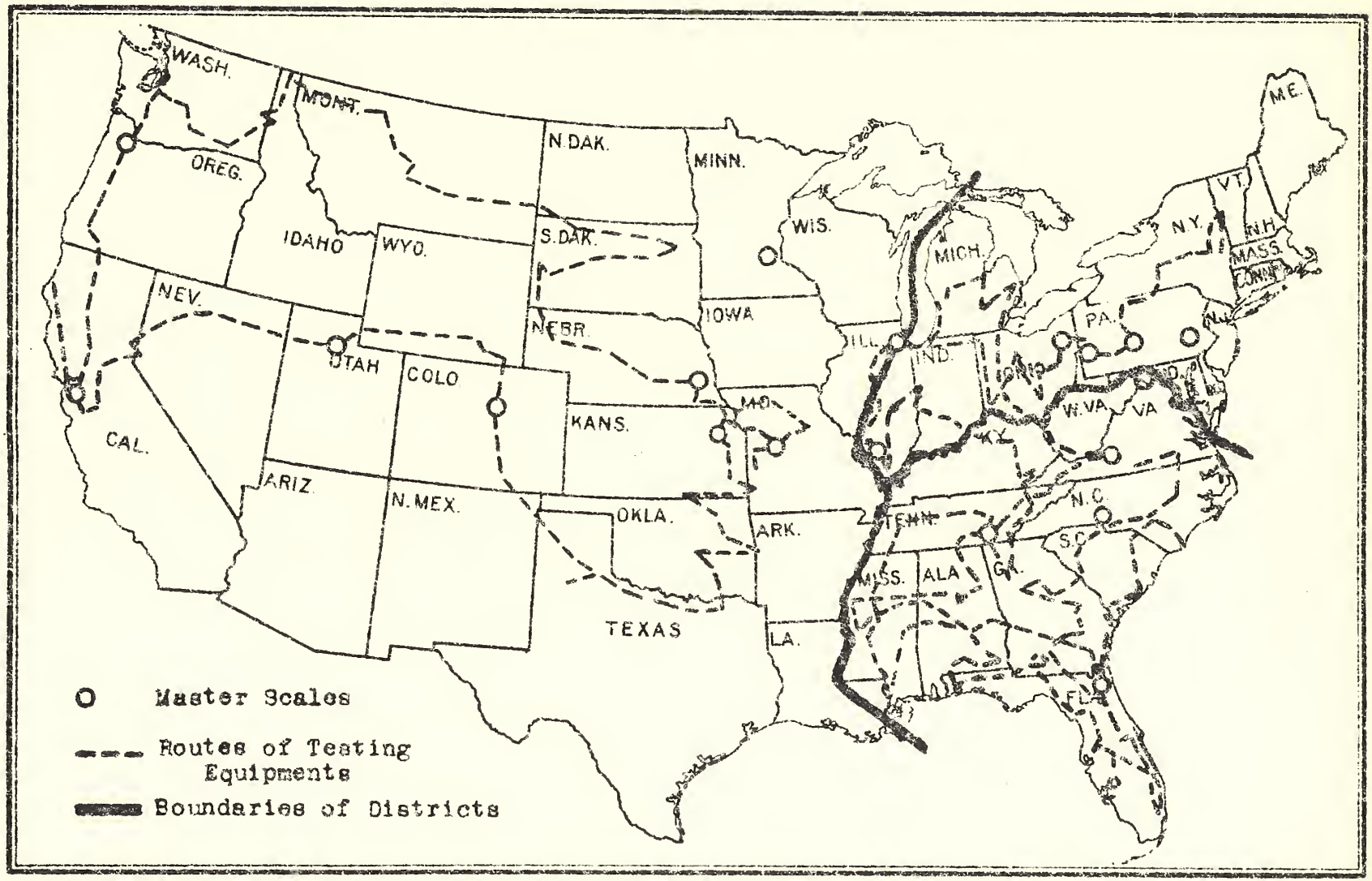
(d) Performance of related work.

The activities described above are supplemented by research, special testing, preparation of specifications, and related work according to the needs arising and the personnel available to undertake such projects.

RÉSUMÉ OF TESTING ACTIVITIES

Fourteen calibrations were made by the Bureau on 13 railway master track scales during the year. Sixty-three railway track scale test weight cars were standardized on the Bureau master track scale located at Clearing, Ill. Thirty-two test weight cars were weighed in the field. Twelve hundred and thirty-seven railway track scales were tested by the three Bureau track scale testing equipments. Fifty-three and four-tenths percent of these scales were owned by railroads, the remaining 46.6 percent being classed as industry-owned scales. The scales tested were located on the lines of 179 railroads, a number considerably larger than the number heretofore visited in any one year. This increase results from the attention now being given to the testing of scales on short lines and of scales not heretofore tested by the Bureau. Tests were made in 32 States. The distribution of scales by railroads and throughout the country as a whole is considered to be entirely satisfactory.

The routes travelled by the three testing equipments are designated by broken lines, and the points at which are located master scales by circles, on the map shown on the following page. Also shown are the boundaries of the districts into which the country is divided for the purpose of summarizing and analyzing the statistical data. The districts are denominated the Eastern, Southern, and Western. The boundaries are those adopted by the Interstate Commerce Commission in its publication "Reports on the Statistics of Railways in the United States". The assignment to these districts made by the commission, with respect to certain of the carriers, the lines of which lie in two or more districts, has also been followed.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ALA.
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TEXAS
LA.
FLA.
Master Scales
Routes of Testing Equipments
Boundaries of Districts

MASTER TRACK SCALE CALIBRATIONS

It is the intent of the Bureau to test each of the master track scales in the country -- nineteen in all -- approximately once in each twelve months. Ordinarily in the past it has been found possible to do this. However, in the last few years, due to the exigencies of preparing efficient itineraries, the average intervals between tests have been somewhat longer than twelve months. It has recently been the Bureau policy so to route its equipments and to conduct its testing work, that scales not heretofore tested, or not recently tested, would be visited and the service extended to the maximum practicable number of railroads. When travelling on these itineraries it has further been the Bureau policy to test all possible scales on the tracks traversed in order to effect economies by making it unnecessary on the part of the roads to duplicate these movements with their own testing equipments. While this method of procedure is believed to be desirable, it has resulted in slowing up the progress of our equipments, and thus in lengthening the periods necessary for the completion of the itineraries. Without sacrificing the objectives mentioned above, the Bureau is now endeavoring to shorten the itineraries of the equipments so that the intervals of time elapsing between calibrations of a master scale can be reduced. It is hoped that in the near future reasonable progress toward this end may be made. In the meantime, it may be said that the condition of the master scales is entirely satisfactory and it is clearly demonstrated that no ill effects have resulted from the failure regularly to test at twelve-month intervals.

All of the master scales not calibrated during the fiscal year are included on current itineraries of the equipments and consequently they will be reached and calibrated early in the coming fiscal year.

The calibration of a master scale as conducted by the Bureau usually comprises three separate steps:

(1) A preliminary maintenance test with loads of 40,000, 60,000, and 80,000 pounds, applied at the several designated positions on the scale platform. This test is made on the scale in the condition in which it is encountered, and determines the manner in which it has maintained its accuracy since the last preceding calibration and its condition during recent use. The measure of satisfactory performance is that the scale shall be within the "maintenance" tolerance specified for this test. This tolerance is expressed in pounds and amounts to approximately two one-hundredths of one percent (0.02%) of the load applied; for instance, the maintenance tolerance on 80,000-pound load is 12.0 pounds.

(2) An adjustment test with loads of 30,000, 40,000, 50,000, 60,000, 70,000, and 80,000 pounds, applied at the designated

positions. This test is made after the completion of any modifications or adjustments found necessary or advisable. The results of this test express the condition of the scale as it is left to perform its standardizing operations during the following year. The measure of satisfactory performance on this test is that the scale shall comply with the "adjustment" tolerance specified. This tolerance is one-half the maintenance tolerance and amounts to approximately one one-hundredth of one percent (0.01%) of the applied load. When the performance of a scale on the maintenance test is within the allowable adjustment tolerance and no repairs, modifications, or adjustments are indicated, then the maintenance test is incorporated in and becomes a part of the adjustment test.

(3) A test of the counterpoise weights which are used in determining weights on the master scale. This test is made by calibrating these weights against a set of accurate standards on a special precision balance carried on the equipment.

As mentioned heretofore, 14 master scales were calibrated during the year. All of these were found to be within the maintenance tolerance; eleven were found on first inspection to be within the adjustment tolerance. The three scales found within the maintenance tolerance but not within the adjustment tolerance as the scale was encountered, were adjusted. It was also found advisable to make adjustments of four additional scales to improve their weighing performance somewhat. Modifications were made on three scales, these including two of those which were not found with the adjustment tolerance. All the scales as left, were weighing well within the adjustment tolerance.

RAILWAY TRACK SCALE TESTS

It may be that some readers of this report will not be thoroughly familiar with the methods employed by the Bureau in the test of a railway track scale. For their information there may be quoted from last year's report a brief outline of the method of inspection, test, and reporting employed, and a statement of the tolerances applied.

"The test consists essentially in determining the indications of the scale when standard test loads are placed at certain specified positions on the scale rails. The loads utilized are 40,000 pounds and 80,000 pounds. Repeat observations are made for each position. In the case of one equipment an added test is conducted with a distributed load of 120,000 pounds. The sensitiveness of the scale and the performance with respect to the zero balance condition are also determined.

"Following the test a thorough inspection of the scale parts is made. When it is found that the character of error and the condition of the scale parts justify an adjustment, this may be made to improve the weighing accuracy.

"In the case of each test an individual report is issued to the owner of the scale. This report states the accuracy of the scale, and in the case of scales not performing within tolerance, gives the detailed results of all observations. The report also includes the results of the inspection, detailing any faulty conditions found, and, when indicated, making recommendations in relation to repair and to maintenance measures.

"Railway track scales are considered to be correct or incorrect according to the requirements of the tolerance adopted by the Bureau. Substantially it is required that the maximum indicated percentage error of weighing, computed in accordance with methods detailed on the reverse of the report forms issued, shall not exceed two-tenths of one percent (0.20%) in the case of all scales except those used in grain-weighing service, and one-tenth of one percent (0.10%) for scales in this special class. For the statistical purposes served by table 1 of this report, each scale is listed as "within tolerance" or "not within tolerance" on the basis of the tolerance of two-tenths of one percent whether or not the scale is in grain-weighing service. In a subsequent section of the report the accuracy of grain scales is analyzed on the basis of the tolerance of one-tenth of one percent."

In table 1 which follows are summarized the railway track scale test data for fiscal year 1936. Number of scales tested, percentage within tolerance, and mean numerical errors -- percent of applied load -- are given. For the purposes of this summary scales are divided into two classes: (1) "Railroad", denoting those owned by common carriers and used for the purpose of determining freight charges, and (2) "Industry", denoting those owned by industries and used largely for establishing or verifying weights for the purchase and sale of materials; often the weights so determined may be accepted by the railroads as the basis of freight charges. The industry class includes a few scales owned by the Federal, State, and local governments. The data are shown for each district of the country, as defined heretofore, and for the country as a whole.

TABLE 1. SUMMARY OF RAILWAY TRACK SCALE TEST DATA

FISCAL YEAR 1936

District and scale ownership	Number of scales tested	Within tolerance		Not within tolerance		Mean numerical error -- percent of applied load
		Number	Percent	Number	Percent	
EASTERN						
Railroad	163	115	70.6	48	29.4	0.21
Industry	176	123	69.9	53	30.1	0.25
Totals	339	238	70.2	101	29.8	0.23
SOUTHERN						
Railroad	237	166	70.0	71	30.0	0.26
Industry	174	100	57.5	74	42.5	0.31
Totals	411	266	64.7	145	35.3	0.28
WESTERN						
Railroad	261	235	90.0	26	10.0	0.12
Industry	226	165	73.0	61	27.0	0.23[1]
Totals	487	400	82.1	87	17.9	0.17[1]
ALL DISTRICTS						
Railroad	661	516	78.1	145	21.9	0.19
Industry	576	388	67.4	188	32.6	0.26[1]
GRAND TOTALS	1237	904	73.1	333	26.9	0.22[1]
1935 Totals	1240	963	77.7	277	22.3	0.19[1]

[1] Excluding one scale having abnormal error.

Discussion of Test Results. Of the 1237 scales tested during the fiscal year, 904 or 73.1 percent were within tolerance while the remaining 333 or 26.9 percent were not within tolerance. The percentages found accurate were 78.1 percent for the railroad-owned group and 67.4 percent for the industry-owned group. In the fiscal year preceding the one now being reported, 77.7 percent of all scales were found accurate; for railroad-owned and for industry-owned scales the figures were 80.6 percent and 74.0 percent, respectively. Thus the general figure for percentage of scales found accurate has fallen 4.6 percent; in the case of railroad-owned scales and of industry-owned scales the decreases are 2.5 percent and 6.6 percent, respectively. Thus while both groups of scales have contributed to the decrease, the railroad-owned more nearly maintain last year's percentage than do the industry-owned. (The effect on the percentages for industry-owned scales, of the large number of scales tested at coal mines during the year, will be discussed later in this report.)

Turning to the figures for the individual districts it is found that the Western District still leads in percentage of scales tested found within tolerance, the figure being 82.1 percent, as compared with 70.2 percent in the Eastern District and 64.7 percent in the Southern District. The West also leads in each ownership group, with percentage figures of 90.0 for railroad-owned scales and 73.0 for industry-owned scales. Comparing the figures for the West with the corresponding figures for the preceding year, it is disclosed that the figure for all scales has suffered a considerable decline from 86.2 percent to 82.1 percent. This is almost wholly attributable to the figures for industry-owned scales, since the figures for railroad-owned scales in the two fiscal years under discussion are practically identical, 90.3 in 1935 and 90.0 in 1936. On the contrary, industry-owned scales show a very sharp decrease in the percentage found accurate, 8.1 percent, from 81.1 percent to 73.0 percent.

In the Eastern District the percentage of scales found within tolerance is 70.2 percent. The figures for railroad-owned scales and for industry-owned scales are approximately the same, 70.6 and 69.9, respectively. The corresponding figures for last year indicate that there has been but little change in conditions. Thus the figure for railroad-owned scales is down only 1.8 percent from 72.4 percent and the figure for industry-owned scales is up 1.1 percent from 68.8 percent.

In the Southern District the percentage of scales found within tolerance is 64.7 percent; for railroad-owned scales the figure is 70.0, for industry-owned scales, 57.5. A very considerable decline (5.8 percent) is noted from last year when the percentage of scales found accurate was 70.5 percent. The decline in the percentage of railroad-owned scales is 3.3 percent. In the case of industry-owned scales a more serious decline is noted, 8.8 percent.

A measure of the accuracy being maintained by railway track scales is furnished by the figure, "Mean numerical error -- percent of applied load". The mean error on all scales tested is computed to be 0.22 percent; the figure for railroad-owned scales is 0.19 percent, and for industry-owned scales, 0.26 percent. The general figure shows a significant increase over last year of 0.03 percent, from 0.19 percent to 0.22 percent. As in the preceding analysis the change is largely attributable to the industry-owned group, for while railroad-owned scales show an increase in mean error of only 0.01 percent, the increase in the case of industry-owned scales is 0.06 percent. (As has been noted in the discussion of percentages of industry-owned scales found accurate, an analysis of the condition of scales installed at coal mines, given hereafter, may tend to explain, in part, some of the changes noted herein.)

The districts rank in the same order as is fixed by the percentages of scales found within tolerance. The mean numerical errors of scales in the Western District are, 0.17 percent for all scales, 0.12 percent for railroad-owned, and 0.23 percent for industry-owned, scales. The corresponding figures for the fiscal year 1935 are, 0.15, 0.11, and 0.20. Moderate increases in all figures are thus noted in this district.

The mean numerical errors of scales in the Eastern District are, 0.23 percent for all scales, 0.21 percent for railroad-owned, and 0.25 percent for industry-owned, scales. The corresponding figures for last year are, 0.23, 0.25, and 0.22. The general percentage is unchanged; railroad-owned scales have a smaller mean error than last year while the reverse is true of industry-owned scales.

The mean numerical errors in the Southern District are, 0.28 percent for all, 0.26 percent for railroad-owned, and 0.31 percent for industry-owned, scales. The corresponding figures for last year are, 0.20, 0.19, and 0.20. The decrease in accuracy in this district in the case of each of the three categories is very considerable, amounting, respectively, to 0.08 percent, 0.07 percent, and 0.11 percent.

The Bureau tested during the year five or more railroad-owned railway track scales on the lines of 44 railroads. The number of tests made on these roads was 532 or 80.5 percent of the 661 total tests of these scales. Four hundred and twenty-eight of these scales, or 80.5 percent, were found to be within tolerance. Of the remaining 129 scales tested for those railroads upon which fewer than 5 scales were tested, 88 scales, or 68.2 percent, were found to be within tolerance.

In the case of each of 17 of the 44 railroads mentioned above, 100 percent of the scales tested were found to be within

tolerance. In the case of 30 of these roads 80 percent or more of the scales tested were accurate.

In the case of 2 of the railroads under discussion every scale tested was found to be within one-half the tolerance allowed; in the case of 8 roads 75 percent or more, and in the case of 26 roads at least 50 percent of the scales tested, were in this category.

The scales on 15 of these roads were found to have a mean percentage error of 0.10 percent or less. The scales on 36 roads had a mean percentage error of 0.20 percent or less. The mean percentage error on the remaining 8 roads was from 0.24 percent to 0.98 percent.

TEST DATA SUBDIVIDED BY CLASSES OF RAILWAYS

The National Bureau of Standards made tests during the year on 139 railways. The number of roads of various classes upon which tests were made and the accuracy of the scales tested upon roads of the several classes are shown in table 2, which follows. In the classification of the railroads and the assignment of the various roads to these classes, the information furnished by the Interstate Commerce Commission in its publication "Statistics of Railways in the United States, 1934", has been utilized.

TABLE 2. TEST DATA SUBDIVIDED BY RAILROADS OF VARIOUS CLASSES

Classification of railways	Number of railways	Number of scales tested	Within tolerance		Not within tolerance		Mean numerical error -- percent of applied load
			Number	Percent	Number	Percent	
CLASS I - EXCEPT S.& T.	78	588	470	79.9	118	20.1	0.18
CLASSES II & III EXCEPT S.& T.	32	38	21	55.3	17	44.7	0.36
SWITCHING AND TERMINAL	23	27	20	74.1	7	25.9	0.16
NOT CLASSIFIED	6	8	5	62.5	3	37.5	0.33
TOTALS	139	661	516	78.1	145	21.9	0.19

It will be noted that scales on Class II and Class III railroads are considerably less accurate than scales on Class I lines and on switching and terminal roads. A somewhat greater number of scales were tested on roads of the former classes than is usually the case. The condition of these scales tends to lower the general percentage of scales found accurate and to increase the size of the mean percentage error. The extent to which the figures are affected in comparison with preceding years can not accurately be gauged since the former figures have not been broken down by classes of railroads. However the number of scales tested on roads of Classes II and III, 38, is still not large nor does it represent an important percentage of the total number of railroad-owned scales tested (6.7 percent). Moreover, the figures for each year regularly include some scales on such roads. Therefore it is to be concluded that the inclusion of these scales does not have any pronounced effect on the general figures.

SCALES AT COAL MINES

In preparing itineraries for the testing equipments for the present fiscal year a number of coal mining regions were included in the routings and a special effort was made to test as many scales installed at mines, for the weighing of coal, as was practicable. This was done since it was believed that scales of this class throughout the United States were in particular need of attention. As a result, 136 of the total of 576 industry-owned scales tested, or some 24 percent, were located at coal mines. In view of the importance of these scales and the general interest existing as to their accuracy, table 3, which will follow, has been prepared to present these data.

Table 3 has also been so arranged as to present some additional facts which may be of interest to the reader. In view of the large number of scales at coal mines which were tested, it is clear that if the condition of this class of scales differs materially from the average industry-owned scale, then the inclusion of these scales will have a pronounced effect upon the general averages of industry-owned scales. Moreover since the number of tests made in the fiscal year 1935 on scales located at coal mines was too small to have any pronounced effect on the general averages for that year, then the figures for the two fiscal years in question will not be entirely comparable. To facilitate comparisons, figures for all industry-owned scales, and for industry-owned excluding scales at coal mines, are also shown.

TABLE 3. SUMMARY OF TEST DATA ON RAILWAY TRACK SCALES AT COAL MINES - FISCAL YEAR 1936

District; and character of scales	Number of scales tested	Within tolerance		Not within tolerance		Mean numerical error -- percent of applied load
		Number	Percent	Number	Percent	
EASTERN						
Coal mine	22	16	72.7	6	27.3	0.21
All industry	176	123	69.9	53	30.1	0.25
Industry excluding coal mine	154	107	69.5	47	30.5	0.25
SOUTHERN						
Coal mine	39	17	43.6	22	56.4	0.40
All industry	174	100	57.5	74	42.5	0.31
Industry excluding coal mine	135	83	61.5	52	38.5	0.29
WESTERN						
Coal mine	75	44	58.7	31	41.3	0.33[1]
All industry	226	165	73.0	61	27.0	0.23[1]
Industry excluding coal mine	151	121	80.1	30	19.9	0.13
ALL DISTRICTS						
Coal mine	136	77	56.6	59	43.4	0.33[1]
All industry	576	388	67.4	188	32.6	0.26[1]
Industry excluding coal mine	440	311	70.7	129	29.3	0.24

[1] Excluding one scale having abnormal error.

Discussion of Data. While it is believed that the table is sufficiently detailed to present a rather complete picture, the results may be discussed briefly for the benefit of the reader who is particularly interested in this class of scales.

In all districts the percentage of coal mine scales found within tolerance is 56.6 percent. This figure is to be compared with the figure of 67.4 percent for all industry-owned scales. Similarly the mean percentage error on scales at coal mines is 0.33 percent, while the mean error on all industry-owned scales is 0.26 percent.

The most important fact brought out by the table is that the general condition of scales at coal mines is highly unsatisfactory. As a class these scales are much more seriously inaccurate than the average scale of the group to which they belong and they are urgently in need of remedial measures.

A further examination of the table discloses that figures for coal mine scales have a very considerable effect on the general averages computed for industry-owned scales. This is the case throughout the country as a whole, where, as has been noted, about one-quarter of the industry-owned scales tested were located at coal mines, and in the Western and Southern Districts where one-third and more than one-fifth respectively, of the industry-owned scales tested were in this category. In the Eastern District not only was the number of coal mine scales smaller, but also the condition of these was found not greatly different from that of the average industry-owned scale. It results that the general averages for this district are but little changed by the inclusion of scales of this group.

The analysis given earlier in this report has demonstrated that the figures for the present year in respect to accuracy of industry-owned scales are considerably less satisfactory than the corresponding figures for the fiscal year 1935. The figures in table 2 indicate that one-half of the decline in the percentage of industry-owned scales found within tolerance is attributable to the condition of scales at coal mines. Again, it may be noted that that group of scales is responsible for one-third of the increase in the mean error of all.

In the Western District the results are still more striking. Only 58.7 percent of the scales at coal mines are found to be within tolerance, with a mean error of 0.33 percent. When these scales are excluded from the industry-owned group, the figures for the remaining industry-owned scales become 80.1 percent and 0.18 percent. The general decline noted hereinbefore, of 8.1 percent from the figure for the fiscal year 1935, in percentage of scales found accurate, is found to be almost entirely attributable to the figures for coal mine scales. When these are excluded the percentage for the remaining industry-owned scales is only 1.0

percent lower than the figure for industry-owned scales reported last year. Similarly an increase in mean error of 0.03 over the fiscal year 1935, has been noted in this district. When scales at coal mines are excluded from this year's figures, it is found that the error on the remaining industry-owned scales is actually 0.02 percent smaller than the figure for industry-owned scales in the preceding fiscal year.

In the Southern District almost half of the 8.8 percent decline in the percentage of scales found within tolerance is caused by the condition of scales at coal mines. The mean error is not affected so greatly however since the mean error of all industry-owned scales, 0.31 percent, is reduced only to 0.29 percent, when the errors on scales at coal mines are excluded.

It is to be concluded that the decrease in accuracy of industry-owned scales disclosed in this report is due to a considerable extent to the condition of the scales at coal mines which were tested in considerable numbers.

Before dismissing the subject of scales tested at coal mines it may be said that when the tests made by each of the three Bureau testing equipments are separately considered, it is disclosed that Bureau track scale testing equipment No. 3 made 91 tests on scales of this group, this number being two-thirds of the total of 135 tests made by all three of the equipments. The preponderance attributable to No. 3 is due to the fact that in preparing the itinerary of this equipment greater freedom can be exercised than when itineraries of Nos. 1 and 2 are being laid out, since the latter must be routed so as regularly to visit master track scales assigned to them for calibration. It would be virtually impossible to arrange such a program as has been conducted this year in testing scales at coal mines, to be carried out by equipments Nos. 1 and 2, without disrupting the program of regular tests of master track scales, a course which would be indefensible. It is apparent, then, that equipment No. 3 is especially effective in performing work of the character under discussion.

SCALES IN GRAIN-WEIGHING SERVICE

In the preceding tabulations those scales which are used in grain-weighing service have been classified as within tolerance or not within tolerance according as they complied or did not comply with the usual tolerance applied to commercial railway track scales, 0.20 percent. However, this class of scale is subject to a special tolerance of one-tenth of one percent (0.10 percent), this being recommended for such scales by the Interstate Commerce Commission in Docket 9009.

Ninety-one scales employed in grain-weighing service were tested during the year. When the special tolerance specified above is applied to this group it is found that 46, or 50.5 percent, comply with this tolerance. The mean error -- percent of applied load -- is 0.16 percent. Neither of these figures is nearly as satisfactory as last year when the condition of this class of scale was very encouraging, the figure for percentage within tolerance having reached a new high of 72.1 percent, and the figure for mean percentage error having equaled the previous low of 0.12 percent. This year the percentage found correct has fallen off more than 20. percent while the mean percentage error has increased materially. It now seems that either the figures found last year, -- although based on the largest number of grain scales ever tested in any one year -- or the figures for the present year -- also based on a number heretofore deemed reasonably adequate -- cannot be representative of general conditions. The percentage found accurate this year is lower than in any year since the fiscal year 1930, and the mean error is slightly higher than the average of the last seven years and is also higher, though very slightly so, than in any year since 1929, when this figure was separately reported for the first time since 1923. The only encouraging fact in the situation is that the mean error on this group of scales is still very much smaller than the mean error on all industry-owned scales -- of which group they form a part -- which is 0.26 percent, and than the mean error on all industry-owned scales excluding scales at coal mines, namely, 0.24 percent.

The distribution of the scales tested, used in grain-weighing service, was reasonably satisfactory, 19 scales, or 21 percent of the total, being located in the Eastern District, 17 scales, or 19 percent, in the Southern District, and 55 scales, or 60 percent, in the Western District. The percentages within tolerance and mean percentage errors on grain scales by districts are 37 percent and 0.20 percent in the East, 71 percent and 0.13 percent in the South, and 49 percent and 0.15 percent in the West, where the majority of the tests were made.

On account of the great importance of the trade in grain it is felt that a very determined effort should be made by all interested agencies not only to prevent a further decline in accuracy of scales used in weighing this commodity, but radically to improve conditions now existing.

Table 4, which follows, has been prepared to show the general accuracy in respect to this class of scales for each fiscal year from 1923 to date.

TABLE 4. SUMMARY OF TEST DATA ON RAILWAY TRACK SCALES IN GRAIN-WEIGHING SERVICE

Fiscal Year	Number of scales tested	Within special grain scale tolerance		Not within special grain scale tolerance		Mean numerical error -- percent of applied load
		Number	Percent	Number	Percent	
1923	32	2	6.2	30	93.8	0.40
1924	89	31	34.8	58	65.2	(a)
1925	82	34	41.5	48	58.5	(a)
1926	90	37	41.1	53	58.9	(a)
1927	67	26	38.8	41	61.2	(a)
1928	54	32	59.2	22	40.8	(a)
1929	97	54	55.7	43	44.3	0.15
1930	47	22	46.8	25	53.2	0.15
1931	97	51	52.6	46	47.4	0.12
1932	72	46	63.9	26	36.1	0.13
1933	58	34	58.6	24	41.4	0.13
1934	96	55	57.3	41	42.7	0.15
1935	122	88	72.1	34	27.9	0.12
1936	91	46	50.5	45	49.5	0.16

(a) Values of the mean errors for the years 1924 to 1928, inclusive, are not available.

CORRECTION OF SCALES IN FAULTY CONDITION

It is the practice of the Bureau to make an adjustment on a scale at the time of test when this is needed, when the owner requests the service, and when time is available for the work of adjustment and the subsequent retest that is then required. Correction of minor defects, such as poor alinement of parts, slight binds, and other faulty conditions may be made under thd same circumstances by the Bureau or by representatives of the owners. The Bureau does not undertake such work when the general condition of the scale is not such as to justify it, for in such a case the owner of a scale needing major repairs might be tempted to postpone these, relying upon the adjustment made by the Bureau. In such event,the work would do more harm than good. However, this service is obviously very worth while in cases where slight corrections will put the scale in proper mechanical condition, and where adjustment will reduce the error found without masking faults which should be corrected.

During the year corrections of the character mentioned were made on 150 scales, or 12.1 percent of the total number tested. The mean numerical error on these scales as encountered, was 0.28 percent; the mean error on the scales as they were left had been reduced to 0.09 percent. Of course, the figures tabulated and discussed in the preceding sections of this report represent percentages of accuracy and mean errors of the scales as encountered, and thus do not reflect the effects of the corrections made at the time of test.

ANALYSIS OF ERRORS OF INCORRECT SCALES

The usual analysis of the character and distribution of errors on scales found not within tolerance, is made in table 5.

TABLE 5. ANALYSIS OF ERRORS OF INCORRECT SCALES

FISCAL YEAR 1936

District and scale ownership	Total number of incorrect scales	Mean numerical error--percent of applied load	Errors in excess (+)			Errors in deficiency (-)		
			Number of scales	Percent of incorrect scales	Mean error--percent of applied load	Number of scales	Percent of incorrect scales	Mean error--percent of applied load
EASTERN								
Railroad	48	0.46	26	54.2	0.38	22	45.8	0.56
Industry	53	0.56	27	50.9	0.41	26	49.1	0.71
Totals	101	0.51	53	52.5	0.40	48	47.5	0.64
SOUTHERN								
Railroad	71	0.64	29	40.8	0.56	42	59.2	0.69
Industry	74	0.57	27	36.5	0.43	47	63.5	0.66
Totals	145	0.61	56	38.6	0.50	89	61.4	0.67
WESTERN								
Railroad	26	0.36	13	50.0	0.32	13	50.0	0.39
Industry	61	0.58[1]	32	52.5	0.46	29	47.5	0.71[1]
Totals	87	0.51[1]	45	51.7	0.42	42	48.3	0.61[1]
ALL DISTRICTS								
Railroad	145	0.53	68	46.9	0.45	77	53.1	0.60
Industry	188	0.57[1]	86	45.7	0.44	102	54.3	0.69[1]
GRAND TOTALS	333	0.55[1]	154	46.2	0.44	179	53.8	0.65[1]
1935 Totals	277	0.50[1]	138	49.8	0.36	139	50.2	0.69[1]

[1] Excluding one scale having abnormal error.

The mean numerical error -- percent of applied load -- on the 333 scales found to be not within tolerance is 0.55 percent. The scales of the railroad-owned group and of the industry-owned group do not differ materially in this respect, the mean errors being 0.53 percent and 0.57 percent, respectively. All of these figures are slightly greater than last year when they were, 0.50 percent for all, and for each group.

The errors on 46.2 percent of all scales found incorrect are in excess (+), while the remaining 53.8 percent of the scales have errors in deficiency (-). Again there is no significant difference between the railroad-owned group and the industry-owned group.

As has been found to be the case in all former tabulations the mean percentage error in excess, 0.44 percent, is materially smaller than the mean error in deficiency, 0.65 percent.

(In the computation of mean errors shown above and elsewhere in this report, the error on one industry-owned scale in the Western District has been omitted, since it is abnormal and since it would have so great an influence on the average for the district as to make the comparative averages somewhat unrepresentative. The error thus rejected was -9.44 percent. Errors of similar size have been rejected in the case of former reports, also.)

ERROR FREQUENCY DISTRIBUTION

The error frequency distribution of errors on railway track scales is presented in table 6, which follows:

TABLE 6. FREQUENCY DISTRIBUTION OF RAILWAY TRACK SCALE ERRORS - FISCAL YEAR 1936

Errors -- percent of applied load	EASTERN DISTRICT		SOUTHERN DISTRICT		WESTERN DISTRICT		ALL DISTRICTS	
	Railroad 163 scales	Industry 176 scales	Railroad 237 scales	Industry 174 scales	Railroad 261 scales	Industry 226 scales	Railroad 661 scales	Industry 576 scales
	Percent of scales tested	Percent of scales tested	Percent of scales tested	Percent of scales tested	Percent of scales tested	Percent of scales tested	Percent of scales tested	Percent of scales tested
Correct scales								
0.00 to 0.05 incl.	14.7	8.0	18.6	8.6	29.1	15.5	21.8	11.1
0.06 to 0.10 "	27.6	28.4	28.7	20.7	29.5	25.2	28.8	24.8
0.11 to 0.15 "	20.9	22.7	13.8	12.7	19.9	22.1	18.0	19.5
0.16 to 0.20 "	7.4	10.8	8.9	15.5	11.5	10.2	9.5	12.0
Incorrect scales								
0.21 to 0.25 incl.	9.2	7.4	4.6	8.6	1.9	4.4	4.7	6.6
0.26 to 0.30 "	7.4	4.5	3.8	5.2	2.3	6.6	4.1	5.6
0.31 to 0.35 "	3.7	5.7	4.2	5.7	1.9	2.7	3.2	4.5
0.36 to 0.40 "	1.8	3.4	3.0	5.2	0.8	3.1	1.8	3.8
0.41 to 0.45 "	1.2	0.0	3.0	2.9	1.5	0.5	2.0	1.0
0.46 to 0.50 "	1.2	0.6	0.8	2.3	0.4	2.2	0.7	1.7
0.51 to 1.00 "	3.1	5.7	5.5	8.6	1.2	3.1	3.2	5.6
Over 1.00	1.8	2.8	5.1	4.0	0.0	4.4	2.2	3.8
Mean numerical errors								
Correct scales	0.10	0.11	0.10	0.12	0.09	0.10	0.09	0.11
Incorrect scales	0.46	0.56	0.64	0.57	0.36	0.58[1]	0.53	0.57[1]
All scales	0.21	0.25	0.26	0.31	0.12	0.23[1]	0.19	0.26[1]
Mean errors, 1935								
All scales	0.25	0.22[1]	0.19	0.20	0.11	0.20	0.18	0.20[1]

1 Excluding one scale having abnormal error.

The data in the above table show that about 50 percent of the 661 railroad-owned track scales tested are within one-half the tolerance, a figure practically identical with that found last year. The Eastern and Southern Districts both show substantial gains while in the Western District the percentage has dropped about 7 percent. In the case of industry-owned scales only about 36 percent are in this category, 8 percent less than last year. The Eastern and Southern Districts are unchanged in this respect, the Western District again showing a loss, 15 percent in this instance.

Turning to the other extreme of the tabulation it is found that the percentage of scales having exceptionally large errors -- more than 0.5 percent -- has not varied greatly in the case of railroad-owned scales (5.4 percent in 1936, 4.8 percent in 1935), but in the case of industry-owned scales the figure is considerably larger than in 1935, a rise from 4.3 percent to 9.4 percent being noted. The figure for railroad-owned scales has decreased considerably in the East, has doubled in the South, and has remained stationary in the West. In this last mentioned district no railroad-owned scale was found to have an error of as much as 1.0 percent in either year, and but 3 scales in 1936, and 4 scales in 1935 were found in error by more than 0.5 percent.

In the case of the industry-owned group the percentage of scales having large errors has increased somewhat in the East and West (2.9 percent and 2.3 percent, respectively) and very greatly in the South (9.1 percent from 3.5 percent to 12.6 percent). Doubtless scales at coal mines have a considerable influence on these increases.

The above figures throw light on the general increases in mean errors of scales discussed earlier in this report.

STANDARDIZATION OF RAILWAY TRACK SCALE TEST WEIGHT CARS ON BUREAU MASTER TRACK SCALE

The results of all standardizations of railway track scale test weight cars on the master track scale of the National Bureau of Standards, are shown in table 7. Individual cars are designated by letters. When the letter is enclosed in a parenthesis ( ) it indicates that the car in question conforms in essential respects with recommended specifications for test weight cars. An error in the column headed "Plus" denotes that the actual weight of the car in question exceeded its nominal weight value by the amount shown; an error in the column headed "Minus" denotes the converse. A special symbol, an asterisk,*, is used in connection with the error in instances where information was procured to the effect that the car had been repaired or altered since the last preceding standardization by the Bureau, or where there was evidence that this was the case. On account of the difficulties often experienced in obtaining the desired information, it can by no means be said with certainty that when the symbol is omitted, the car in question had not been so altered or repaired. The absence of the symbol indicates only that this was not ascertained or apparent.

TABLE 7. STANDARDIZATIONS OF RAILWAY TRACK SCALE TEST WEIGHT CARS ON NATIONAL BUREAU OF STANDARDS MASTER TRACK SCALE, CLEARING, ILLINOIS -- FISCAL YEAR 1936

Designation	Report No.	Nominal weight in pounds	Period since last preceding standardization in months	Error in pounds (Plus)	Error in pounds (Minus)
(A)	384	80,000	2	21*	
	414		4	46*	
	445		7		4*
(B)	385	61,600	5	35*	
	412		4		6
	433		5	5*	
(C)	386	30,000	32	5	
	422		7	18*	
	442		4		24
(D)	387	80,000	21	5	
	423		7		11*
	443		4		5
(E)	388	80,000	9		6
(F)	389	80,000	2	4*	
	440		10		13
G	390	61,400	3		9*
	415		3	36	
	426		3	9	
	441		3		41
(H)	391	80,000	3		2
(I)	392	40,000	3	1	
(J)	393	80,000	6		100*
	425		6		3*
(K)	394	80,000	34	0	
	418		4	7	
(L)	395	30,000	3		51
	419		4	0	
M	396	75,000	3	4*	
	416		3	11*	
	428		3		2*
	444		3		68*
N	397	80,000	5	19*	
	439		8	32*	

TABLE 7 (Continued)

Designation	Report No.	Nominal weight in pounds	Period since last preceding standardization in months	Error in pounds (Plus)	Error in pounds (Minus)
O	398	80,000	5		30*
	446		10		147*
P	399	80,000	5	87*	
(Q)	400	80,000	7		3*
	432		6		4
R	401	92,500	6		46
	434		6	465*	
(S)	402	83,120	8	335*	
(T)	403	80,000	7		6*
	437		7		2
U	404	50,000	11	2	
V	405	60,600	4		25
	421		3	25	
	436		3		19
W	406	60,000	12		12*
(X)	407	80,000	12		13*
Y	408	60,000	6		43
(Z)	409	40,000	5		4*
	430		5		7
(AA)	410	80,000	5		4*
	429		5		1*
BB	411	60,000	11		29*
(CC)	413	80,000	13	34*	
(DD)	417	80,000	6		4
	438		5	699*	
EE	420	60,000	8		35
	435		3		28
(FF)	424	80,000	11	86*	
(GG)	427	80,000	1st test - new		437*
(HH)	431	80,300	26		12*
34 cars	63 standardizations			24 heavy	2 zero 37 light

Discussion of Standardization Results. Sixty-three standardizations were made on 34 railway track scale test weight cars during the year. The number of standardizations exceeds by 8 and the number of cars exceeds by 4, the corresponding totals for the fiscal year 1935. In 24 cases the cars were found to be heavy, in 37 they were found to be light, while in 2 cases they were without appreciable error.

In the case of 62 of the 63 standardizations, the cars had been standardized previously by the Bureau at Clearing, one car being new. As to these 62 cars, information was secured or there was evidence to the effect that 16 heavy cars and 18 light cars had been subject to repairs since the last preceding standardization. There remain 8 heavy cars, 18 light cars and 2 correct cars, which are not known to have been intentionally altered in weight since the next previous standardization was made.

These 28 cars were found to have an average numerical error of 16 pounds. The 8 heavy cars had an average error of 11 pounds; the 18 light cars had an average error of 20 pounds.

Of the above 28 cars, 17 essentially complied with accepted specifications for test weight cars while the remaining 11 did not. On the 17 cars so complying 4 cars found heavy had an average error of 4.5 pounds, 11 found light had an average error of 11 pounds, while 2 were recorded as having zero error. The average numerical error of all specification cars was 8 pounds. The average error on 4 cars found heavy, not complying with accepted specifications, was 18 pounds, while 7 light cars had an average error of 34 pounds. The average numerical error of all non-specification cars was 28 pounds.

Two cars were submitted for standardization 4 times each, five were submitted 3 times, thirteen twice, and fourteen were submitted only once during the fiscal year.

In the case of the 62 standardizations made of cars which had previously been standardized by the Bureau at Clearing, the average time elapsing since the last preceding standardization was 7.2 months. In 5 cases, more than a year had elapsed since the last prior standardization by the Bureau. When these cars are eliminated from the averages it is found that in the case of 57 standardizations an average period of 5.6 months had elapsed since the last prior standardization at Clearing.

WEIGHING OF RAILWAY TRACK SCALE TEST WEIGHT CARS IN FIELD

In connection with the testing of railway track scales it is customary for the Bureau to weigh railroad and industry-owned test weight cars in the field when such cars are presented for this service. When this service is furnished the car is weighed on a scale which is suitable for the purpose and has just been tested by the Bureau, and a method of substitution weighing

against a known load is employed. Many of the cars so weighed are not regularly standardized on master scales, whether because they are operated in a section remote from such a scale, or because they are of too long a wheel-base to be accommodated on a master scale, or for some other reason.

Thirty-two test weight cars were weighed in the field by the Bureau during the fiscal year; of these 22 were owned by 16 railroads, 10 by 8 industries.

Of the 22 railroad-owned cars, 6 were found to weigh more than their nominal weight value, the average error being 25 pounds; 12 were found to be light, the average error being 44 pounds; and 4 were found to agree with the standard within the degree of accuracy susceptible of being obtained on the scales employed. The average numerical error of all these cars was 31 pounds.

One of the 10 industry-owned cars was heavy, the error being 30 pounds; 4 were light, the average error being 38 pounds; and 4 were without appreciable error. In the case of one car an error could not be assigned since the nominal weight value of the car was not known. The average numerical error of 9 of these cars was 20 pounds.

Combining the above data there are found an average error of 26 pounds on 7 heavy cars, an average error of 42 pounds on 16 light cars, and an average numerical error of 28 pounds on 31 cars. Corrections were made to bring the cars to their nominal weights, or information was given to owners to enable them readily to accomplish this result.

The above service is considered a very important one by the Bureau since it is obvious that the testing means must be correct before scales can be correctly tested and adjusted to accuracy. While the weighings in the field cannot be expected to produce test weight cars which are as accurately adjusted as those standardized on a master scale, nevertheless when master scale service is not available, the method of weighing in the field should be utilized as frequently as it is available.

PERCENTAGE OF TOTAL SCALES IN SERVICE TESTED BY BUREAU DURING THE YEAR

In the last few years the Bureau has not attempted to take a census of railway track scales in service, for two reasons: First, it was not considered advisable to throw an additional load upon scale departments of railroads already carrying a heavy burden of work; and second, it was felt unwise to attempt a new census during a time when economic conditions were in a state of flux. However, for several years the Bureau inspectors in the field have been regularly furnishing information as to scales permanently out of service, changes in ownership, duplicate listings, etc., and this information has regularly been incorporated

in the census records. These records are thus believed to be more nearly authentic as of July 1, 1935, than they have been for some years.

Based upon these figures the following summary is presented.

The Bureau tested in the fiscal year 1936:

In All Districts

661 or 19. percent of some 3450 railroad-owned scales
576 " 16. " " " 3550 industry-owned scales
1237 " 18. " " " 7000 total scales

In Eastern District

163 or 13. percent of some 1300 railroad-owned scales
176 " 12. " " " 1500 industry-owned scales
339 " 12. " " " 2800 total scales

In Southern District

237 or 32. percent of some 750 railroad-owned scales
174 " 25. " " " 700 industry-owned scales
411 " 28. " " " 1450 total scales

In Western District

261 or 19. percent of some 1400 railroad-owned scales
226 " 17. " " " 1350 industry-owned scales
487 " 18. " " " 2750 total scales.

It will be seen from the above tabulation that the distribution of tests by districts was reasonably good. The Western District received almost exactly the number of tests, both in the case of railroad-owned and industry-owned scales, that it was entitled to receive when the percentages of total scales located in that district are considered. The Eastern District received somewhat less than its pro rata share and the South proportionally more. This is considered satisfactory when it is remembered that the scales in the Southern District are in somewhat poorer condition than those in other districts. The condition was brought about since equipment No. 3, which is proceeding on a long itinerary, spent the majority of its time

in the Southern District. It was also necessary, of course, to route equipment No. 1 into the South in order to standardize the master scales located in that district. It is believed that the percentage of scales tested in the Eastern District will be greater during the coming fiscal year.

The above tabulation again serves to indicate something which has been pointed out before, that the Bureau equipments can, at best, during any given year, test only a small percentage of the railway track scales in use. It is essential therefore that the service be distributed as widely as possible and that routine tests be avoided. Later in this report the efforts being made toward this end will be discussed in some detail. It is now again emphasized that no scale owner can rely, nor should he attempt to rely, upon National Bureau of Standards tests to keep himself informed as to the condition of his scale. Frequent competent tests and continuous maintenance are vitally necessary to insure continuous accuracy. Such service is routine; it must be supplied by the owner whether through his own tests and inspections or through procurement of service from some agency having adequate equipment and skilled personnel.

SCALES TESTED CLASSIFIED ON BASIS OF LAST FORMER TEST BY BUREAU EQUIPMENT

In order that the railway track scale testing service of the Bureau might not become routine in its nature and might be distributed as equitably as possible, it was announced two years ago that, in general, there would be made each year as many tests as was practicable on scales not formerly tested and on scales not recently tested, by Bureau equipments. It was stated that thereafter itineraries would be drafted with this idea in mind and also that when all scales on an itinerary could not be tested preference would ordinarily be given to scales not formerly, or not recently, tested. Progress toward this end was announced in last year's report.

This is the first fiscal year in which the equipments have worked exclusively on itineraries drafted after the above announcement of future policy was made. It may be of interest therefore to tabulate the tests made this year by dates of last former tests by Bureau equipments and to present similar figures for the fiscal year 1934, the last year during which the Bureau equipments travelled wholly on itineraries prepared before the above policy was enunciated. These data are shown in table 8, which follows:

TABLE 8. SCALES TESTED CLASSIFIED ON BASIS OF LAST FORMER TEST BY BUREAU EQUIPMENTS

Scale ownership and district	No former test[1]		Last former test: 10 years or more ago		5 - 9 years ago		Less than 5 years ago	
RAILROAD-OWNED	1936	1934	1936	1934	1936	1934	1936	1934
	[Percentages of scales tested]							
EASTERN	36.	25.	20.	13.	18.	8.	26.	54.
SOUTHERN	29.	9.	20.	4.	18.	19.	33.	68.
WESTERN	18.	12.	18.	11.	25.	12.	39.	65.
TOTAL	26.	15.	19.	10.	21.	13.	34.	62.
INDUSTRY-OWNED								
EASTERN	72.	66.			11.	1.	17.	33.
SOUTHERN	71.	40.			7.	5.	22.	55.
WESTERN	61.	32.			10.	4.	29.	64.
TOTAL	67.	48.			10.	3.	23.	49.

[1] Records on railroad-owned scales are complete from the beginning of the service, on industry-owned scales from July 1, 1928.

It will be seen from the above that 26 percent of all railroad-owned and 67 percent of industry-owned track scales tested during the fiscal year 1936, had not formerly been tested by the Bureau. In 1934 the corresponding figures were 15 percent and 48 percent. Nineteen percent of the railroad-owned track scales tested this year had not been tested for ten years or more; in 1934 only 10 percent of the scales tested were in this category. In 1936, 21 percent of the railroad-owned and 10 percent of the industry-owned scales were tested 5 years or more ago but less than 10 years ago; corresponding figures for 1934 were 13 percent and 3 percent. The other side of the picture is shown in the percentages of scales tested which had previously been tested within 5 years. Of the railroad-owned scales tested in 1936 only 34 percent had previously been tested within this period as compared with 62 percent in 1934. Of the industry-owned scales the figures are 23 percent in 1936 and 49 percent in 1934.

It may again be stated that where there is some special reason why a recently tested scale encountered should again be tested, this is done. Thus "key" scales -- heavy-duty scales at important weighing points -- are not neglected; these scales are tested in every case where they are encountered and a test is desired by the owner.

PROGRESS MADE IN TESTING SCALES FORMERLY UNTESTED BY BUREAU

In connection with the estimate of number of scales in service heretofore mentioned, there was also made an estimate as of July 1, 1935, of the number of railroad-owned scales not theretofore tested by the Bureau and the number of industry-owned scales not tested since July 1, 1928. The progress made during the fiscal year 1936 in reducing the number of these scales can therefore be shown. Data in this regard are included in table 9, which follows:

TABLE 9. SUMMARY OF TESTS MADE ON SCALES FORMERLY UNTESTED

District	Total scales in service (Est.)	Number not tested by Bureau as of July 1, 1935 (Est.)	Percent of total scales in service	Number of formerly untested scales tested in 1936	Percent of total of formerly untested scales	Number not tested by Bureau as of July 1, 1936 (Est.)	Percent of total scales in service
RAILROAD-OWNED SCALES							
EASTERN	1300	256	20.	59	23.	197	15.
SOUTHERN	750	97	13.	68	70.	29	4.
WESTERN	1400	210	15.	48	23.	162	12.
ALL DISTRICTS	3450	563	16.	175	31.	388	11.
INDUSTRY-OWNED SCALES							
EASTERN	1500	801	53.	126	16.	675	45.
SOUTHERN	700	391	56.	123	31.	268	38.
WESTERN	1350	676	50.	136	20.	540	40.
ALL DISTRICTS	3550	1868	53.	385	21.	1483	42.

The above tabulation discloses that the number of railroad-owned scales in service not tested by the Bureau was reduced during the year from 563 scales to 388 scales; thus 31 percent of all scales untested as of July 1, 1935, were tested, and the percentage of total scales in service not tested was reduced from 16 percent to 11 percent. Similarly there was a percentage reduction in the case of industry-owned scales from 53 percent to 42 percent. The progress made in the testing of formerly untested railroad-owned scales in the Southern District is most noteworthy. Here 68 scales, or 70 percent of this group, were tested during the year.

Further analyzing the data in relation to scales tested by the Bureau for the first time it is found that of the total of 560 of these, Bureau equipment No. 1 tested 173 or 31 percent of the total, No. 2 tested 140, or 25 percent, and No. 3 tested 247, or 44 percent. As in the case of tests of scales at coal mines, discussed earlier in this report, equipment No. 3 is found to make more tests of this character than do the other equipments. Again the advantage of the flexibility that exists in preparing this itinerary, is demonstrated.

ACCURACY OF SCALES FORMERLY UNTESTED BY BUREAU

In view of the large number of scales which were tested during the year by the Bureau for the first time, it is reasonable to compare the average accuracies of scales formerly tested by the Bureau and those not so tested. If these classes materially differ in accuracy the inclusion in the general figures of a greater proportion of formerly untested scales than have usually been tested in recent years, will have had a measurable influence on the general figures presented. Information as to the relative accuracy of the two classes will then throw additional light on accuracy trends based on a comparison of the general figures found this year with those found in 1935.

The essential data have therefore been assembled in table 10, which follows:

TABLE 10. SUMMARY OF TRACK SCALES NOT FORMERLY TESTED BY BUREAU - FISCAL YEAR 1936

Scale ownership and classification	Number of scales tested	Within tolerance		Not within tolerance		Mean numerical error -- percent of applied load
		Number	Percent	Number	Percent	
RAILROAD						
Scales not formerly tested	175	125	71.4	50	28.6	0.24
Total scales	661	516	78.1	145	21.9	0.19
Scales formerly tested	486	391	80.5	95	19.5	0.17
INDUSTRY						
Scales not formerly tested	385	244	63.4	141	36.6	0.29[1]
Total scales	576	388	67.4	188	32.6	0.26[1]
Scales formerly tested	191	144	75.4	47	24.6	0.20
Coal Mine Scales						
Mine scales not formerly tested	95	47	49.5	48	50.5	0.34[1]
Total mine scales	136	77	56.6	59	43.4	0.33[1]
Mine scales formerly tested	41	30	73.2	11	26.8	0.30
Scales Other Than Mine Scales						
Other scales not formerly tested	290	197	67.9	93	32.1	0.28
Total other scales	440	311	70.7	129	29.3	0.24
Other scales formerly tested	150	114	76.0	36	24.0	0.17

[1] Excluding one scale having abnormal error.

The data in the table disclose that in all classifications, scales formerly tested by the Bureau are materially better than scales not formerly tested -- the percentages found accurate are higher, the mean numerical errors are lower in each case. The size of the differences, taken in conjunction with the fact that the numbers of scales not formerly tested form important percentages of the total number of scales tested, demonstrates that the general percentages for the year, presented heretofore, have been sensibly reduced by the inclusion of scales in this category. It appears that had there been tested this year only the same percentages of these scales as in recent years the decline in accuracy previously indicated would have been smaller than has been indicated to be the case.

To furnish some indication of the numerical value of this factor new percentages of scales accurate have been computed on the basis of first, the 1935 proportion of scales not heretofore tested by the Bureau and scales formerly tested and second, the accuracy figures determined this year for the scales of the two classes. It is found that in the case of railroad-owned scales the percentage of scales accurate is increased by 0.6 percent from 78.1 percent to 78.7 while the percentage of industry-owned scales is increased by 2.0 percent from 67.4 to 69.4 percent. The decline from 1935 to 1936 in percentage of railroad-owned scales found accurate has been seen to be 2.5 percent and of industry-owned scales 6.6 percent. Thus it is indicated that perhaps some one-quarter of the decline is attributable to the fact that a greater proportion than formerly of the scales tested this year had not previously been tested by the Bureau.

ANALYSIS OF DECREASES IN PERCENTAGES OF SCALES WITHIN TOLERANCE, SINCE 1933

In the fiscal year 1932 the percentage of all railway track scales found within tolerance was 80.1 percent. In 1933 this figure rose very slightly to 80.6 percent. Subsequent developments have demonstrated that in that year an accuracy peak was reached. In 1934 the percentage showed a falling off to 77.9 percent. In 1935 the figure for percentage found accurate (77.7 percent) was practically identical with that of the year before and it appeared that the decline had been halted. The figure for the present year presented heretofore in this report (73.1 percent) indicates that this is not the case. A serious decline from last year's figures is indicated, this being greater than that occurring in 1934.

Unless maintenance measures are fluctuating considerably from year to year, which is not understood to be the case, it would seem that if yearly results are truly representative of conditions there would be more uniformity in the trend of the above figures than has recently been found to be the case.

The general percentages developed annually in these reports have in the past been such as to indicate that the figures might be relied upon as reasonably representative. Especially should this be true in the last few years when important increases in the number of tests, acting in conjunction with a marked decrease in the number of scales in service, has resulted in a considerably greater percentage of the scales in service being tested each year than was formerly the case. It has been shown earlier in this report that some 18 percent of all the scales in service were tested during the present year. It is believed that such a percentage as this, when scales are taken at random, should certainly produce representative results.

However, on the basis of the figures the fact remains that there was a decline in accuracy in 1934, this decline appeared to be checked in 1935, but this was followed by a further decline in 1936. Moreover there is no reason to suppose that maintenance measures, on the whole, were better in 1935 than in 1936. Therefore the figures were critically examined to determine whether there could be assigned a reasonable cause for the fluctuations noted.

One factor having a bearing on the question but applicable to industry-owned scales only, was determined and has been discussed heretofore. The decline in accuracy of industry-owned scales is in part attributable to the inclusion this year of a large percentage of scales at coal mines, which class of scales was in much poorer condition than others. Similarly the influence of the inclusion of a larger than normal proportion of scales not formerly tested by the Bureau has been analyzed, but these factors seem not sufficient fully to explain the matter under discussion. Therefore the distribution of tests in the various districts was given attention.

It has been demonstrated in the past that there is a considerable and consistent difference in the results of the various districts. Thus the Western district is uniformly better than the Eastern and Southern districts. The Eastern district usually has higher percentages than the Southern. This being the case it is apparent that if the proportional amounts of work done in the various districts are not constant the percentages for the total number of scales tested will be influenced. If more work is done in the best district, general percentages of scales within tolerance will tend to rise; if more work is done in the worst district, these percentages will tend to fall.

The distribution of total tests made in each district for the fiscal years 1933 to 1936, inclusive, are as follows:

DISTRIBUTION OF TOTAL TESTS BY DISTRICTS

Fiscal year	Total tests	Districts: Eastern No.	Eastern % of total	Eastern Departure from 4-year average	Southern No.	Southern % of total	Southern Departure from 4-year average	Western No.	Western % of total	Western Departure from 4-year average
1933	864	312	36.1	+1.2	212	24.5	-0.9	340	39.4	-0.3
1934	1309	505	38.6	+3.7	341	26.1	+0.7	463	35.3	-4.4
1935	1240	465	37.5	+2.6	217	17.5	-7.9	558	45.0	+5.3
1936	1237	339	27.4	-7.5	411	33.2	+7.8	487	39.4	-0.3
	4650	1621	34.9		1181	25.4		1848	39.7	

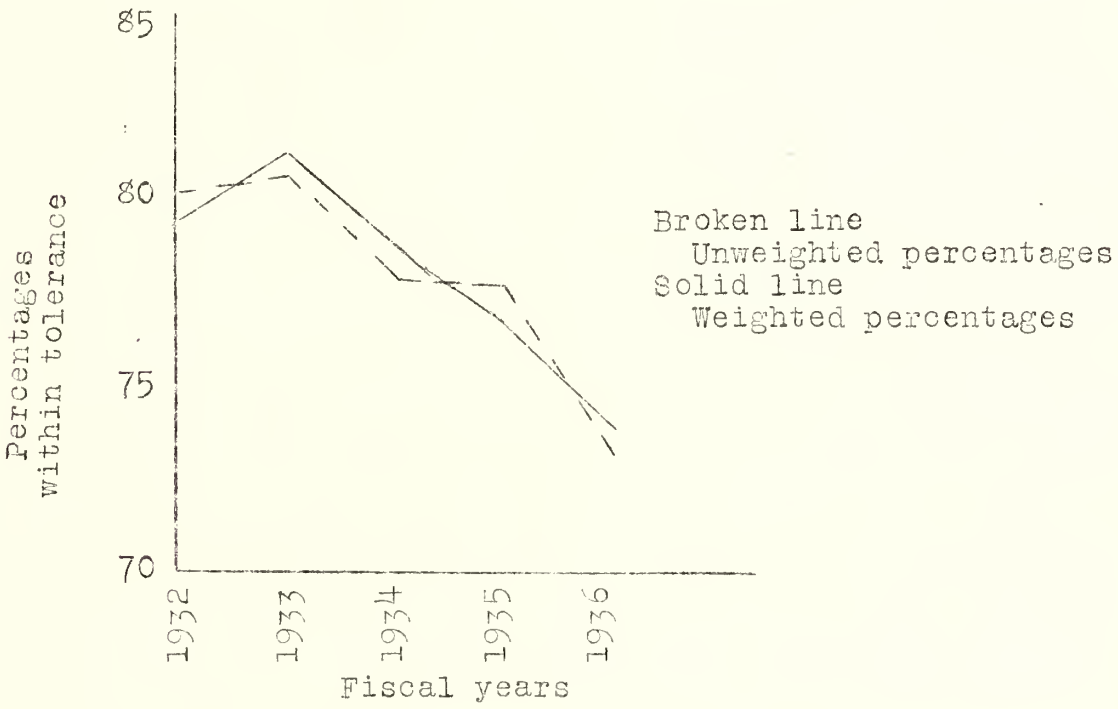
This tabulation discloses that the percentage of total tests made in the Western District is considerably lower in 1934 and materially higher in 1935, than the four-year average. The percentages in the Southern District are materially lower in 1935 and higher in 1936. The percentage in the Eastern District falls off in 1936. It appears then, that a condition exists that may make the general percentages for the several years not entirely comparable.

Accordingly the figures for the four years in question were recomputed in such a way as to "weight" percentages according to the percentage in each district of the total number of scales in service. These figures are compared with the unweighted percentages, below.

PERCENTAGE OF SCALES WITHIN TOLERANCE

Fiscal year	Unweighted percentage	Change from preceding year	Weighted percentage	Change from preceding year
1932	80.1	---	79.4	---
1933	80.6	+0.5	81.1	+1.7
1934	77.9	-2.7	78.6	-2.5
1935	77.7	-0.2	76.8	-1.8
1936	73.1	-4.6	73.8	-3.0
1936 (excluding coal mine scales)	(75.1)	(-2.6)	(75.8)	(-1.0)

The following graph utilizes the figures representing the unweighted and weighted percentages of scales found within tolerance for the fiscal years 1932 to 1936, inclusive.



It will be seen from the preceding tabulation and graph that in the period considered the total declines in percentages of scales found within tolerance are almost identical whether unweighted or weighted percentages are employed, these being 7.5 percent and 7.3 percent, respectively, in the three years. (These figures are reduced to 5.5 percent and 5.3 percent respectively when scales at coal mines tested in 1936 are eliminated.) Moreover the differences in the percentages computed, whether unweighted or weighted, are in every case small -- in no year do the two percentages differ by as much as 1 percent. Therefore no false impressions will ordinarily be gained by using either the one set of figures or the other. However, it is probable that the weighted figures do somewhat more accurately demonstrate the character of the decline in accuracy which has taken place in the three years. In the light of these figures the decrease in percentage of scales found accurate is seen to be steady rather than intermittent.

PERIODS ELAPSING BETWEEN ROUTINE TESTS OF SCALES

In the report for the fiscal year 1934 there was discussed the frequency of routine tests being made on scales by regular testing agencies. These data were derived from the periods of time elapsing between the date of last prior test of the scale by any agency and the date of the test made by the National Bureau of Standards. It was considered reasonable to assume that in the case of scales taken at random the average period between routine tests is of the order of twice the average period elapsing between the next preceding routine tests and the tests by the Bureau. It was accordingly computed that the average time elapsing between routine tests was some 7.4 months for all scales, 6.7 months for railroad-owned scales and 8.2 months for industry-owned scales. A similar computation made for the present fiscal year develops that the corresponding periods are 8.0 months for all scales, 7.0 months for railroad-owned scales, and 9.0 months for industry-owned scales.

The changes noted are not such as to be significant. However, it probably can be said with some confidence that routine tests on scales made by regular testing agencies were not being made with greater frequency in 1936 than in 1934.

Turning to the figures by districts it appears that there is no significant difference in the frequency of test between the Eastern District and the Southern District, while in the Western District tests are less frequently made. In each district the average railroad-owned scale is tested more frequently than the average industry-owned scale. It appears from the figures that railroad-owned scales are probably being tested more frequently in 1936 than in 1934 only in the Eastern District and that in the Western District this class of scale is being tested somewhat less frequently than was the case two years ago. In the Southern District the average period elapsing between tests of industry-owned scales is considerably longer in 1936 than in 1934.

REVISION OF SPECIFICATIONS BY AMERICAN RAILWAY ENGINEERING ASSOCIATION

A member of the staff of the National Bureau of Standards serves on the Subcommittee on Scales of the Yards and Terminals Committee of the American Railway Engineering Association. He assisted in the formulation of the revisions of "Specifications for the Manufacture and Installation of Four-Section, Knife-Edge Railway Track Scales" and of "Specifications for the Manufacture and Installation of Motor Truck, Built-In, Self-Contained and Portable Scales for Railway Service", which were adopted by the AREA during the year. These superseded former specifications for scales of these classes adopted by this Association, and contained in publications of the Bureau. "Circular of the National Bureau of Standards C 83", January, 1920, contained

the specifications for railway track scales. These requirements were adopted as "Federal Specification for Scales; Railroad-Track, AAA-S-101" for the use of departments and independent establishments of the Government in the purchase of scales of this character. "Letter Circular of the National Bureau of Standards LC 152", January, 1925, contained the specifications for motor-truck scales, etc., and these were also widely employed as a basis for Federal purchases. Consideration will be given to the publication by the Bureau of the new specifications.

PUBLICATIONS AND SPECIAL REPORTS

"National Bureau of Standards Letter Circular LC 450, Railway Track Scale Testing Service of the National Bureau of Standards, Fiscal Year 1935 (July 1, 1934 to June 30, 1935)" was issued during the year and was widely distributed among railroads, industries, and other agencies interested in the accuracy of railway track scales.

There was issued during the year and distributed to a small group entitled to this information a "Report of Master Track Scale Calibrations for the Period July 1, 1934 to October 31, 1935."

There was complied and issued to the interested officials of each railroad upon the lines of which ten or more scales were tested during fiscal year 1935, a summary report of the condition of track scales on the railroad in question, supplementing the reports on individual scales which are issued as a matter of course immediately following each test. These reports enable the interested official to obtain a comprehensive view of conditions on his line and to compare these with general conditions in his district and throughout the country as a whole. They were issued for the first time several years ago. They were so well received and seemed to serve so useful a purpose that the practice of furnishing them will be continued in the future.

CONCLUSION

In former reports of this series there have been presented the conditions in respect to accuracy of railway track scales throughout the country from the foundation of the service in 1914 to the date of the report in question. It has been shown that the conditions at first were very unsatisfactory -- in the fiscal years 1914-1915 only about 33 percent of the scales tested were found to be within the allowable tolerance and the mean percentage error of the scales was 0.57 percent. General improvement was noted through the fiscal year 1919 followed by fluctuating percentages, experienced until 1922. In 1923 a period of tremendous improvement began. Remarkable increases in percentages were noted for three years, and the improvement thereafter steadily continued, though at a somewhat less rapid rate, until a peak was reached in the fiscal year 1933. During

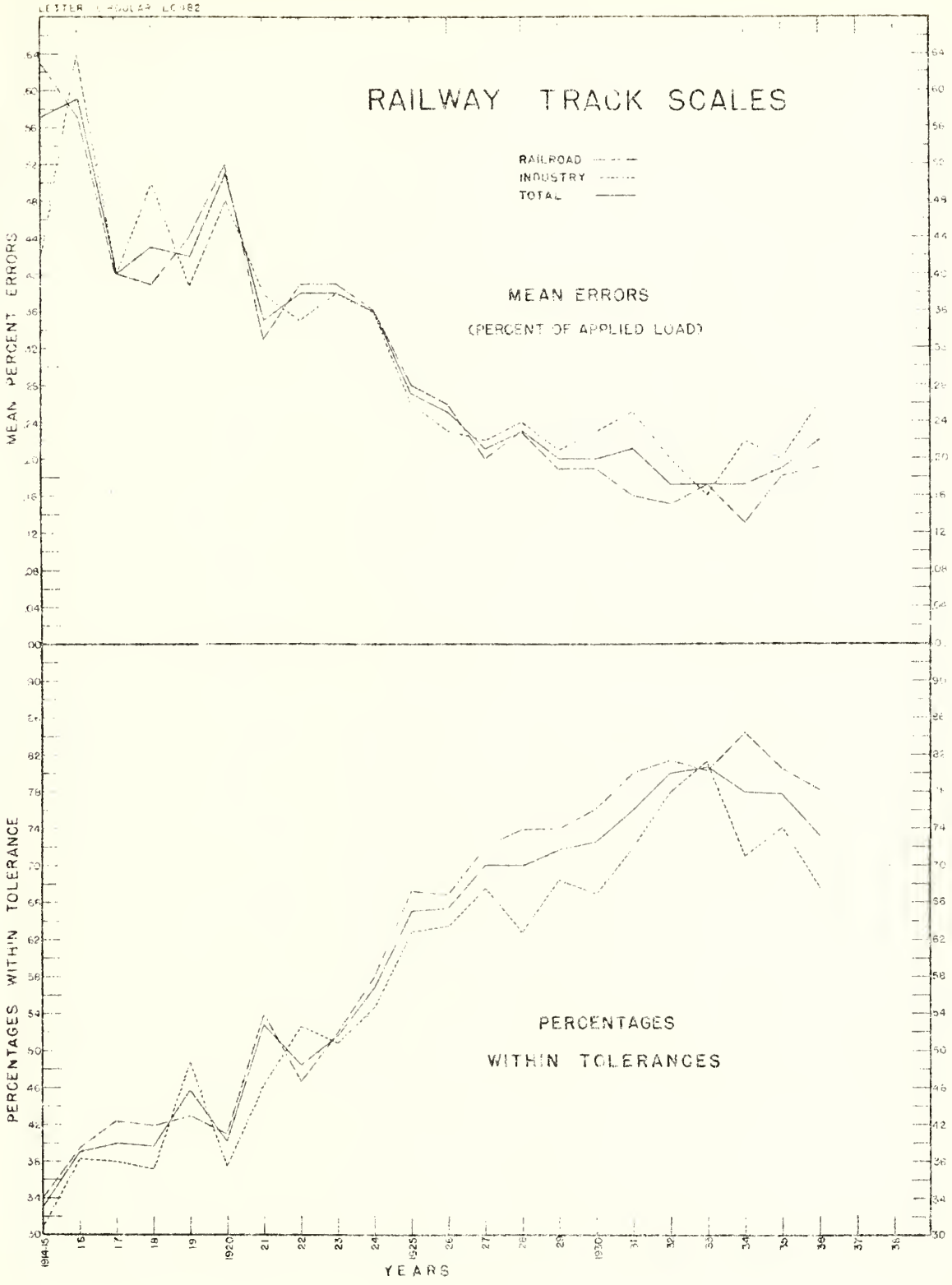
the 11-year period noted, percentages of scales within tolerance rose from about 48.5 percent to 80.6 percent and mean percentage errors decreased from 0.38 percent to 0.17 percent, a remarkable achievement and one which reflected great credit on the owners of the scales and on the various agencies which were striving for increased accuracy of railway track scales.

In 1934 a retrogression was noted for the first time. This report marks the third successive year in which conditions have been steadily growing less satisfactory. During this period, the percentage of scales found within tolerance has fallen from 80.6 percent to 73.1 percent; the mean percentage error has risen from 0.17 percent to 0.22 percent. The percentage of scales found within tolerance is now about the same as the figure for 1930; in other words the gains of 1931, 1932, and 1933 have been cancelled by the losses sustained in 1934, 1935, and 1936. In the case of the percentage figure representing mean error, this is now seen to be greater than in any year since 1928.

If the retrogression is to be halted in the near future and if lost ground is to be regained, prompt and effective steps are indicated. In cases where maintenance measures are not adequate--they have been relaxed in many instances to effect economy of expenditure -- these should be strengthened. But this in itself is not enough. It is a matter of common knowledge that the ordinary average programs for replacement of obsolete and obsolescent scales have been considerably slowed down for several years so that the average age of railway track scales is greater than it was five or six years ago. Maintenance of scales which have outlived their period of usefulness is uneconomical and unsatisfactory and even increased attention will not suffice to produce satisfactory weighing machines. The resumption of replacement programs designed to retire from use scales which are no longer capable of meeting the demands of modern service is imperative. The owners of railway track scales and the various agencies which are interested in accuracy of railway track scales and of the weighing of commodities in car load lots, have in the past demonstrated their ability to improve conditions in this field. The National Bureau of Standards urges these groups to direct their united energies to the attainment of the objectives mentioned.

APPENDIX: GRAPHICAL REPRESENTATION OF CONDITIONS

On the following page will be found graphs which set out the results found by the Bureau year by year, from the inauguration of the service to the present time. In the lower graph are plotted the percentages of railway track scales within tolerance, in the upper the mean percentage errors of the scales.


RAILWAY TRACK SCALES
RAILROAD
INDUSTRY
TOTAL
MEAN ERRORS
(PERCENT OF APPLIED LOAD)
MEAN PERCENT ERRORS
PERCENTAGES
WITHIN TOLERANCES
PERCENTAGES WITHIN TOLERANCE
1914-15
16
17
18
19
1920
21
22
23
24
1925
26
27
28
29
1930
31
32
33
34
35
36
37
38
YEARS

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