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RAILWAY TRACK SCALE TESTING SERVICE

OF THE

NATIONAL BUREAU OF STANDARDS

FISCAL YEAR 1939 (JULY 1, 1938 to JUNE 30, 1939)

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I. INTRODUCTION

One of the important functions of the National Bureau of Standards is the translation of the national standard of mass to the field of commercial weighing operations in the United States, to the end that commercial weights may be determined with uniformity and accuracy throughout the country. This report deals with the results of the Bureau's activity in the particular sphere of railway track scale weighing for the fiscal year 1939 -- July 1, 1938 to June 30, 1939 -- and is one of a series of reports on this subject, issued annually. The purpose of these reports is to summarize each year the conditions existing with respect to facilities for the weighing of commodities in carload lots, as disclosed by the results of the Bureau operations, to analyze these conditions, and to make such recommendations for improvement as seem appropriate in the premises.

For the benefit of the reader unfamiliar with the specific activities of the Bureau which affect railway track scale weighing, the following condensation of the detailed statements of earlier reports of this series is here included:

1. The Calibration of Master Railway Track Scales. There are in the United States nineteen "master" railway track scales, one owned by the National Bureau of Standards, two owned by State governments, and sixteen owned by railroads, used for the standardization of the test-weight cars which are employed in the routine testing of commercial railway track scales. Under an agreement with the Association of American Railroads, the Bureau calibrates these master track scales at approximately yearly intervals, using for this purpose two equipments specially designed for this service and carrying 80,000 pounds of accurately adjusted standard weights.

2. The Testing of Commercial Railway Track Scales. The two Bureau equipments designed for master track scale calibration and a third Bureau equipment comprising a 40,000-pound and an 80,000-pound test-weight car of standard design, are utilized for the testing of commercial railway track scales operated by railroads and industrial agencies. The itineraries followed by these equipments are drawn up with the view of reaching from time to time all commercial track scales in the country and of avoiding, insofar as practicable, duplication of Bureau tests at less than five-year intervals. This service is in no sense one of routine testing, but is investigational in character; the number and distribution of the Bureau tests are such that in the course of any annual period the scales examined are considered to be representative of all scales in service.

3. The Standardization of Railway Track Scale Test-Weight Cars. Upon its own master track scale located in the Chicago area (Clearing, Ill.), and upon occasion in connection with the field test of a commercial track scale, the Bureau standardizes the

weights of railway track scale test-weight cars operated by the railroads and by industries in maintaining their own railway track scales.

4. Activities Related to Railway Track Scales. The calibration and testing of scales and the standardization of test-weight cars are supplemented by research, special testing, preparation of specifications, and related activities, according to the needs arising and the personnel available to undertake such projects.

II. RÉSUMÉ OF TESTING ACTIVITIES

The scope of the activities during fiscal year 1939 which are discussed in detail in later sections of this report, is shown by the following summary:

1. Master railway track scales calibrated, 16.
2. Commercial railway track scales:
 - a. Total number tested, 1165.
 - (1) Railroad-owned, 635 or 54.5 percent of total.
 - (2) Industry-owned, 530 or 45.5 percent of total.
 - b. States in which tests were made, including the District of Columbia, 37.
 - c. Railroads upon the lines of which tests were made, 110.
3. Railway track scale test-weight cars:
 - a. Standardizations on Bureau Master Scale, 51.
 - b. Weighings in the field, 26.

III. MASTER RAILWAY TRACK SCALES

METHOD OF CALIBRATION, AND TOLERANCES.

For the information of those unfamiliar with the Bureau method of master track scale calibration, the following condensed statement of the normal procedure is here included:

Test-weight loads utilized are 30,000, 40,000, 50,000, 60,000, 70,000, and 80,000 pounds. Duplicate test runs are made with each load positioned successively at each of five positions on the weighrails. Two sets of tolerances are observed, "maintenance"

tolerances ranging up to ± 12 pounds at the 80,000-pound load (0.015 percent), and "adjustment" tolerances ranging up to ± 6 pounds at the 80,000-pound load (0.0075 percent).

A "maintenance" test is first made at loads of 40,000, 60,000, and 80,000 pounds, followed by any corrections or adjustments considered advisable. The final, or "adjustment", test follows, at all six loads. If the results of the maintenance test are within "adjustment" tolerances, and if no corrections or adjustments are made, the maintenance and adjustment tests are combined.

The weighbeam is separately checked. Removable counterpoise weights are separately tested on a balance against Bureau standards; tolerances on such weights range from 1 grain on a 1-pound weight to 6 grains on a 20-pound weight.

RESULTS OF MASTER TRACK SCALE CALIBRATIONS.

There were calibrated during the year sixteen master railway track scales. All of these scales, as found, were weighing within the maintenance tolerances. Eleven of the sixteen scales were found weighing within the adjustment tolerances; of the five scales which were not weighing within the adjustment tolerances, one failed to meet the adjustment tolerance by only 0.1 pound at a single observation, and in no case did the errors even approach the values of the maintenance tolerances. Adjustments were made, combined with other corrective measures in three cases, on each of the five scales which failed to meet the adjustment tolerances as found; each of these scales was left weighing within the adjustment tolerances. Adjustments were also made, combined in one instance with other corrective measures, on three scales originally found weighing within the adjustment tolerances, but on which it appeared advisable to reduce somewhat the size of the weighing errors.

The counterpoise weights in use on ten of the master scales calibrated were separately tested. Inaccurate counterpoise weights were found on only two scales, the total number of such inaccurate weights being ten; in no case was a weight in error by an amount seriously in excess of the tolerance.

Specific recommendations for improvement were considered necessary in connection with only five scales. In two instances the recommendations related to the scale counterpoise weights, in two instances they related to conditions external to the actual scale structure, and in only one instance were the recommendations directed to actual scale parts.

The condition of the master track scales of the United States, as to both accuracy and general maintenance, may be said to be excellent.

FREQUENCY OF CALIBRATION.

The adjustment of itineraries for the Bureau testing equipments to approximate a twelve-month average interval between successive master-scale calibrations was continued during the year, and the average interval between calibrations made in 1938 and 1939 was reduced slightly from the average interval reported a year ago. The exigencies of the service are such that delays in the progress of the equipments cannot always be avoided, and special circumstances at times make advisable a major modification of an itinerary, which may temporarily disrupt a testing schedule; however, continued effort will be directed toward achieving the aim of annual calibrations of all master track scales.

ADDITIONAL MASTER SCALE FACILITIES.

There are two sections of the United States at present without master railway track scale facilities and in which the Bureau believes such facilities to be badly needed, namely, Texas and the New England area. This deficiency is illustrated by the map on page 7 of this report, on which the locations of the nineteen master scales now in service are indicated by small circles. When equipments of the Bureau visit Texas and the New England areas, numerous test-weight cars are weighed for the carriers, but the results of this character of standardization fall short of those realized when cars are standardized on a properly maintained master scale, notwithstanding that the field weighings are made with the greatest care and that the method of substitution weighing against Bureau standards is used. Moreover, in any event, the periods elapsing between the visits of Bureau equipments are such that these equipments cannot furnish weighing service with the frequency desirable for proper maintenance of accuracy of the test-weight cars in service, and in the intervals between Bureau visits dependence is necessarily placed upon less satisfactory methods of standardization.

It is believed that in each of the sections in question, one master track scale could be installed in a more or less central location where it would be accessible, without hauls of excessive length, to all test-weight cars operating in the section, and that such master scales would make it possible to maintain a materially higher standard of accuracy for test-weight cars and, in consequence, a higher standard of accuracy for the commercial railway track scales in service. It is urged upon the carriers of Texas and the New England section, therefore, that this matter receive their careful study, to the end that, through either joint or individual action, master track scale facilities in their respective areas may be provided at the earliest practicable date.

IV. COMMERCIAL RAILWAY TRACK SCALES

METHOD OF TEST, AND TOLERANCES.

The supplement to the Bureau reports on tests of commercial railway track scales, appearing on the reverse of the report form, has been revised and is reproduced and appended to this report. Therein will be found a statement of the testing methods employed, the tolerances, and the sensibility reciprocal requirements. The form reproduced is that used in connection with reports of tests made by Equipments 1 and 2, these being the equipments designed especially for master-scale testing and which, when used for the test of commercial scales, apply tests with loads of 40,000 and 80,000 pounds only. In the case of Equipment 3, comprising two test-weight cars of seven-foot wheelbase weighing 40,000 and 80,000 pounds, respectively, an added test at 120,000 pounds is made using both cars; in this respect, the tests made with this equipment differ from the test outlined in the supplement referred to above.

The tolerances applied by the Bureau in its tests of railway track scales have been revised to bring these into closer harmony with corresponding tolerances adopted by the Association of American Railroads, by the adoption of the added maintenance tolerance of ± 0.30 percent for individual sectional errors on scales of more than two sections, and of tolerances for scales in which are embodied or to which are attached automatic indicating or recording devices. Conformable to the definition adopted by the National Conference on Weights and Measures for "new" scales, the Bureau has recognized the applicability of the tolerance for new scales to scales which have been newly reconditioned, and has denominated this tolerance as the "acceptance and adjustment tolerance". The tolerances for scales in grain-weighing service, which were recommended some years ago by the Interstate Commerce Commission and which have been recognized by the Bureau, have now been specifically adopted by the Bureau. Although these changes in the Bureau's tolerances were made effective as of July 1, 1939, it is considered appropriate that their adoption be noted in this report.

As an indication of the probable effect of the adoption of the new limiting tolerance of ± 0.30 percent for individual sectional errors on scales having more than two sections, it may be noted that of the 1165 scales covered by this report, only four classified as accurate would have been classified as inaccurate had the tolerances in question been in effect. It is seen, therefore, that statistics which will be published on tests made on July 1, 1939, and thereafter, may be directly compared with those previously published, without the introduction of any significant discrepancy.

ITINERARIES OF TESTING EQUIPMENTS.

The itineraries followed by the three railway track scale testing equipments of the Bureau are worked out upon the basis of approximately twelve months of travel, and are submitted to and approved by the Association of American Railroads in advance of their inauguration. The routes followed during the period covered by this report are indicated by the dotted lines on the map on the following page.

CLASSIFICATION OF SCALES.

Two general bases have been followed, as in preceding reports, for the classification of scales, namely, ownership and geographical location. Two ownership groups are recognized, "railroad-owned" and "industry-owned", frequently designated for brevity merely as "railroad" and "industry" scales. Railroad-owned scales are those owned by common carriers; in the very large majority of instances these scales are used primarily or solely by the carriers for determining weights of commodities in carload lots for the purpose of the assessment of freight charges; however, from necessity or for convenience, shippers and consignees often utilize these weights in the sale or purchase of the commodity transported. All scales not falling within the category of railroad-owned scales are classified as industry-owned; as the term suggests, these scales are usually owned by industrial concerns, although a very few are owned by other agencies, such as Federal, State, or local governments. The scales in the industry group are largely used for determining weights in connection with the purchase or sale of goods; a small percentage of these scales are employed in manufacturing operations; when a "weight agreement" is in effect between a shipper and a carrier, weights ascertained on an industry-owned scale are accepted by the carrier as the basis for the assessment of freight charges.

The geographical classification for scales is that followed by the Interstate Commerce Commission in its "Reports on the Statistics of Railways in the United States", and recognizes three "districts", the Eastern, the Southern, and the Western. The common boundaries of these districts are shown by the heavy lines on the map comprising page 7 of this report; it should be noted, however, that the Interstate Commerce Commission has in certain cases necessarily assigned to a particular district a carrier some of the tracks of which lie in another district, and that such decisions have been followed in the classification of scales in this report.

As to classification upon the basis of weighing performance, all railway track scales tested are designated as "accurate" or "inaccurate" according to the results of the tests made upon the scales in the condition in which they were found, upon the

criterion of a basic maintenance tolerance of ± 0.20 percent. The special requirements prescribed for scales in grain-weighing service have been disregarded except in computing the data presented in that section of this report devoted to "Scales in Grain-Weighing Service", for which the criterion of accuracy observed is the special basic maintenance tolerance of ± 0.10 percent applicable to such scales.

SUMMARY OF TEST RESULTS.

In Table 1 which follows, there is presented a statistical summary of the results of the tests made on all railway track scales tested during the year. The data are arranged to show results on railroad-owned and industry-owned scales for each district and for all districts, and on total scales for each district and for the country as a whole. Total numbers of scales tested, numbers and percentages of accurate and inaccurate scales, and numerical means of maximum percentage errors reported for individual scales, are shown.

TABLE 1. SUMMARY OF RAILWAY TRACK SCALE TEST DATA
FISCAL YEAR 1939

District and scale ownership	Number of scales tested	Accurate		Inaccurate		Mean numerical error -- percent of applied load
		Num- ber	Per- cent	Num- ber	Per- cent	
EASTERN						
Railroad	269	241	89.6	28	10.4	0.12
Industry	290	236	81.4	54	18.6	0.16
Totals	559	477	85.3	82	14.7	0.14
SOUTHERN						
Railroad	154	121	78.6	33	21.4	0.18
Industry	122	93	76.2	29	23.8	0.19
Totals	276	214	77.5	62	22.5	0.18
WESTERN						
Railroad	212	193	91.0	19	9.0	0.11
Industry	118	97	82.2	21	17.8	0.15
Totals	330	290	87.9	40	12.1	0.12
ALL DISTRICTS						
Railroad	635	555	87.4	80	12.6	0.13
Industry	530	426	80.4	104	19.6	0.16
GRAND TOTALS	1165	981	84.2	184	15.8	0.15
1938 Totals	1160	940	81.0	220	19.0	0.17

Discussion of Test Data. A total of 1165 railway track scales were tested during the year; 54.5 percent of these were owned by the railroads, while 45.5 percent are classified as industry-owned scales. Of the total tests, 48 percent were made in the Eastern District, 24 percent in the Southern District, and 28 percent in the Western District.

Of the total of 1165 scales tested throughout the country, 981, or 84.2 percent, were found to be accurate. This may be compared with the corresponding figure of 81.0 percent found in fiscal year 1938. The gain of 3.2 percent is a substantial and gratifying one. Especially is this true, when it is considered that last year's figure established a record high for accuracy up to that time, since the start of the investigation in 1914.

Considering separately the two classes of scales included in the figures in the preceding paragraph -- namely, railroad-owned and industry-owned, it is found that the percentage of accuracy of the 635 railroad-owned scales tested during the year is 87.4 percent. Last year's figure for the accuracy of scales of this class was 82.8 percent. The increase is 4.6 percent, an excellent improvement. This figure is significantly higher than any figure heretofore realized, the best previous figure having been 84.4 percent in fiscal year 1934. The percentage of industry-owned scales found accurate is 80.4 percent. This is 1.2 percent higher than last year's figure of 79.2 percent; it has been eclipsed in only one previous year, 1933, when an accuracy of 81.1 percent was realized. The fact that the percentage of industry-owned scales is somewhat higher than last year, albeit only slightly so, is particularly encouraging in view of the fact that last year's percentage represented the large increase of 13.5 percent over 1937. Since this year's figure maintains and even improves that percentage, it tends to demonstrate that last year's figure was a valid one.

It may be of some interest briefly to consider the accuracy figures and trends for each of the districts into which the country is divided.

In the Eastern District 89.6 percent of the 269 railroad-owned track scales tested were found to be accurate. This represents an increase of 11.5 percent over last year's figure of 78.1 percent and is very considerably higher than the best figure previously found -- 83.7 percent in 1931. Of the 290 industry-owned scales tested, 81.4 percent were found accurate, a figure which betters by 5.7 percent last year's figure of 75.7 percent. The figure for all scales tested is 85.3 percent, an improvement of 8.4 percent over last year's figure, and 3.6 percent over the best figure heretofore found.

In the Southern District declines instead of increases, are noted. The percentage accuracy of 154 railroad-owned scales tested is 78.6 percent, off 1.5 percent; of 93 industry-owned

scales, 76.2 percent, off 8.6 percent; of all scales, 77.5 percent, off 4.9 percent. The decrease in the case of industry-owned scales is not surprising since last year the improvement over the preceding year (13.5 percent) was so very large that it was questioned in that report whether the figure was wholly representative; it now appears that it may not have been. However, the fact that improvement has been realized in the Southern District will be evident when it is considered that the figures for railroad-owned, industry-owned, and total scales are better than any previously found, except in 1938.

In the Western District, of 212 railroad-owned scales tested, 91.0 percent were found accurate; of 118 industry-owned scales, 82.2 were accurate; combining these figures it is found that of a total of 330 scales tested, 87.9 percent were accurate. Each of these figures is higher than the corresponding figure for last year, the respective improvements being 3.8 percent, 3.4 percent, and 4.7 percent. The general average figure has never been equaled heretofore; the best previous figure was very slightly lower, 87.6 percent in 1933.

The basis of the above discussion is the percentage of scales found accurate. Another excellent criterion of conditions is the figure representing "Mean numerical error -- percent of applied load".

The mean error for all scales tested throughout the country is found to be 0.15 percent. As in the analysis given above, this indicates that never before have general conditions been so satisfactory. This value is 0.02 percent lower than the best figure formerly found -- 0.17 percent in fiscal year 1938 and in 1932 to 1934, inclusive.

The figure for railroad-owned scales is 0.13 percent, a value 0.04 percent better than last year and equalled only once before -- in 1934. For industry-owned scales the value is 0.16 percent, 0.01 percent better than last year and equalled before only in 1933.

Turning now to the several districts it is found that in the Eastern District the mean error for railroad-owned scales is 0.12, for industry-owned scales, 0.16, and for all scales, 0.14 percent. Corresponding figures for 1938 were 0.20, 0.18, and 0.19 percent. Thus improvements are noted in all cases -- 0.08, 0.02, and 0.05 percent, respectively. This year's figures for railroad-owned scales and for total scales are the best ever found for this district.

The Southern District shows much the same characteristics as in the analysis of percentage accuracies presented heretofore. The mean errors are 0.18 percent for railroad-owned, 0.19 percent for industry-owned, and 0.18 percent for all scales. Last year's figures were respectively, 0.18, 0.16, and 0.17 percent. Thus

the figure for railroad-owned scales is unchanged, while the mean errors for industry-owned and for total scales are larger by 0.03 percent and 0.01 percent, respectively.

In the Western District the mean errors of railroad-owned, industry-owned and total scales are 0.11, 0.15, and 0.12 percent, respectively. Last year's figures were 0.14, 0.17, and 0.15 percent. Improvement in each category is noted, namely, 0.03, 0.02, and 0.03 percent, respectively. The figure of 0.12 percent for total scales has never heretofore been realized in any district.

TEST DATA SUBDIVIDED BY CLASSES OF RAILROADS.

In order properly to distribute the services of the Bureau and also to make the data in these reports truly representative of conditions existing throughout the country, it is essential, in planning itineraries, to include as large a number of railroads as is practicable. It has been noted earlier that tests were made upon scales located on 110 railroads, representing what is believed to be a reasonably typical cross-section of the carriers of the country. In view of this it may be of interest to break down the test data into groups which will portray conditions existing in respect to the various classes into which the railroads are divided by the Interstate Commerce Commission in its publication "Statistics of Railways in the United States, 1937". This has been done in Table 2, which will follow. The "Not Classified" group includes electric lines, and steam roads which were not classified by the Commission. Only railroad-owned scales are included in this presentation. Upon a very few of the total number of roads only industry-owned scales were tested.

TABLE 2. TEST DATA SUBDIVIDED BY RAILROADS OF
VARIOUS CLASSES - FISCAL YEAR 1939

Classification of railroads	Number of rail- roads	Number of scales tested	Accurate		Inaccurate		Mean nu- merical error -- percent of applied loa
			Num- ber	Per- cent	Num- ber	Per- cent	
CLASS I - EXCEPT S. & T.	60	566	505	89.2	61	10.8	0.12
CLASSES II & III - EXCEPT S. & T.	23	29	19	65.5	10	34.5	0.30
SWITCHING AND TERMINAL	19	26	23	88.5	3	11.5	0.11
NOT CLASSIFIED	8	14	8	57.1	6	42.9	0.27
TOTALS	110	635	555	87.4	80	12.6	0.13

Discussion of Data. It will be noted from the preceding table that the greatest accuracy is achieved upon railroads of two classes, namely, "Class I" and "Switching and Terminal". The character of results found on these is practically identical; about 89 percent of the scales are accurate and the mean error is about 0.12 percent. Conditions on railroads of Classes II and III (except switching and terminal) are decidedly inferior, the figure for percentage of scales found accurate being 65.5 percent, some 24.5 percent lower, and the mean error being 0.30 percent, about two and one-half times as large as the equivalent figure on the two classes first mentioned. On the group designated as "Not Classified", only 57 percent of the scales are found accurate, with a mean error of 0.27 percent.

The character of the results is the same as has been reported heretofore. Last year also, Class I and Switching and Terminal railroads did not differ greatly and the scales on these classes of railroads were considerably better than those on roads of Classes II and III. This year the superiority of the roads in the first category is even greater than was the case last year; this results from the fact that the condition of the scales on the roads in the first category has shown a material improvement, in which improvement roads in the second category do not share, conditions on the latter being essentially unchanged. On "Not Classified" roads also, no significant change is noted.

RAILROADS CLASSIFIED ON BASIS OF CHARACTER OF RESULTS OBTAINED.

It may be of interest briefly to consider the character of results obtained for some railroad lines upon which a considerable number of scales were tested during the year. This discussion will be limited to railroad-owned scales and to railroads upon the tracks of which 5 or more such scales were tested. There were 37 railroads in this group. The number of scales tested on these roads varied from 5 to 68, the average number being 15.

In Table 3 which will follow, the railroads of this group have been classified on the basis of percentages of scales found accurate upon test by the Bureau equipments during the year.

TABLE 3. RAILROADS CLASSIFIED ON BASIS OF PERCENTAGE OF SCALES FOUND ACCURATE

Groups -- Percentages of scales accurate	Railroads falling in the several groups		Scales tested on railroads in the several groups	
	Number	Percent	Number	Average number per railroad
100%	13	35	137	11
90% - 99%, incl.	9	25	192	21
80% - 89%, incl.	6	16	110	18
70% - 79%, incl.	4	11	63	16
Less than 70% (60% to 20%)	5	13	39	8
Totals	37	100	541	15

In the case of 13 of the 37 railroads under consideration, 100 percent of the scales tested were found to be accurate. Two of these roads also had a similar record last year, while on 3 of them there were found last year one or more inaccurate scales; upon the 8 remaining railroads, fewer than 5 scales were tested last year.

In Table 4 this same group of roads is classified upon the basis of the mean error of all scales tested. This table follows.

TABLE 4. RAILROADS CLASSIFIED ON BASIS OF MEAN ERROR OF SCALES TESTED

Groups -- Ranges of mean errors of scales	Railroads falling in the several groups		Scales tested on railroads in the several groups	
	Number	Percent	Number	Average number per railroad
Not more than 0.05%	3	8	38	13
0.06% to 0.10%, incl.	14	38	219	16
0.11% to 0.15%, incl.	11	30	191	17
0.16% to 0.20%, incl.	4	11	52	13
More than 0.20% (0.23% to 0.54%)	5	13	41	8
Totals	37	100	541	15

The data presented in Table 4 may be summarized as follows. Three railroads, or 8 percent, have a mean error on all scales tested of not more than 0.05 percent (one-quarter of the tolerance), 17 railroads, or 46 percent, have mean errors of not more than 0.10 percent (one-half the tolerance), and 32 roads, or 87 percent, have mean errors of not more than 0.20 percent (the tolerance figure); in the case of the remaining 5 roads, or 13 percent, the mean errors are more than 0.20 percent. These figures show a marked improvement over last year's percentages of railroads in these four accuracy groups, which were, respectively, 0 percent, 13 percent, 80 percent, and 20 percent, of the 30 railroads involved last year.

Five hundred and forty-one scales in all were tested on these 37 railroads. Four hundred and eighty, or 88.7 percent, were found accurate. Of the remaining 94 scales tested upon all other lines, 75 scales, or 79.8 percent, were accurate.

RELATIVE ADEQUACY OF RAILROAD-OWNED AND INDUSTRY-OWNED SCALES.

There have been assembled in Table 5 certain data which will enable the reader to compare the quality of performance of railroad-owned scales and industry-owned scales, from fiscal year 1930 to date. This table follows.

TABLE 5. RELATIVE QUALITY OF PERFORMANCE OF RAILROAD-OWNED AND INDUSTRY-OWNED RAILWAY TRACK SCALES

1 Year	2 Percentage of scales tested found		4 Differ- ence (2)-(3)	5 Mean numerical error -- percent of applied load		7 Differ- ence (6)-(5)
	3 accurate			6		
	Railroad	Industry		Railroad	Industry	
1930	76.2	67.6	+8.6	0.19	0.22	+0.03
1931	79.9	72.3	+7.6	0.16	0.25	+0.09
1932	81.4	77.6	+3.8	0.15	0.20	+0.05
1933	80.3	81.1	-0.8	0.17	0.16	-0.01
1934	84.4	71.1	+13.3	0.13	0.22	+0.09
1935	80.6	74.0	+6.6	0.18	0.20	+0.02
1936	78.1	67.4	+10.7	0.19	0.26	+0.07
1937	83.7	65.7	+18.0	0.14	0.27	+0.13
1938	82.8	79.2	+3.6	0.17	0.17	0.00
1939	87.4	80.4	+7.0	0.13	0.16	+0.03

Review of Subject. Columns 4 and 7 in the preceding table enable the reader directly to compare the quality of performance of railroad-owned and industry-owned scales for each fiscal year from 1930 to the present year; 1939. Column 4 relates to the percentages found accurate of the total number of scales tested during a fiscal year. Column 7 relates to the mean errors of the scales tested. The data have been so arranged that a plus (+) sign indicates that the railroad-owned scale is superior to the industry-owned scale in respect to the criterion in question.

It will be noted that the railroad-owned scales have almost invariably been found to be superior in performance to those owned by industry. In only one year since 1930 has the contrary result been noted; this was in 1933 and in that year the differences were insignificant. Last year, however, there was no difference between scales of the two classes in respect to mean errors and the percentage of railroad-owned scales found accurate was only slightly higher than the equivalent figure for industry-owned scales.

Earlier in this report it has been shown that a higher percentage of industry-owned scales were found accurate this year than was the case last year; also the mean error has decreased. Notwithstanding this, these improvements did not keep pace with those shown by railroad-owned scales. It results that the performance of the scales of the latter class is again found superior in respect to both criteria.

ERROR FREQUENCY DISTRIBUTION.

The data assembled in Table 6, which will follow, disclose the frequency distribution of the errors on railway track scales tested during the year. The arrangement is such as to give the information in question for railroad-owned scales and for industry-owned scales, first for each district into which the country is normally divided and then for the country as a whole.

Discussion of Data. An analysis of the above table discloses that of a total of 635 railroad-owned railway track scales tested throughout the country, 87.4 percent were within the tolerance, 59.6 percent were within one-half the tolerance, and 27.2 percent were within one-fourth of the tolerance. Particular attention may be directed to the Western District where 91.0 percent of these scales were within the tolerance, 68.4 percent were within one-half the tolerance, and 35.4 percent were within one-fourth of the tolerance.

Turning to industry-owned scales it is found that throughout the country as a whole, 80.4 percent of these scales were within the tolerance, 45.3 percent were within one-half the tolerance, and 18.3 percent were within one-fourth the tolerance; again the Western District is in somewhat better condition than the others, the respective figures being 82.2 percent, 52.5 percent, and 27.1 percent. While these figures are somewhat lower than those for railroad-owned scales, they are nevertheless commendable.

Considering now scales seriously in error we find that 2.0 percent of the railroad-owned scales throughout the country (13 scales) were in error by more than 0.5 percent, and 0.6 percent (4 scales) were in error by more than 1.0 percent. In the industry-owned scale group, 3.4 percent (18 scales) were in error by more than 0.5 percent but only 0.2 percent (1 scale) was in error by more than 1.0 percent. In the Eastern District only 0.8 percent (2 scales) of the railroad-owned scales were in error by more than 0.5 percent; in the Western and Southern Districts the figures were 1.4 percent (3 scales) and 5.2 percent (8 scales), respectively. In the Eastern, Southern, and Western Districts, 2.8 percent (8 scales), 4.1 percent (5 scales), and 4.2 percent (5 scales) of the industry-owned group were in error by more than 0.5 percent. In the Western District no scale of either group was encountered which was in error by more than 1.0 percent. The Eastern District had one railroad-owned scale and no industry-owned in error by more than 1.0 percent, while in the Southern District 3 railroad-owned and 1 industry-owned were in this condition.

In general, the conditions in respect to seriously inaccurate scales in the country as a whole and in the several districts is better than was the case last year. Only in the Southern District is this not the case.

SCALES IN GRAIN-WEIGHING SERVICE.

In the foregoing material the basis used for determining the accuracy of all railway track scales tested has been the regular maintenance tolerance of ± 0.20 percent. However, it has been mentioned that a special tolerance of ± 0.10 percent is applicable to scales in grain-weighing service, this being the tolerance for such scales recognized by the Bureau, in accordance with the recommendation of the Interstate Commerce Commission in Docket 9009 (56 ICC 347), effective in January 1921. The accuracy of the industry-owned scales in grain-weighing service tested during the year, when this special tolerance is made the criterion, will now be considered.

This character of information was first included in the report for fiscal year 1923. In that year 32 scales in grain-weighing service were tested; of this number the performance of only two was found to be within the newly recommended tolerance and the mean error was 0.40 percent. In 1924 the figure for percentage accuracy was very considerably better, 34.8 percent being within the special tolerance. In the years succeeding 1924 gradual improvement was noted; by 1929, 55.7 percent were within the special tolerance, the average error being 0.15 percent. A summary of data on tests made since that date follows:

TABLE 7. 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	Grain scales	All industry scales
1930	47	22	46.8	25	53.2	0.15	0.23
1931	97	51	52.6	46	47.4	0.12	0.25
1932	72	46	63.9	26	36.1	0.13	0.20
1933	58	34	58.6	24	41.4	0.13	0.16
1934	96	55	57.3	41	42.7	0.15	0.22
1935	122	88	72.1	34	27.9	0.12	0.20
1936	91	46	50.5	45	49.5	0.16	0.26
1937	40	21	52.5	19	47.5	0.16	0.27
1938	105	68	64.8	37	35.2	0.12	0.17
1939	58	33	56.9	25	43.1	0.12	0.16
1930-1934, incl.	370	208	56.2	162	47.8	0.14	0.22
1935-1939, incl.	416	256	61.5	160	38.5	0.13	0.21

Review of Subject. The data in the preceding table indicate that over a long period of years the scales used in grain-weighing service have regularly been found to be considerably more accurate than industry-owned scales as a class. However it can not be said that marked success has been achieved in securing compliance with the special tolerance. Furthermore there has been no substantial improvement in this respect for a number of years. Thus in the period from 1932 to 1935, inclusive, and in 1938, larger percentages of scales in grain-weighing service were found to comply with the special tolerance than is the case this year. Nor has the mean numerical error been considerably reduced. In 1931, 1935, and 1938, the mean error was found to be the same as it is in the current year.

A consideration of results obtained over two five-year periods tends to fortify the conclusions stated above. In the five-year period, 1930-1934, inclusive, 56.2 percent of the railway track scales encountered in grain-weighing service were found to be within the special tolerance, with a mean error for all these scales of 0.14 percent. In the five-year period, 1935-1939, inclusive, the corresponding figures are 61.5 percent and 0.13 percent. While both figures are somewhat better for the latter period, they can hardly be considered to demonstrate a substantial improvement in conditions.

Over the periods in question the results on scales used in grain-weighing service parallel with considerable fidelity the results on industry-owned scales as a whole. Thus in the latter group during the first five-year period in question 73.2 percent of the scales were found accurate with a mean error of 0.22 percent while in the second five-year period the corresponding figures were 73.4 percent and 0.21 percent, respectively.

A detailed analysis of the condition of grain-weighing scales tested during the year is included in Table 8, following, which shows the frequency distribution of errors. For purposes of comparison similar data are included on industry-owned scales other than grain scales, and on all railroad-owned scales.

TABLE 8. FREQUENCY DISTRIBUTION OF ERRORS OF SCALES IN SEVERAL GROUPS - FISCAL YEAR 1939

Errors -- percent of applied load		Grain-weighing	Industry-owned	Railroad-
		service 58 scales	other than grain 472 scales	owned 635 scales
		Percent of scales tested	Percent of scales tested	Percent of scales tested
0.00 to 0.05	incl.	22	17.8	27.2
0.06 to 0.10	"	34	26.0	32.4
Subtotals		(56)	(43.8)	(59.6)
0.11 to 0.15	"	19	22.5	18.0
0.16 to 0.20	"	14	12.9	9.8
Subtotals		(89)	(79.2)	(87.4)
0.21 to 0.25	"	5	5.5	3.6
0.26 to 0.30	"	2	3.2	1.3
0.31 to 0.35	"	-	2.8	1.9
0.36 to 0.40	"	-	1.9	1.6
0.41 to 0.45	"	2	1.9	1.3
0.46 to 0.50	"	2	1.7	0.9
0.51 to 1.00	"	-	3.6	1.4
Over 1.00		-	0.2	0.6
Mean numerical errors for above groups				
Scales in error from				
0.00 to 0.20%		0.10	0.10	0.09
Scales in error by				
more than 0.20%		0.32	0.40	0.43
All scales		0.12	0.17	0.13

The data in the preceding table make possible a direct comparison for the fiscal year 1939 between the accuracy of scales used in grain-weighing service and scales of the other groups included. Thus it will be seen that some 89 percent of the 58 scales used in grain-weighing service are accurate within the ordinary tolerances applied to railway track scales. This figure may be compared with the corresponding figure for industry scales in other than grain-weighing service, 79.2 percent, and with all railroad-owned scales, 87.4 percent. In respect to this criterion, then, grain scales are markedly better (10%) than industry scales in other services -- only about one-half as many fail to comply with the tolerances. Grain scales are also slightly better than railroad-owned scales (2%).

When percentages of scales not in error by more than half the tolerance ($\pm 0.10\%$) are considered, it is noted that the percentages for grain scales, other industry scales, and railroad-owned scales are 56 percent, 43.8 percent, and 59.6 percent. Thus in this respect grain scales are 12 percent better than other industry scales; however, railroad-owned scales are 4 percent better than grain scales.

The mean numerical errors on grain scales, other industry scales, and railroad-owned scales are 0.12, 0.17, and 0.13 percent, respectively. Judged by this criterion, grain scales are decidedly superior to other industry scales -- the mean error is 0.05 percent smaller. However, the mean errors on grain scales and railroad-owned scales are substantially the same.

In general the superiority of grain scales over industry scales employed in other services will be seen to be due to two causes: First, as has been noted, greater percentages of grain scales are in error by less than 0.10 percent and by less than 0.20 percent. Second, the errors on the remaining grain scales average smaller than the errors on other industry scales -- fewer excessive errors are found; thus no grain scale was found to be in error by more than 0.50 percent while 3.8 percent of other industry scales were in this condition.

Recommendations. The intention of those interested in the weighing of grain in carload lots to demand superior performance of the railway track scales used for this purpose, is demonstrated by the promulgation of the special tolerance and sensibility-reciprocal requirement for such scales, by the absence of subsequent criticism of these requirements, and by the fact that throughout the years following promulgation of these special requirements there has been no concerted move to rescind them. Recognition has been accorded to this intention by the formal adoption by the National Bureau of Standards, as of July 1, 1939, of the special requirements in question.

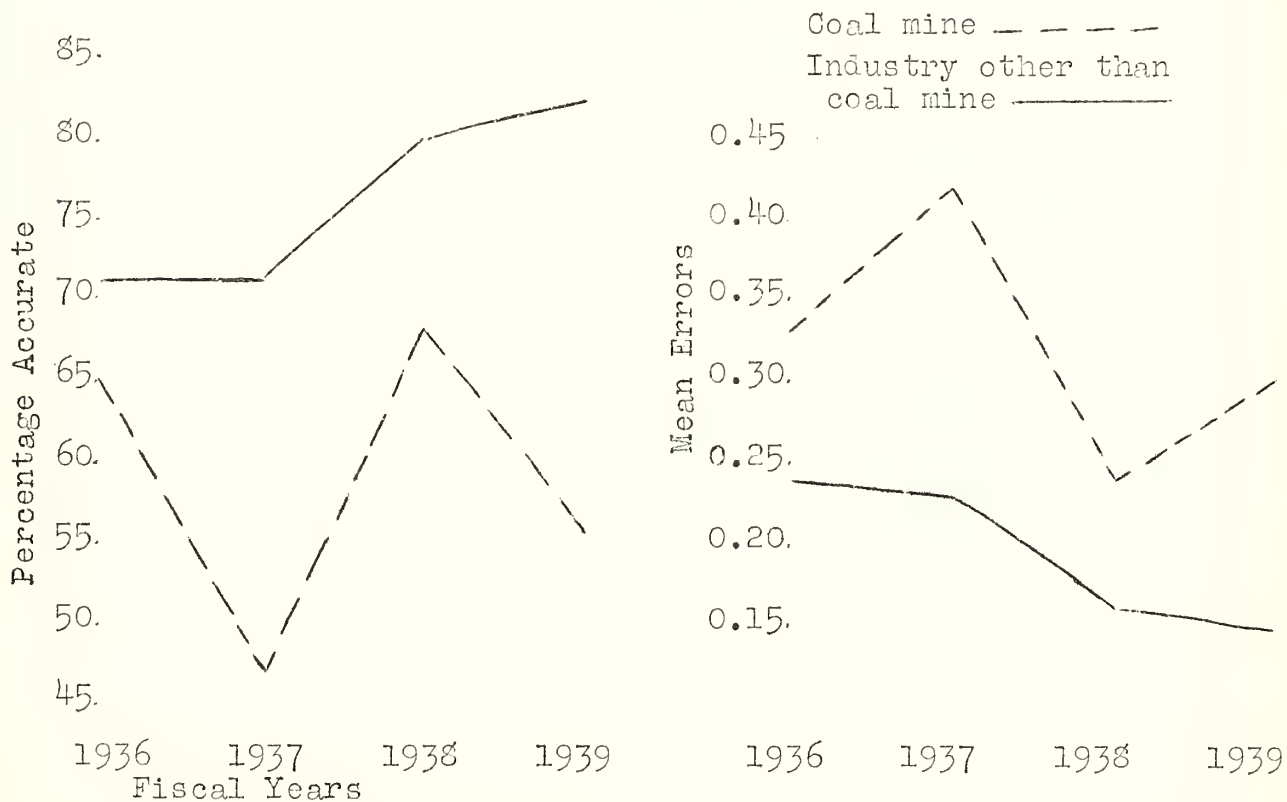
The Bureau feels that results demonstrate that those agencies primarily responsible for the accuracy of railway track scales in grain-weighing service may properly be charged with some degree of laxity with respect to their efforts to improve the condition of the class of scales here under discussion. Agencies, such as the railroads and weighing bureaus, are in a position to exert influence upon the owners of grain-weighing scales. It is strongly recommended that scale owners, and the officials and other representatives of the railroads and of agencies supervising grain-weighing equipment, recognize the special requirements applicable to railway track scales in grain-weighing service as the practical criterion for the performance of such scales, and make determined efforts to improve the quality of weighing service being rendered by such scales.

SCALES AT COAL MINES.

The number of industry-owned scales at coal mines tested this year was very considerably smaller than the numbers which have been tested in each of the last several years. This year 36 such scales were tested; of these, 20 scales or 56 percent of the total were accurate, while 16, or 44 percent, were found to be outside the tolerance. The mean numerical error of all of these scales was 0.30 percent.

While it is recognized that the number of scales involved is too small to be depended upon as necessarily representative of conditions, nevertheless they are generally similar to the figures found during the preceding three years when a large number of coal mine scales were tested. These former figures disclosed that over the period 1936-1938, inclusive, only 56 percent of the scales in this service throughout the country were accurate and that the mean error was 0.34 percent.

The following graphs disclose the trend of accuracy of coal mine scales and of industry scales other than coal mine scales for the fiscal years 1936 to 1939, inclusive, on two bases; first, the percentages of scales found accurate, and second, the mean errors of scales.



It appears to be amply demonstrated that industry-owned scales located at coal mines are deplorably inaccurate; moreover, it is not evidenced that conditions are improving as has been shown to be the case in respect to other industry-owned scales. The condition of industry-owned scales at coal mines should be substantially improved and efforts expended toward this end would be very much worth while. The replacement of obsolete scales on the one hand and better maintenance of scales in use which are of reasonably adequate design on the other, are both indicated as being necessary.

ADJUSTMENTS MADE ON SCALES ENCOUNTERED.

It is not deemed to be a primary function of the Railway Track Scale Testing Service of the Bureau generally to improve, as a part of its test, the mechanical condition or the accuracy of a scale encountered. The futility of such a policy will be at once apparent when it is considered that the Bureau operates but three equipments, each in charge of one inspector, and that these equipments each year must test scales in large numbers and in all sections of the United States. Obviously the Bureau must primarily operate as a fact-finding agency. In general, other agencies must function to effect improvement of conditions as found.

However, the Bureau would feel that it was not operating with maximum efficiency and was not doing its full duty in the premises if it did not do what it could at the time of test to improve the accuracy of the scale, when such improvement could be effected without loss of time and thus without curtailing its primary activities. Especially is the Bureau ready so to proceed when requested so to do by the representative of the owner present at the test. Thus it is found possible in some cases to adjust scales and to correct minor mechanical faults. It is the practice to limit adjustments to scales not having mechanical faults such that repairs should be made before adjustments are justifiable.

During the year, then, corrective adjustments and/or slight modifications were attempted on 87 railroad-owned scales and 50 industry-owned scales. In the case of the railroad-owned scales, 36 originally found inaccurate were determined to be accurate after adjustment, while in the case of 48 accurate scales the weighing errors were reduced. In 48 instances these scales as left were found to be within the adjustment tolerance of ± 0.05 percent. In the case of the industry-owned group of 50 scales, 22 scales originally found inaccurate were left within tolerance. In the case of 27 scales originally accurate, the error was reduced. Twenty-five of the scales were found to be within the adjustment tolerance upon retest.

Data of interest in this connection are included in Table 9 which follows.

TABLE 9. SUMMARY OF CONDITION OF RAILWAY TRACK SCALES AS ENCOUNTERED AND AFTER ADJUSTMENTS AND CORRECTIONS MADE FISCAL YEAR 1939

Scale Ownership	Number of scales tested	Accurate		Inaccurate		Mean numerical error -- percent of applied load
		Num-ber	Per-cent	Num-ber	Per-cent	
RAILROAD						
As found	635	555	87.4	80	12.6	0.13
As left	635	591	93.1	44	6.9	0.11
INDUSTRY						
As found	530	426	80.4	104	19.6	0.16
As left	530	448	84.5	82	15.5	0.15
TOTALS						
As found	1165	981	84.2	184	15.8	0.15
As left	1165	1039	89.2	126	10.8	0.13

NUMBER OF RAILWAY TRACK SCALES IN SERVICE.

Recently an estimate of the number of railway track scales in service in the United States as of July 1, 1939, has been made. A comparison with the former estimate made a few years ago indicates that the numbers of railroad-owned railway track scales in the Eastern and Western Districts have declined somewhat, while there has been no appreciable change in the Southern District. The numbers of industry-owned scales in commercial use in all districts is somewhat smaller than was formerly found. This is in part due to the fact that the cards for certain scales which are not in commercial use and the test of which is not particularly desired by the owners thereof, have now been withdrawn from our files.

DISTRIBUTION OF TESTS BY DISTRICTS.

There were tested by the Bureau in fiscal year 1939:

In All Districts

635	or 19 percent	of some	3400	railroad-owned	scales
530	or 16 percent	of some	3350	industry-owned	scales
<u>1165</u>	or 17 percent	of some	6750	total	scales

In Eastern District

269	or 21 percent	of some	1275	railroad-owned	scales
290	or 21 percent	of some	1375	industry-owned	scales
<u>559</u>	or 21 percent	of some	2650	total	scales

In Southern District

154	or 21 percent	of some	750	railroad-owned	scales
122	or 18 percent	of some	675	industry-owned	scales
<u>276</u>	or 19 percent	of some	1425	total	scales

In Western District

212	or 15 percent	of some	1375	railroad-owned	scales
118	or 9 percent	of some	1300	industry-owned	scales
<u>330</u>	or 12 percent	of some	2675	total	scales

It will be noted that during the fiscal year covered by this report, the percentage of scales in service which were tested in the Southern District slightly exceeded the general percentage tested in the country as a whole. The same situation was noted last year. The percentage of scales tested in the Eastern District this year exceeds while the percentage in the Western District is smaller than the general percentage of scales tested in the country as a whole. This is a desirable distribution of tests since it was shown in the report issued last year that the contrary was the case -- a smaller percentage of the scales in service in the Eastern District were tested than was the case in the Western District.

SCALES NOT FORMERLY TESTED OR NOT RECENTLY TESTED BY THE BUREAU.

Several years ago the Bureau announced that a special effort would be made to test scales which had not formerly been tested or which had not recently been tested, by the Bureau, to the end that the service rendered should have maximum distribution and that the figures depicting conditions should be as representative as it is practicable to make them. Since that date itineraries have been prepared with this policy in mind and accordingly in the last several years the percentages of scales tested in the not-formerly-tested and not-recently-tested groups have been larger than was formerly the case and the numbers of scales in these groups have been sub-

stantially reduced. An analysis of scales tested this year has been made and Table 10 which follows has been prepared to bring out pertinent facts in this general relation.

TABLE 10. SCALES TESTED CLASSIFIED ON BASIS OF PERIODS ELAPSING SINCE LAST FORMER TESTS BY BUREAU EQUIPMENTS FISCAL YEAR 1939

Scale Ownership	Number of scales tested	No former test ¹		Last former test:					
				10 years or more ago		5 - 9 years ago		Less than 5 years ago	
		Num-ber	Per-cent	Num-ber	Per-cent	Num-ber	Per-cent	Num-ber	Per-cent
RAILROAD	635	95	15	64	10	217	34	259	41
INDUSTRY	530	202	38	2	1	155	29	171	32
TOTAL	1165	297	25	66	6	372	32	430	37

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

In connection with the new estimate of the number of track scales in service throughout the country, there were again estimated, as of July 1, 1939, the numbers of scales in service which have not been tested by the Bureau equipments (1) as to railroad-owned scales since the inauguration of the Railway Track Scale Testing Service in 1914, and (2) as to industry-owned scales since July 1, 1928. The figures now derived make it appear that the former figures representing scales not tested were somewhat too small.

The new estimate is given in Table 11 which follows.

TABLE 11. SUMMARY OF SCALES NOT TESTED BY THE BUREAU

Ownership and District	Total scales in service (est.)	Number not tested by Bureau as of June 30, 1939 ¹ (est.)	Percentage of total scales in service
RAILROAD			
Eastern	1275	72	6
Southern	750	30	4
Western	1375	124	9
All Districts	3400	226	7
INDUSTRY			
Eastern	1375	223	16
Southern	675	92	14
Western	1300	338	25
All Districts	3350	653	19
ALL SCALES			
Eastern	2650	295	11
Southern	1425	122	9
Western	2675	462	17
All Districts	6750	879	13

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

The above data indicate that great progress has recently been made in reducing the number of scales not as yet tested by the Bureau.

V. RAILWAY TRACK SCALE TEST-WEIGHT CARS

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

Essential data in relation to all standardizations of railway track scale test-weight cars on the master track scale of the National Bureau of Standards, at Clearing, Ill., are shown in Table 12. As in previous reports, individual cars are designated by letters. When the letter is enclosed in parentheses, (), it indicates that the car in question conforms in the most 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 12. STANDARDIZATION OF RAILWAY TRACK SCALE TEST-WEIGHT CARS ON NATIONAL BUREAU OF STANDARDS MASTER TRACK SCALE, CLEARING, ILLINOIS -- FISCAL YEAR 1939

Designation of test car	Bureau Report No.	Nominal weight in pounds	Period since last preceding standardization in months	Error in pounds		
				(Plus)	(Minus)	
(A)	557	80 000	5	5		
	579		4	301*		
	589		4	104*		
B	558	61 400	3	10*		
	580		3	10*	2*	
	590		4	15*		
	597		1 ¹			106*
	600		1 ¹		29*	
C	559	80 000	11		41	
	602		3		80*	
D	560	80 000	12		7	
E	561	80 000	7		3	
	591		6		8	

¹Restandardization necessitated by repairs.

TABLE 12 (Continued)

Designation of test car	Bureau Report No.	Nominal weight in pounds	Period since last preceding standardization in months	Error in pounds	
				(Plus)	(Minus)
F	562 583	75 000	4 4	9*	50*
(G)	563 598	80 000	7 6	1* 34*	
(H)	564 587	30 000	4 5	1	9*
(I)	565 588	80 000	9 5	11* 4	
(J)	566	80 000	6		4
(K) ¹	567	30 000	10		16
(L)	568 603	80 000	7 6		8* 2
(M)	569 607	83 000	13 7	231* 5*	
N	570 605	60 000	7 7	27	63
O	571 606	80 000	7 7		297* 336*
(P)	572	80 000	12		12*
(Q)	573	80 000	12	68*	
R	574	50 000	11		4*
(S)	575 595	61 600	5 5		2 20*
T	576 601	92 500	6 6	61* 14*	
(U)	577 594	80 000	12 5		30* 8

¹Not in use since preceding standardization. Error may have resulted from drying of oil in journals.

TABLE 12 (Continued)

Designation of test car	Bureau Report No.	Nominal weight in pounds	Period since last preceding standardization in months	Error in pounds	
				(Plus)	(Minus)
V	578	60 000	12		37*
W	581	60 000	12	86*	
(X)	582	80 000	8		17*
Y	584 604	60 600	9 3	17 133*	
(Z)	585	40 000	16 ¹	5	
(AA)	586	80 000	16 ¹	1	
(BB)	592	80 000	12	60*	
(CC)	593	80 000	13	67*	
(DD)	596	80 300	36	24*	
EE	599	50 000	13		39*
31 cars	51 standardizations			26 heavy	25 light
1938					
35 cars	52 standardizations			23 heavy	29 light

¹Intermediate standardization or standardizations made on another master scale.

Summary of Standardization Results. There were submitted one or more times to the National Bureau of Standards Master Scale for standardization, 31 track scale test-weight cars belonging to 16 owners, and on these cars 51 standardizations were made. The various individual cars submitted ranged in nominal weight from 30,000 pounds to 92,500 pounds. More than half of them (16 cars) weighed 80,000 pounds. Eighteen of the cars generally conformed with specifications for test-weight cars.

Fifteen cars, or 48 percent of the total number, were submitted only once during the year, 14 cars, or 45 percent, were submitted twice, while 1 car was submitted three times and another five times (this latter car was submitted twice after intervals of one month, early returns to the Station for restandardizations being necessitated as a result of repairs.)

The period elapsing between a standardization and the latest preceding standardization on the Bureau master scale is shown in the above table for each standardization. In an analysis of these intervals it seems that four of them might well be disregarded; (1) the two intervals of one month mentioned, since these were not normal resubmissions, and (2) two periods of 16 months each in which cases it is known that another master scale was utilized for restandardizations during the periods in question.

Considering, then, the remaining 47 standardizations, it is found that the shortest period since the preceding standardization on the Bureau master scale was 3 months (in 3 instances) and the longest was 36 months (in 1 instance). Twenty-one standardizations, or 45 percent, were made following periods of not more than 6 months, 22, or 47 percent, were made following periods of more than 6 months but not more than 12 months, and in the remaining 4 cases, or 8 percent, more than 12 months had elapsed, although it should be noted that three of these four were made after 13-month periods.

The average time elapsing since the date of the last preceding submittal of the cars was 8.1 months. If the one abnormal interval of 36 months is disregarded, this average is shortened to 7.5 months.

These figures are not greatly different from those reported last year. However, this year fewer cars were submitted in which excessively long periods had elapsed since the last former submittal.

In the case of 17 of the 51 standardizations made at Clearing, it was not ascertained that since the date of the last preceding standardization repairs had been made to the cars involved nor did the cars show evidences of recent repairs. The cars were found to be over nominal weight in 7 instances, averaging 9 pounds heavy; in 10 cases the cars averaged 15 pounds light. The average error of all was 13 pounds.

Of the 17 standardizations noted above in which it does not appear that the cars in question had been repaired since the last former standardization, there were involved 10 cars conforming in essential respects with modern specifications and 7 cars which did not so conform. Of the first group, 5 were heavy and 5 were light; the average numerical error of all was 5 pounds. Of the second group, 2 were heavy and 5 were light; the average numerical error was 24 pounds.

As in former years the number of standardizations of cars of each type not repaired was small so that too much reliance should not be placed on the figures. However the fact that year after year the specification cars are found to have smaller errors than non-specification cars is persuasive of the conclusion that considerably less variation is to be expected in the case of the specification cars.

It was ascertained that 2 cars in the group just discussed had been standardized on another master scale since their last standardization at Clearing. Eliminating these, it may be noted that the average elapsed time since the former standardization at Clearing in the case of 15 standardizations was 7 months. The shortest period was 5 months, the longest 12 months. The average error of 8 cars standardized within a period not in excess of 6 months was 4 pounds; the average error of 7 cars in which a period of more than 6 months had elapsed was 25 pounds. However, these figures are inextricably intermingled with those given heretofore in relation to types of cars, since in the case of 7 out of 8 standardizations involving specification cars a period of not more than 6 months had elapsed while in 6 out of 7 cases non-specification cars had not been standardized within the 6-months period. It seems to be indicated that owners of specification cars are more careful to ascertain their accuracy; these cars which are less in need of frequent standardization are nevertheless submitted more frequently than the non-specification cars which more urgently need frequent checks.

WEIGHING OF TEST-WEIGHT CARS IN THE FIELD.

In connection with tests of commercial track scales by the Bureau, there are customarily weighed in the field such railway track scale test-weight cars as are made available for this purpose. Through this service the accuracy of the nominal weight of the car is determined, and indicated corrections can then be made. In each case the weighing is made on a scale which is suitable for the purpose and which has just been tested, a method of substitution being used. While it is not to be supposed that as high a degree of accuracy can be obtained as when a master scale is utilized, nevertheless the weights are determined with a reasonable degree of accuracy. For cars which are of too long a wheel base to be accommodated on a standard master scale, or for cars which do not have access to such a scale, the field weighing is a proper substitute, and the Bureau encourages owners of such cars to take advantage of this service.

Twenty-six weighings of as many cars were made in the field during the year. Five of these cars were found heavy, 14 were light, while 7 were accurate within the degree of accuracy inherent in the method of weighing necessarily adopted in the field.

In considering mean errors two cars should not be included in the calculation since one had just undergone heavy repairs and the other had recently been modified. Eliminating these, it is found that 4 cars were heavy by an average of 36 pounds and 13 cars were light by an average of 47 pounds. As mentioned above, there were 7 cars to which no numerical error was assigned. The average numerical error of all cars was 31 pounds. The corresponding figure reported last year was 41 pounds.

The most seriously inaccurate car found in use was 165 pounds light. Other cars had errors of -90 and -70 and of +65 and +50 pounds.

In a number of instances the weights of cars were corrected by the Bureau inspectors immediately following the weighing. In the remaining cases the information obtained made it possible for the corrections to be made by the owners.

VI. CONCLUSION

The calibration of master railway track scales, the standardization of test-weight cars, and the testing of commercial railway track scales, as carried on by the National Bureau of Standards, are all directed to a single end -- the raising of the level of accuracy with which determinations of the weights of carload lots of merchandise may be made. As in all operations involving both men and machines, the accurate determination of commercial weights demands proper equipment and intelligent use of such equipment. The second of these two factors is beyond the scope of the Bureau's field of activity; the training of weighmasters, the methods of weighing, the precision with which weights are recorded, the tare weighing of railway cars, the methods of accounting, reweighing, treatment of claims, and similar aspects of the personal term in the equation are left entirely to other agencies. As to the master track scales, the test-weight cars, and the commercial weighing devices, however, those mechanical elements upon which accuracy of weight determination is dependent, the Bureau of Standards has continuously devoted thought and effort since the inauguration of its railway track scale investigation in 1914.

The best available criterion of conditions in the field of commercial weighing of commodities in carload lots is to be found in the condition of railway track scales as tested by the Bureau. It should be unnecessary at this time to review in detail the progress made from year to year in the direction of the goal of errorless weighing, as revealed by the published results of the Bureau investigation. For this, reference may be made to earlier reports in this series, where basic data and analyses based thereon will be found. It is, however, appropriate to say that the optimism expressed in the report for the fiscal year of 1938 appears to have been well founded, for the results of the past year disclose the largest percentage of scales found accurate and the smallest mean percentage error ever achieved since the beginning of the Bureau work on railway track scales.

It is felt that the number and distribution of the Bureau tests of commercial scales are such that the results may be considered as truly representative of conditions throughout the country. Upon this assumption it is gratifying, indeed, to report that conditions are better than they have ever been before, notwithstanding the handicaps imposed by the general economic condition which has prevailed for years. That the depression took its

toll of accuracy in fiscal years 1934, 1935, and 1936 has formerly been shown. That definite progress has been so promptly and so effectively resumed is a tribute to the energy and efficiency of the agencies responsible for maintaining the country's largest type of commercial weighing devices. This progress during the past year is most marked in the case of railroad-owned equipment, and is in contrast with a decline, even though this was a very small one, for the preceding year. The mean percentage error for railroad-owned scales equals the smallest corresponding figure for any previous year, and the percentage of scales found accurate has risen three percent above the former maximum.

Industry-owned scales show a reduction of mean percentage error and an increase in the percentage found accurate, as compared with the results of a year ago; in the first instance the previous low figure is equalled, and in the second instance the current figure exceeds all but one previous figure and falls short of the record by less than one percent.

It is the figures for all scales, however, which are most gratifying. Attention is invited to the graphs appearing on a later page of this report. From these it will be noted that since 1936 there has been a consistent downward slope in the solid curve representing the mean percentage error for all scales tested by the Bureau, and a consistent upward slope in the solid curve representing the percentage of scales found accurate. Most pleasing is the fact that each curve is now in the most favorable position yet reached, representing a record for each of the characteristics plotted.

Eventually there must be reached a point where further progress in the direction of reduction of the mean percentage error can not be made -- a relatively stable point about which the computed figures will fluctuate from year to year, and representing in general a minimum value consistent with commercially adequate maintenance, normal depreciation in service, and normal replacement of existing facilities with new equipment. The Bureau is confident that this point is considerably below that now reached, an opinion supported by the data presented in Table 6 of this report, which shows an undesirable frequency of scale errors of relatively large magnitude. Further improvement through elimination of the larger errors and reduction of the frequency of occurrence of errors in the upper portion of the range is confidently anticipated.

As to the percentage of scales found accurate, it seems not too much to expect that particularly in the field of railroad-owned scales, the maximum value of 100 percent is a goal which may be substantially realized in the future, if effort is consistently directed to this end. The possibilities in this direction, as well as the need for an appreciation of existing conditions, are strikingly illustrated by Table 3 of this report. That

100-percent accuracy is practicable is clearly demonstrated; that definite programs of improvement should be inaugurated and vigorously pursued is equally plain.

The National Bureau of Standards, therefore, renews its earnest recommendation for the cooperation of all interested agencies in a sustained drive to continue the improvement of railway track scale accuracy in the United States. To hold present gains is not enough; further progress should be made. To do this, obsolete and obsolescent equipment must be replaced by scales adequate to meet present and anticipated demands, and all equipment in service must receive that regular and intelligent attention which is essential to the maintenance of accuracy. It is recognized that such a program will require the expenditure of funds for equipment and maintenance service, and it may be advanced by some that funds for such purposes are not conveniently available. It is submitted that for any factor of a business as vital to its success as accuracy of weighing, necessary funds should be provided without question as a matter of business insurance.

RAILWAY TRACK SCALES

RAILROAD - - - -
INDUSTRY - · - -
TOTAL - - - -

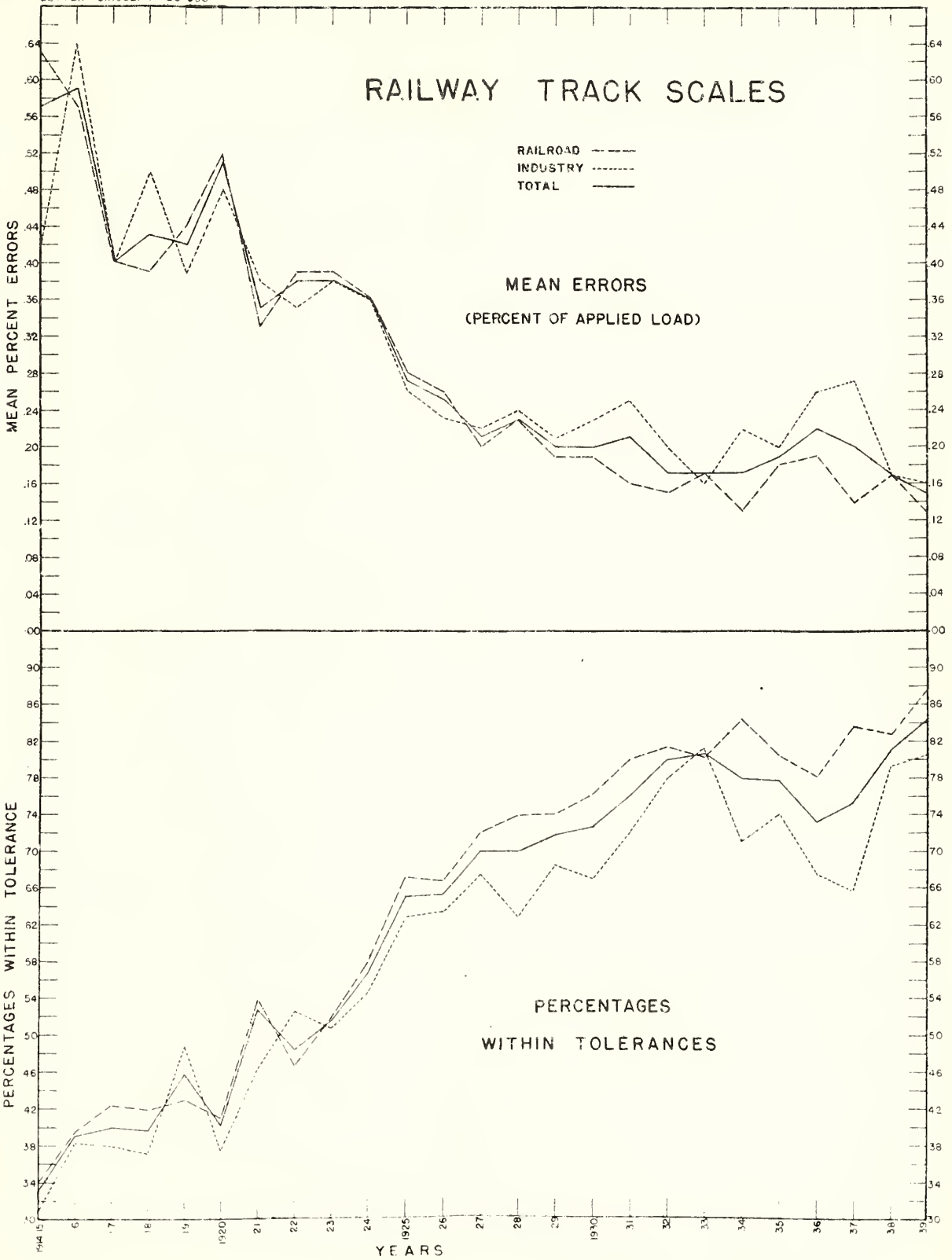
MEAN ERRORS
(PERCENT OF APPLIED LOAD)

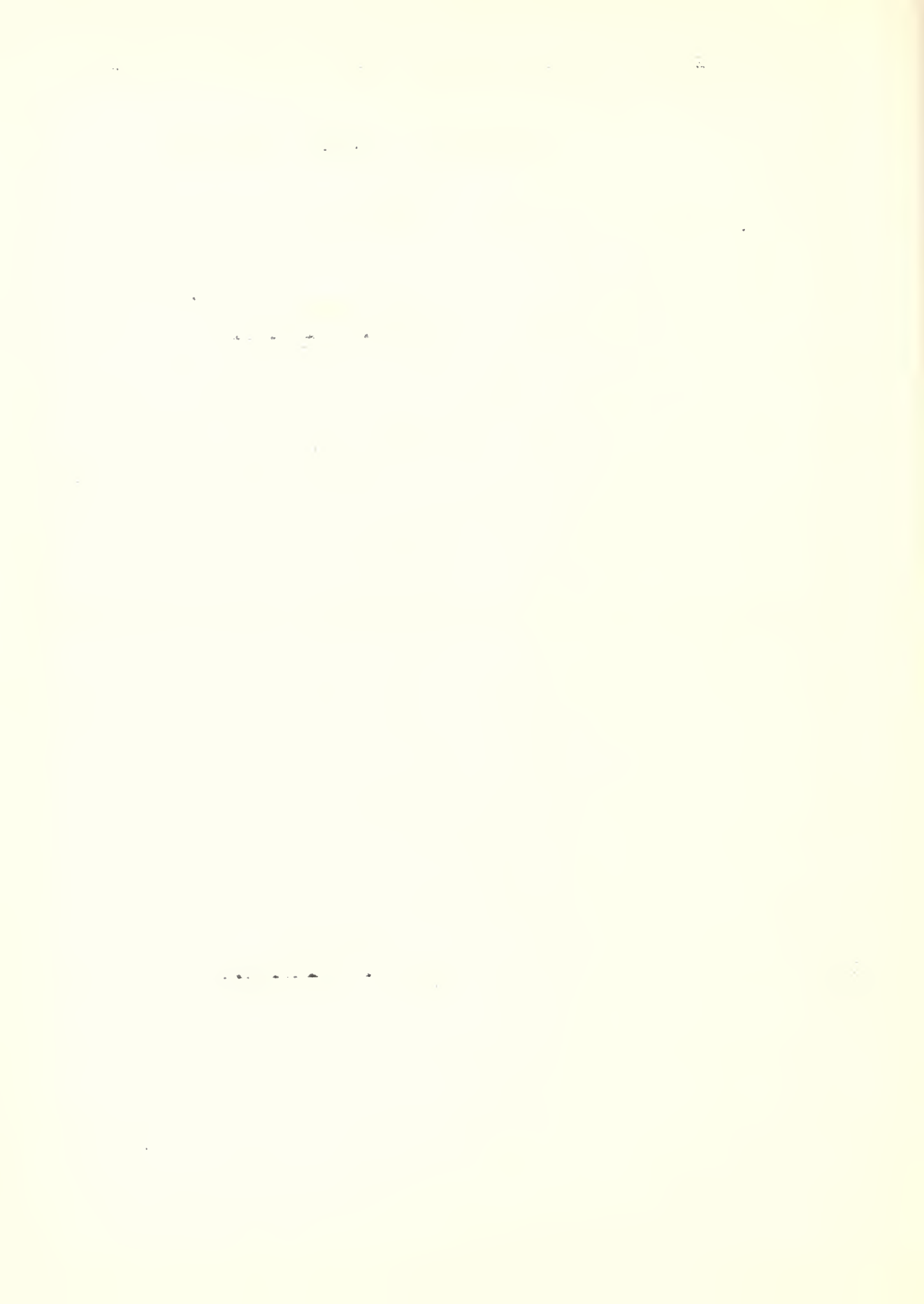
MEAN PERCENT ERRORS

PERCENTAGES WITHIN TOLERANCE

PERCENTAGES
WITHIN TOLERANCES

YEARS





SUPPLEMENT TO REPORT OF RAILWAY TRACK SCALE TEST

1. *Test loads.*—The test loads used consist of standard test weights carried on a 4-wheel truck of known weight having a wheel base of 5 feet.

2. *Test load positions.*—A section of a railway track scale comprises a pair of main levers (straight-lever type), or a single main lever (torsion-lever type). The location of a section is defined by a vertical plane passing through the midpoints of its load knife-edges. Sections are designated as 1, 2, 3, etc., being numbered from the left to the right of an observer at the weigh-beam facing the scale deck.

A test run comprises normal positions of the test load assumed when each pair of wheels of the truck is successively positioned over each section of the scale (except at each end section, where only one truck position is possible), except that in the case of a two-section scale an additional position is utilized with the center of the truck midway between the sections, a position designated as "Center." Sectional positions are designated as 1R, 2L, 2R, 3L, etc., the number denoting the section and the letter denoting that the body of the truck lies to the right or to the left of the section. Any position offset from a normal position is designated by its distance to the right (+) or to the left (−) of the nearest normal position; thus the position 1R+10" is 10 inches to the right of position 1R.

3. *Method of test.*—The normal test consists of test runs made with loads of 40,000 pounds and 80,000 pounds, two runs in opposite directions being made with each load. For a scale to which is attached an automatic indicating or recording device, tests are made with the device attached and with the device detached.

4. *Character of error.*—The amount by which the scale indication differs from the actual value of the applied test load is the error of the scale for the given position and load. A plus (+) sign denotes that the weight indication exceeds the value of the test load; a minus (−) sign denotes the converse.

5. *Maximum indicated percentage error of weighing.*—The "maximum indicated percentage error of weighing" is computed for scales of more than two sections, and is the largest mean value which can be derived from two errors developed during a single test run for positions (1) not closer together than the distance between adjacent sections on all scales except those in grain-weighing service or (2) farther apart than the distance between adjacent sections on all scales in grain-weighing service.

6. *Tolerances.*—I. The tolerances adopted by the Bureau for all railway track scales not equipped with automatic indicating or recording devices and for these latter scales while such devices are detached, are as follows:

A. The maintenance tolerance (applicable to scales in use) for all scales except those in grain-weighing service, is ± 0.20 percent of the test load being utilized, applied as follows:

(1) For a scale of more than two sections, to the maximum indicated percentage error of weighing as defined above, but with the added requirement that no individual sectional error shall exceed 0.30 percent of the test load being utilized.

(2) For a scale of more than two sections, to the maximum individual percentage error developed when two or more test loads are applied to the scale at the same time at normal positions not closer together than the distance between adjacent sections.

(3) For a two-section scale, to the maximum individual percentage error developed for any position of the test load or loads.

B. The maintenance tolerance (applicable to scales in use) for scales in grain-weighing service is ± 0.10 percent of the test load being utilized, applied as follows:

(1) For a scale of more than two sections, to the maximum indicated percentage error of weighing as defined above.

(2) For a scale of more than two sections, to the maximum individual percentage error developed when two or more test loads are applied to the scale at the same time and at normal positions which are farther apart than the distance between adjacent sections.

(3) For a two-section scale, to the maximum individual percentage error developed for any position of the test load or loads.

NOTE.—The tolerance for scales in grain-weighing service was adopted pursuant to the recommendations of the Interstate Commerce Commission (Docket No. 9009; 56 ICC 347). These recommendations also contain a provision that a scale shall be corrected whenever a test discloses an error in excess of 0.10 percent for any position of a test load; this provision will be adhered to by the Bureau in its recommendations.

C. The acceptance and adjustment tolerance (applicable to new or newly reconditioned scales) for all scales is ± 0.05 percent of the test load being utilized, applied to the maximum individual percentage error developed for any position of the test load.

II. The tolerances adopted by the Bureau for all railway track scales in which are embodied or to which are attached automatic indicating or recording devices, for the respective types of scales and conditions of test, are the same as those for scales independent of such devices, except as follows:

A. If the weight is indicated on a reading face, or by means of a printed impression showing the position of an indicating line with reference to a series of graduations, the maintenance tolerance shall not be less than the value of the minimum graduation on the reading face or printed impression, or of one five-hundredth of the capacity of the automatic device, whichever is the smaller value, and the acceptance and adjustment tolerance shall not be less than one-half the minimum specified for the maintenance tolerance.

B. If the weight indication is a printed record comprising figures only, there shall be added to the tolerance which would otherwise be appropriate, an amount equal to 50 percent of the value of the increment between indications that can be printed by the device, or 50 pounds, whichever value is the smaller.

7. *Sensibility reciprocal.*—The term sensibility reciprocal, or SR, is defined as the amount of weight required to move the position of equilibrium of the weighbeam or other indicating device of the scale a definite amount at the capacity or at any lesser load. Except as is provided below for a scale equipped with a multiplying balance indicator, the SR for a scale provided with a weighbeam and trig loop is the change in load on the weighrails required to move the weighbeam from a position of equilibrium at the center of the trig loop to a position of equilibrium at the top or at the bottom of the trig loop.

For a scale equipped with a multiplying indicator cooperating with a single balance-indicating or "zero" graduation, the SR is the change in load required to move the indicator from its position of equilibrium when the scale is in proper balance to a position of equilibrium such that there is a clear interval of $\frac{1}{4}$ inch between adjacent edges of the indicator and of the graduation; for a scale equipped with a similar indicator but cooperating with a series of graduations which do not directly indicate weight values, the SR shall be as defined above, or the specified movement shall be increased to a value equal to one division on the graduated scale if this value is greater than that first specified.

NOTE.—SR requirements are not applicable to scales equipped with automatic indicating or recording devices when such devices are attached.

The maximum SR values allowable, as adopted by the Bureau, are as follows:

A. For scales in use: For all scales except those in grain-weighing service, 100 pounds; for scales in grain-weighing service, 50 pounds.

B. For all new or newly reconditioned scales, 50 pounds.

