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# National Bureau of Standards

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Letter
Circular
LC 537

December 2, 1938



RAILWAY TRACK SCALE TESTING SERVICE

OF THE

NATIONAL BUREAU OF STANDARDS

FISCAL YEAR 1938 (JULY 1, 1937 to JUNE 30, 1938)

Letter
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# RAILWAY TRACK SCALE TESTING SERVICE OF THE NATIONAL BUREAU OF STANDARDS FISCAL YEAR, 1938

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INTRODUCTION

This report on the Railway Track Scale Testing Service of the National Bureau of Standards for Fiscal Year 1938 is one of a series of annual reports on this subject issued by the Bureau. The purpose of these reports is to set out for the stated fiscal year, conditions existing in respect to facilities for the weighing of commodities in carload lots throughout the United States, and to related matters. The reports contain a variety of pertinent data collected by the Bureau, which serve to summarize these conditions during the period covered by the report. Thus these reports are of primary interest to railroads which assess charges for the transportation of commodities determined by weights taken on railway track scales, to shippers or consignees who pay these charges, and finally to industries which maintain railway track scales for their own purposes, such as the determination of weights for the purchase and sale of commodities or for manufacturing processes. Other agencies concerned include weighing and inspection bureaus, boards of trade, State and local weights and measures officials, and manufacturers of weighing equipment.

The concern of the National Bureau of Standards in the subject is in the establishment of a standard for the testing of railway track scales, which may be maintained uniformly throughout the United States, and in the improvement of the accuracy of the scales in use and of weights which are determined on them. The service which is furnished by the Bureau in this connection has been set out in considerable detail in former reports of this series, and in other publications. For convenience, the summary utilized in last year's report may be repeated here, as follows:

"(a) Calibration of master track scales

Scales which are designed for and employed in the standardization of railway track scale test-weight cars are denominated master track scales. The cars so standardized, as their name implies, are used as standard weights in the test and adjustment of railway track scales. There are, in all, 19 master track scales, located in various parts of the United States. The National Bureau of Standards operates three railway track scale testing equipments, two of which are especially designed for the calibration of these master scales. 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 are so planned that one of the equipments will visit each of the master scales at approximately yearly intervals. Thus each master scale in the country is regularly calibrated 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

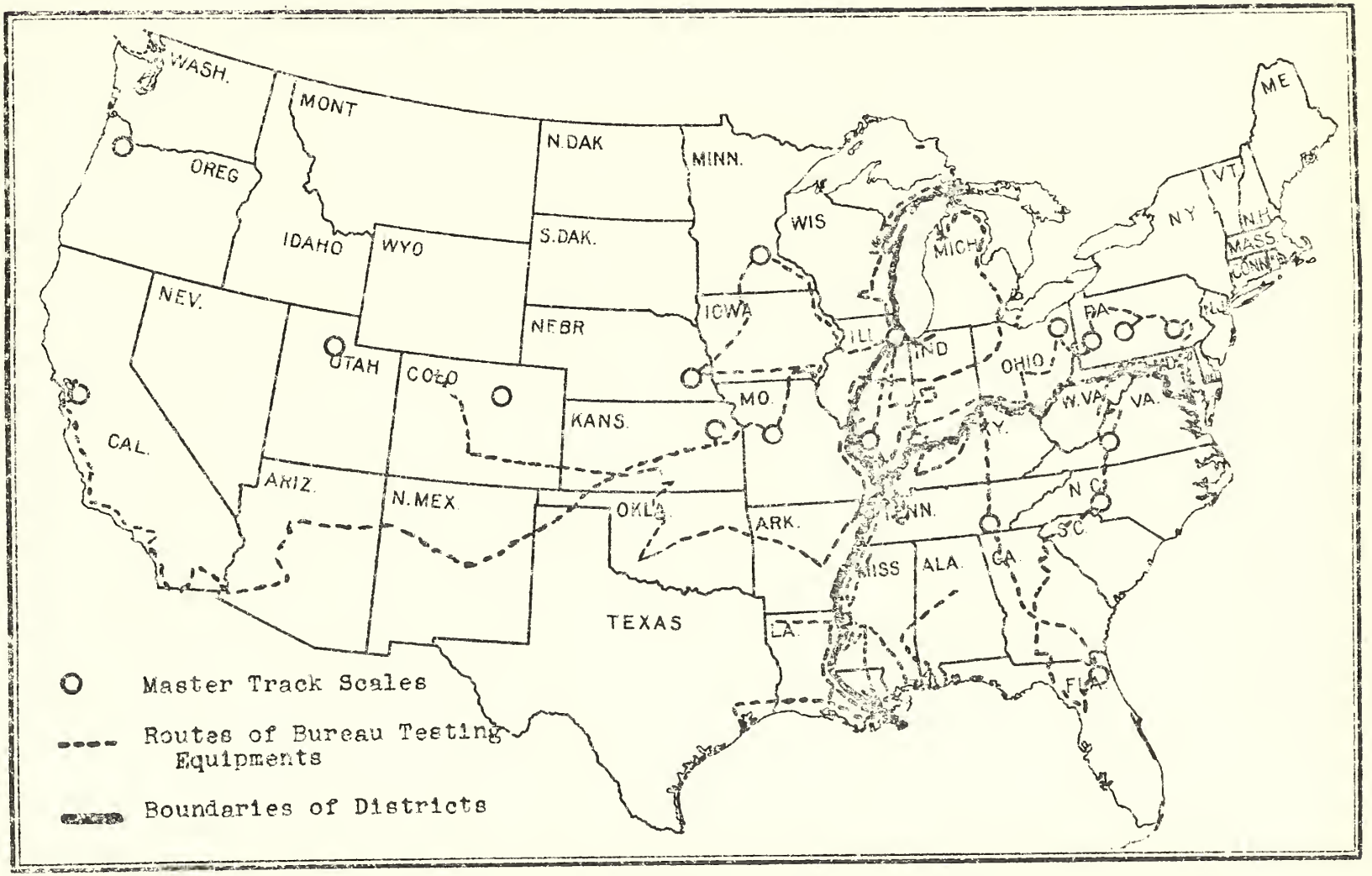
The itineraries of the Bureau track scale testing equipments are so prepared that from time to time the equipments travel on the lines of all the important railroads of the country and many of the shorter lines as well; care is taken to insure that a movement is not duplicated until after a satisfactory interval has elapsed. 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 prevailing 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."

In order to make the data presented in this report of maximum value, scales will usually be found to be divided into two groups, denominated "railroad-owned" and "industry-owned", sometimes shortened to "railroad" and "industry", respectively. "Railroad-owned" scales are those owned by common carriers; in the great majority of instances they are used by them primarily or solely 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 adopt these weights as the basis for the purchase and sale of the commodity transported. All scales not falling in the category of "railroad-owned" are included in the group denominated "industry-owned". As the term suggests, these scales are usually owned by industries, although a very few owned by others, such as by Federal, State, or local governments, are included. Scales in this group are largely utilized for determining weights for the purchase or sale of commodities; a small percentage of these scales are employed in manufacturing operations. Finally, when there is an agreement to this effect, weights ascertained on industry-owned scales may be accepted by the railroads as the basis for assessment of freight charges.

A geographical classification of scales will also be found to be adopted in this report; thus scales will be grouped by districts, denominated the Eastern, the Southern, and the Western. They are those adopted by the Interstate Commerce Commission in its publication, "Reports on the Statistics of Railways in the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W.VA.
VA.
PA.
N.Y.
ME
VT.
N.H.
MASS.
Master Track Scales
Routes of Bureau Testing Equipments
Boundaries of Districts

United States." The heavy lines shown on the map on the preceding page are the boundaries of the districts. The Commission has also been followed in its decisions respecting the assignment of the various roads to the several districts. The map is also utilized to give some additional information: The dotted lines represent the routes followed during fiscal year 1938 by the three testing equipments operated by the Bureau; the circles indicate the location of master track scales throughout the country.

## AGREEMENT IN REGARD TO MOVEMENT OF RAILWAY TRACK SCALE TESTING EQUIPMENT OF THE BUREAU

Very shortly after the first railway track scale testing equipment of the National Bureau of Standards was acquired and put into service, an agreement in relation to movement of the equipment was negotiated between the American Railway Association and the Bureau. This was issued as Circular 1599 of the American Railway Association, dated November 1, 1915, and it has been in force and effect ever since that date.

During the year the terms of the agreement were reviewed under the auspices of the General Committee of the Operating-Transportation Division, Operations and Maintenance Department, Association of American Railroads, and that Committee at its meeting held May 17, 1938, approved a revision of Circular 1599, which was entirely satisfactory to the Bureau. This is known as Circular No. 9 of the Association of American Railroads, and is dated May 19, 1938. By its terms the arrangement between the Bureau and the Association for handling of the testing equipment of the Bureau is as follows:

"1. The Bureau will test each Master Scale (and other scales used as Master Scales) at least once in every twelve months.

"2. In consideration of the benefits derived from the testing of Master Scales, member roads will move the test equipment free of charge to and from such scales, such movements to be made by advance arrangement with the interested roads through the Association.

"3. When the equipment used in testing Master Scales can be utilized for testing other railroad or industrial scales without interfering with the itinerary established for testing Master Scales, such utilization may be arranged between any individual road and the Bureau representatives in charge of the equipment. There will be no charge for such usage of the equipment unless it involves a road haul movement requested by an industry or by the Bureau, not covered by the itinerary, in which case the regular tariff charge for such additional road haul movement will be made.

"4. Utilization of testing equipment No. 3 will be arranged through the Association of American Railroads and its itinerary will be published by that Association, no charge being made for movements covered thereby.

"5. Test equipment will be moved only on freight or mixed trains. There will be no sleeping accommodations on the test equipment nor will any representative of the Bureau accompany it unless mutually agreed between an individual road and the Bureau.

"6. In case of damage to the test equipment, for which a railroad is responsible, settlement will be made for the car itself under the M.C.B. Rules."

## RÉSUMÉ OF TESTING ACTIVITIES

During the fiscal year 1938, the National Bureau of Standards made 16 calibrations of 15 master track scales, one scale being calibrated on two occasions. There were performed 52 standardizations involving 35 railway track scale test-weight cars, on the Bureau master scale at Clearing, and 22 additional test cars were weighed in the field. Eleven hundred and sixty railway track scales were tested by the equipments of the Bureau, these scales being located on the lines of some 104 railroads, in 29 States.

## MASTER TRACK SCALE CALIBRATION METHOD AND TOLERANCES

Many of the readers of this report -- probably a considerable majority -- are thoroughly familiar with the methods used by the Bureau in the calibration of master track scales and in the inspection, test, and reporting of railway track scales. However, some readers will not be cognizant of these things and it is felt that this report will be of more value to such readers if some information along these lines is furnished before the results are detailed. It is for this reason that the following material, relating to the calibration of master scales and taken from last year's report, is included. At a later point similar material in relation to the testing of railway track scales will be found.

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

"(1) A preliminary maintenance test with two runs made in appropriate directions with loads of 40,000, 60,000, and 80,000 pounds, applied at five 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' tolerances specified for this test, which are 8.4, 10.4, and 12 pounds, respectively, at the test loads stated above. These tolerances range from approximately two one-hundredths of one percent (0.02%) of the 40,000-pound load to fifteen one-thousandths of one percent (0.015%) of the 80,000-pound load.

"(2) An adjustment test with loads of 30,000, 40,000, 50,000, 60,000, 70,000, and 80,000 pounds, applied in the same manner and at the same designated positions as in the maintenance test. 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' tolerances specified. For corresponding loads, these tolerances are one-half the maintenance tolerances; appropriate tolerance values are added for test loads of 30,000, 50,000, and 70,000 pounds. When the performance of a scale on the maintenance test is within the allowable adjustment tolerances 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 weighbeam at half and full weighbeam capacity, made while the scale is under an 80,000-pound load, to determine the accuracy of the weighbeam indications.

"(4) 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.

"(5) An inspection of the scale to determine the level and alinement of parts and the general maintenance conditions. The inspection may or may not precede the adjustment test."

MASTER TRACK SCALE CALIBRATIONS

The purpose of the calibration of master track scales by the National Bureau of Standards is to establish and maintain accurate standards to be used by the carriers and by governmental agencies for adjusting to standard mass the railway track scale test-weight cars which, in turn, are used for the testing of railway track scales in commercial service.

There has been no change in the number or location of the scales which are recognized as master track scales in the United States, during the period covered by this report. There are 19 of these scales in all; 16 are owned by steam railways, 2 are owned by State governments, and one is owned by the National Bureau of Standards.

During the year 16 calibrations were made of 15 master track scales; one scale was calibrated twice. In the case of 14 of the 16 calibrations, the scales as encountered were found to be within adjustment tolerances. However, it appeared desirable to make adjustments, or modifications and adjustments, in the case of 3 of these scales. Two scales were found not to be within the adjustment tolerance as encountered; one of these was within the

maintenance tolerance on all observations and the other failed to meet this tolerance only in the case of a single observation. Adjustments were made on the first and modifications and adjustments were made on the second of these scales. As left, all master scales were accurate within the adjustment tolerance at all test loads and positions.

Ten counterpoise weights used with master scales were found not to be within tolerance when independently tested against standards of the Bureau, but the amounts by which their errors exceeded the tolerance were in all cases small; for instance, the error of some weights was found to be only 0.1 grain in excess of the tolerance.

In relation to the frequency of calibrations of master scales, it was pointed out last year that while a somewhat longer average period than 12 months -- which is the length of time which it is desired to realize -- had been elapsing between calibrations, nevertheless the average periods were being shortened and further efforts would be made to calibrate these scales more frequently. The progress made this year toward this end may be noted. Sixteen calibrations were made this year. The average period elapsing since the last former calibrations by the Bureau in these cases was a little less than 14 1/2 months; last year the equivalent period was 17 1/4 months. Thus the period elapsing has been very materially decreased and is now not very seriously in excess of one year. In the case of the four master scales not calibrated this year, the average period elapsing between the date of the latest calibration and the end of the present fiscal year (June 30, 1938) was about 12 3/4 months. The corresponding period last year was 13 1/2 months. Since the master scales not tested during the present fiscal year are scheduled for test early in the coming year, the average period between calibrations in the case of these scales, also, will not seriously exceed 12 months.

The master track scales in the United States are in an excellent condition of accuracy and maintenance.

## RAILWAY TRACK SCALE TEST METHOD AND TOLERANCES

The test of a railway track scale as conducted by the National Bureau of Standards 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 accurate or inaccurate 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.

## RAILWAY TRACK SCALE TESTS

There will be found in Table 1, which will follow, a summary of the railway track scale test data for fiscal year 1938. The data are arranged in the customary form. The number of scales tested, the number and percentage within tolerance and not within tolerance, and the mean numerical error -- percent of applied load --have been tabulated for railroad-owned, industry-owned, and total scales, for each district -- Eastern, Southern, and Western -- and for the country as a whole.

TABLE 1. SUMMARY OF RAILWAY TRACK SCALE TEST DATA

FISCAL YEAR 1938

| 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 | 178 | 139 | 78.1 | 39 | 21.9 | 0.20 |
| Industry | 185 | 140 | 75.7 | 45 | 24.3 | 0.18 |
| Totals | 363 | 279 | 76.9 | 84 | 23.1 | 0.19 |
| SOUTHERN | | | | | | |
| Railroad | 141 | 113 | 80.1 | 28 | 19.9 | 0.18 |
| Industry | 138 | 117 | 84.8 | 21 | 15.2 | 0.16 |
| Totals | 279 | 230 | 82.4 | 49 | 17.6 | 0.17 |
| WESTERN | | | | | | |
| Railroad | 273 | 238 | 87.2 | 35 | 12.8 | 0.14 |
| Industry | 245 | 193 | 78.8 | 52 | 21.2 | 0.17 |
| Totals | 518 | 431 | 83.2 | 87 | 16.8 | 0.15 |
| ALL DISTRICTS | | | | | | |
| Railroad | 592 | 490 | 82.8 | 102 | 17.2 | 0.17 |
| Industry | 568 | 450 | 79.2 | 118 | 20.8 | 0.17 |
| GRAND TOTALS | 1160 | 940 | 81.0 | 220 | 19.0 | 0.17 |
| 1937 Totals | 1071 | 806 | 75.3 | 265 | 24.7 | 0.20 |

Discussion of Test Data. Of the 1160 scales tested, 51 percent were railroad-owned and 49 percent were industry-owned scales. The distribution was 31 percent in the Eastern District, 24 percent in the Southern District, and 45 percent in the Western District.

A brief résumé of the data and a comparison with results found in fiscal year 1937 may be made. It is disclosed then, in general, that 81.0 percent of all railway track scales tested during the year were accurate; last year the corresponding figure was 75.3 percent. This rise of 5.7 percent is a very satisfactory one and seems definitely to demonstrate that the moderate upturn of 2.2 percent noted last year was, in fact, a significant reversal of the decline which had been noted for the three years preceding last year. But in another respect the accuracy figure is still more noteworthy. It is the highest percentage of accuracy of all scales tested in any fiscal year, which has been achieved since the investigation of railway track scales was inaugurated by the Bureau some twenty-five years ago. The figure eclipses -- by the very small margin of 0.4 percent -- the previous high of 80.6 percent recorded in 1933.

Turning now to a consideration of the two groups of scales included in the above figures, it is found that of 592 railroad-owned scales tested, the percentage found accurate was 82.8 percent, and of 568 industry-owned scales, 79.2 percent. Comparing these with the figures reported last year, a small decline is noted in the percentage for railroad-owned scales, 0.9 percent, from the figure of 83.7 percent; on the other hand the percentage for industry-owned scales rises very sharply, the increase being 13.5 percent, from 65.7 percent.

In last year's report it was brought out that the general increase then found was due to a very material improvement in railroad-owned scales -- 5.6 percent -- which was sufficient more than to overcome a small decline in industry-owned scales -- 1.7 percent. This year the situation is reversed; the great improvement in accuracy of industry-owned scales results in the substantial advance noted in general accuracy despite a small falling off in the figure for railroad-owned scales. This year's figure for percentage accuracy of railroad-owned scales remains near the peak; the corresponding figure has been higher in only two preceding fiscal years, in 1934 when the figure was 84.4 percent and last year when the figure was 83.7 percent as noted above. This year's figure for percentage accuracy of industry-owned scales has been bettered in only one preceding year, in 1933 when 81.1 percent were accurate.

A brief résumé of percentages found accurate by districts, and a comparison with the results of the preceding year indicate that in the Eastern District 78.1 percent of the railroad-owned scales were found accurate, this representing a rather serious decrease of 5.3 percent from the excellent percentage of 83.4

percent reported last year. On the contrary the figure of 75.7 percent reported for industry-owned scales is very much higher -- 10.7 percent -- than the former figure of 65.0 percent. The figure for all scales improves 2.8 percent, from 74.1 percent to 76.9 percent.

In the Southern District, 80.1 percent of the railroad-owned scales were found to be accurate; the equivalent figure last year was 75.9 percent; the improvement is 4.2 percent, a substantial one. The percentage of industry-owned scales found accurate in the South shows the tremendous increase of 26.0 percent, from 58.8 percent to 84.8 percent. This figure for industry-owned scales is higher than the corresponding figures for the other districts and is, in fact, the highest for either class of scale in any district with the single exception of railroad-owned scales in the West. Whether the figure is reasonably representative of the industry-owned scales in this district is problematical; it does appear that the distribution of industry scales by railroads was not as representative as usual. In any event, it may be said that the figure is a very commendable one. The figure for the percentage accuracy of all scales in the Southern District is 82.4 percent, an improvement of 15.1 percent over last year's figure of 67.3 percent.

In the Western District, 87.2 percent of the railroad-owned scales tested were found to be accurate; while this figure is again found to be off slightly -- this time 1.0 percent from the 88.2 percent reported in 1937 -- it is still an excellent one. The percentage for industry-owned scales is 78.8 percent, 5.0 percent higher than the 73.8 percent reported last year. The general percentage accuracy for all scales tested -- 83.2 percent -- is not substantially different from last year's figure.

In the above, the figures considered are those representing the percentages of scales tested that were found to be within tolerance. Another excellent criterion of the accuracy being attained, is the information contained in the last column of Table 1, "Mean numerical error -- percent of applied load."

The mean numerical error for all railroad-owned scales tested is found to be 0.17 percent. This same error is computed for all industry-owned scales, and thus for all scales. Comparing this figure with those reported last year it is found that the mean error of railroad-owned scales has suffered an increase of 0.03 percent from 0.14 percent; the mean error on industry-owned scales has been tremendously reduced -- by 0.10 percent, from 0.27 percent; the mean error on all scales is substantially smaller, the reduction being 0.03 percent, from 0.20 percent. The mean error of all scales tested in any preceding fiscal year has never been found to be smaller than the figure reported this year; the low of 0.17 percent which was reached first in 1932 and which was repeated in 1933 and 1934, has now been regained. In relation to the figure for industry-owned scales, this has been bettered in only one preceding year, namely, in 1933, when it was 0.16 percent.

In the Eastern District the mean error is 0.20 percent for railroad-owned scales, 0.18 percent for industry-owned scales, and 0.19 percent for all scales. The corresponding figures for fiscal year 1937 were 0.14 percent, 0.30 percent, and 0.22 percent, respectively. Thus this year's figure for railroad-owned scales is not nearly so satisfactory, while that for industry-owned scales has very greatly improved over last year's figure.

In the Southern District the mean error for railroad-owned scales is 0.18 percent, for industry-owned scales 0.16 percent, for all scales 0.17 percent. Last year the corresponding figures reported for the three groups were 0.17 percent, 0.25 percent, and 0.21 percent, respectively. Thus this year the railroad-owned scales are found to be very slightly less accurate, the industry-owned scales make a tremendous advance in accuracy, and the figure for all is substantially improved. The figure for industry-owned scales is the best for this class in any of the three districts. This is in line with the high percentage of industry scales found accurate in this district.

Finally, the figures for mean errors in the Western District are as follows: 0.14 percent for railroad-owned scales, 0.17 percent for industry-owned scales, and 0.15 percent for all scales. The comparable figures for fiscal year 1937 were 0.13 percent, 0.20 percent, and 0.15 percent. It is indicated that the railroad-owned scales have decreased in accuracy very slightly and the industry-owned scales have improved, while the figure for all scales remains unchanged. It may be noted that the figures for railroad-owned scales and for total scales tested, are better than those computed for the other districts.

There were 30 roads upon which 5 or more railroad-owned track scales were tested this year, the number of scales tested ranging from 5 to 51. On 5 of these roads, or 17 percent of the total number, 100 percent of the railroad-owned scales tested were found to be within tolerance, the remaining roads having percentages of accuracy varying from 95 percent to 20 percent. Last year (fiscal year 1937), 5 or more railroad-owned track scales were tested on 47 roads, and on 22 of these, or 47 percent of the total number, 100 percent of the railroad-owned scales were found accurate. It will thus be seen that the number and percentage of roads found to be maintaining a 100-percent standard of accuracy has fallen off very sharply this year, from 22 roads to 5 roads, and from 47 percent to 17 percent, respectively.

Of the 22 roads upon each of which no railroad-owned scale of those tested in fiscal year 1937 was found to be inaccurate, 11 again appear on this year's list. Of these 11 roads maintaining a 100-percent standard of accuracy in 1937, only 4 are found in this category again this year; on the other 7 roads one or more scales were found inaccurate. On the other hand, only one road not having a 100-percent record in 1937 has improved its percentage accuracy to 100 percent this year. Seven roads are on this

year's list which were not represented last year; upon none of these roads were 100 percent of the scales tested found accurate.

There are 23 railroads upon which 5 or more railway track scales were tested by the Bureau in both fiscal years 1937 and 1938. For purposes of comparison there may now be considered the mean numerical percentage errors of the scales on these 23 roads. Thirteen roads, or 57 percent, show an increase in mean error this year as compared with last year, the mean increase being 0.09 percent (eliminating one road having the very abnormal increase in mean error of 0.71 percent, the mean increase is reduced to 0.03 percent). Upon 7 roads, or 30 percent, the mean error is found to be reduced by 0.04 percent. In the case of 3 roads the mean error is unchanged.

Four railroads upon which five or more railroad-owned railway track scales were tested in 1938, or 13 percent of the 30 roads represented in the list, are found to have a mean numerical percentage error of scales tested of not more than 0.10 percent, or not more than one-half the tolerance. Twenty additional roads, or 80 percent in all, have mean errors of not more than 0.20 percent; 6 roads, or 20 percent, have mean errors ranging from 0.21 percent to 0.78 percent (upon this last road 7 out of 9 scales, or 78 percent of those tested, were accurate, the excessive mean percentage error resulting from one scale having an error so large as to destroy the validity of the mean). The corresponding percentages last year were 49 percent, 83 percent, and 17 percent. It is thus apparent that on the lines upon which a representative amount of work was done in each of the two years, the mean percentage errors are somewhat greater this year than was the case last year.

## TEST DATA SUBDIVIDED BY CLASSES OF RAILROADS

It has been said earlier in this report that the Bureau equipments made tests on the lines of 104 railroads. It may again be said that the figure representing the number of roads is a somewhat arbitrary one. While in the majority of cases the facts speak for themselves and no difficulty is encountered, yet there are other cases in which judgment must be exercised in deciding whether or not a particular road should be considered as an entity.

In the last two preceding reports of this series, for the purpose of presentation of data, the various roads visited were divided into "classes" adopted by the Interstate Commerce Commission; this will again be done, in accordance with information contained in the publication "Statistics of Railways in the United States, 1936". Electric lines, and steam roads which for some reason were not classified by the Interstate Commerce Commission, have been assigned to the "Not Classified" group. The test data for all railroad-owned scales have been assembled to summarize the conditions found to exist on these several classes of railways. This information will be found in Table 2. It may be noted that

upon several of the roads visited no railroad-owned scales were tested, the work being confined to industry-owned scales.

TABLE 2. TEST DATA SUBDIVIDED BY RAILROADS

OF VARIOUS CLASSES - FISCAL YEAR 1938

| Classification of railroads | Number of railroads | 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. | 61 | 542 | 457 | 84.3 | 85 | 15.7 | 0.16 |
| CLASSES II & III EXCEPT S.& T. | 14 | 20 | 12 | 60.0 | 8 | 40.0 | 0.24 |
| SWITCHING AND TERMINAL | 21 | 19 | 14 | 73.7 | 5 | 26.3 | 0.16 |
| NOT CLASSIFIED | 8 | 11 | 7 | 63.6 | 4 | 36.4 | 0.46 |
| TOTALS | 104 | 592 | 490 | 82.8 | 102 | 17.2 | 0.17 |

Discussion of Data. The table indicates that in respect to accuracy of railroad-owned scales, Class I railroads lead the other classes shown, 84 percent of the scales tested on these lines having been found to be within tolerance, with a mean numerical error of 0.16 percent; however, roads in the Switching and Terminal group are not far behind, with 74 percent found within tolerance, and a mean error identical with that found for Class I railroads. The similarity of results for these two classes is not surprising since the Switching and Terminal roads are often subsidiary to one or more Class I railroads and the scales owned by the former may be tested as adequately and as frequently and may receive the same character of maintenance as those of the latter. The condition of the scales noted above is considerably better than of those located on railroads of Classes II and III; only 60 percent of the scales on lines in this group were found accurate, and the mean error was 0.24 percent. Sixty-four percent of the scales on roads included in the "Not Classified" group were accurate and the mean error was 0.46 percent, but these data are not of much significance.

In general, the data found this year conform to figures formerly reported in this connection, with surprising fidelity.

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

In Table 3 certain data have been assembled and so arranged as to make it easy to compare the quality of performance of railroad-owned scales and industry-owned scales, over a period of 15 years.

TABLE 3. RELATIVE QUALITY OF PERFORMANCE OF RAILROAD-OWNED AND INDUSTRY-OWNED TRACK SCALES

| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|
| Year | Percentage of scales tested found within tolerance | | Difference (2)-(3) | Mean numerical error -- percent of applied load | | Difference (6)-(5) |
| | Railroad | Industry | | Railroad | Industry | |
| 1924 | 57.9 | 54.3 | +3.6 | 0.36 | 0.36 | 0.00 |
| 1925 | 67.2 | 63.3 | +3.9 | 0.28 | 0.25 | -0.03 |
| 1926 | 66.9 | 64.1 | +2.8 | 0.26 | 0.22 | -0.04 |
| 1927 | 72.0 | 68.1 | +3.9 | 0.20 | 0.22 | +0.02 |
| 1928 | 73.9 | 63.5 | +10.4 | 0.23 | 0.24 | +0.01 |
| 1929 | 74.0 | 68.4 | +5.6 | 0.19 | 0.21 | +0.02 |
| 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 |

Review of Subject. In general it will be observed that the percentages of railroad-owned scales found within tolerance have been higher than in the case of industry-owned scales and that the mean percentage errors of the former group have been smaller. While in 1933 the industry-owned scales were superior -- albeit by almost negligible amounts -- in reference to each criterion, nevertheless from 1934 to 1936, railroad-owned scales were definitely more accurate, and in 1937 the superiority of the railroad-owned group was greater than in any fiscal year since the Bureau track scale testing service was inaugurated. This year, however, the very great improvement in industry-owned scales described earlier in this report, combined with a moderate decline in accuracy of railroad-owned scales, has practically cancelled the differences between the two groups; the difference in the percentages of scales which passed the tolerance is only 3.6 percent, while the mean errors of both groups are identical.

SCALES AT COAL MINES

Three years ago the Bureau reported that special attention would be given to the inclusion in the itineraries of the several equipments, of industry-owned scales located at coal mines, since it was felt that these scales, as a class, were particularly in need of service. This plan was carried out. For the last two years the Bureau has been specially reporting the condition of this class of scales. Again this year a number of coal-mine scales have been tested and while this number is not as great as in fiscal year 1936 or 1937, nevertheless it may be of interest again to note the conditions found. Accordingly in Table 4 there have been arranged test data in this connection. Since this project has now continued over a period of three years, the results for this period are also presented in the table to facilitate comparisons. Table 4 follows:

TABLE 4. TEST DATA ON RAILWAY TRACK SCALES AT COAL MINES AND OTHER INDUSTRY-OWNED SCALES -- FISCAL YEAR 1938 AND SUMMARY

| District and period | INDUSTRY SCALES AT COAL MINES | | | | INDUSTRY OTHER THAN COAL-MINE SCALES | | | |
|---|---|---|---|---|---|---|---|---|
| | Number tested | Number accurate | Percent accurate | Mean percent error | Number tested | Number accurate | Percent accurate | Mean percent error |
| EASTERN | | | | | | | | |
| 1938 | 23 | 16 | 70 | 0.22 | 162 | 124 | 77 | 0.18 |
| 1936-1938 inclusive | 137 | 75 | 55 | 0.37 | 541 | 394 | 73 | 0.22 |
| SOUTHERN | | | | | | | | |
| 1938 | 19 | 11 | 58 | 0.29 | 119 | 106 | 89 | 0.14 |
| 1936-1938 inclusive | 68 | 31 | 46 | 0.36 | 329 | 236 | 72 | 0.22 |
| WESTERN | | | | | | | | |
| 1938 | 19 | 15 | 79 | 0.21 | 226 | 178 | 79 | 0.17 |
| 1936-1938 inclusive | 103 | 65 | 63 | 0.29[1] | 471 | 369 | 78 | 0.18 |
| ALL DISTRICTS | | | | | | | | |
| 1938 | 61 | 42 | 69 | 0.24 | 507 | 408 | 80 | 0.16 |
| 1936-1938 inclusive | 308 | 171 | 56 | 0.34[1] | 1341 | 999 | 74 | 0.21 |

[1] Excluding one scale having abnormal error

Discussion of Subject. During the last three years about 19 percent of all tests on industry-owned scales have been made on scales located at coal mines, and it is estimated that more than 50 percent of all of the scales in this latter class throughout the country have been tested in this period.

It has been noted in the reports for the past two years that since scales located at coal mines were very much less accurate than

industry scales utilized for other purposes, the inclusion of a larger percentage of coal-mine scales had had the effect of somewhat reducing the accuracy figures for industry scales as compared with years in which fewer coal-mine scales were tested. It may be said that the inclusion of coal-mine scales this year has had very little effect on general averages, in part because these scales form a smaller percentage of the total number of industry scales tested, and in part because the discrepancy found this year between the condition of coal-mine scales and of industry scales devoted to other purposes is smaller than formerly.

The coal-mine scales tested this year were in better condition than those tested in 1936 and in 1937. While this may be significant, nevertheless it is not believed that too much reliance should be placed on this nor that conclusions may safely be drawn as to progressive changes in accuracy of these scales as a class, as has been done in these reports in the case of total scales, railroad-owned scales, and industry-owned scales. The work on coal-mine scales in each of the three years has involved different fields, and, to a large degree, different railroads; also the number of mine scales tested in any year has necessarily not been a large one. Thus the figure for any year can only be generally representative of the class as a whole. Perhaps a better criterion of the condition of coal-mine scales will be obtained by combining the figures for the last three years and using the results as representative of the conditions existing in the period in question. Such figures have been included in the preceding table.

It will be noted that only 56 percent of the coal-mine scales tested in the last three years were accurate and that the mean error of all of these scales was 0.34 percent. These figures are very much less satisfactory than those found for industry-owned scales employed for other purposes, for of these 74 percent were accurate and the mean error was 0.21 percent.

Considering the figures by districts, the scales in the Western District were better than those in the Eastern and Southern Districts. The Eastern District was somewhat better than the Southern District insofar as percentage of scale found accurate was concerned, the percentagesbeing 55 percent and 46 percent, respectively; however, in respect to mean errors the two districts were almost identical. In each district the figures for coal-mine scales were very much less satisfactory than for other scales of the industry group.

It is indicated that these scales as a class, are seriously in need of corrective measures directed to the improvement of their accuracy.

SCALES IN GRAIN-WEIGHING SERVICE

As has been noted earlier in this report, there is applicable to scales in grain-weighing service a special tolerance of ±0.10 percent, this being a recommendation made by the Interstate Commerce Commission in Docket 9009. Accordingly it has been customary in these reports to examine into the compliance of this class of scales with this special tolerance.

Briefly to review certain results reported some years ago, it may be said that in fiscal year 1923, of a total of 32 grain scales tested, only 2, or 6.2 percent, were found within the special grain-scale tolerance, the mean numerical error of all being 0.40 percent. During the next five years, the percentage found accurate gradually rose until it was 59.2 percent of 54 grain scales tested in 1928. The annual figures for the last ten years are shown in Table 5, which follows:

TABLE 5. 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 | |
| 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 |
| 1937 | 40 | 21 | 52.5 | 19 | 47.5 | 0.16 |
| 1938 | 105 | 68 | 64.8 | 37 | 35.2 | 0.12 |

Review of Subject. It will be noted that during the year 105 grain scales were tested. This number has been exceeded in only one preceding fiscal year. As in the case of industry scales in general, the condition of this class of scales shows a substantial improvement over the conditions noted in 1937 and 1936. This year 64.8 percent were found in compliance with the special tolerance as compared with 52.5 percent and 50.5 percent in the two preceding years. The mean error was also very considerably reduced; it is 0.12 percent, as compared with 0.16 percent. It is gratifying to note that the figure for the percentage found accurate is higher than it has been before except in one preceding year, and that the figure for mean numerical error equals the best figure heretofore found.

If there be applied to the grain scales tested this year the usual tolerance for ordinary commercial track scales, a direct comparison of the accuracy of grain scales and other industry scales will be possible. On the basis of this criterion 85.7 percent of the grain scales were within the tolerance and the mean numerical error was 0.13 percent. For industry scales other than grain scales the corresponding figures were 77.8 percent and 0.18 percent. From the above it may be concluded that while scales in grain-weighing service are somewhat more accurate than other industry-owned scales, nevertheless the average grain scale fails to meet the applicable requirements, while the average industry scale used for other purposes conforms to the tolerances applicable to such scales. Moreover the data in Table 5 do not indicate that there has been any very marked sustained betterment of conditions in the period elapsing since 1931 or 1932. There are both a need and an opportunity for improvement in the accuracy of scales in grain-weighing service.

## IMPROVEMENT OF ACCURACY OF SCALES

The National Bureau of Standards tests railway track scales for the purpose of determining conditions existing throughout the country and presents each year a comprehensive and unbiased picture of these conditions, to the end that improvement may be effected. Obviously the small number of the equipments operated by the Bureau, the tremendous territory which must be covered each year to reach each of the master track scales in service, and the necessity of testing a number of scales sufficient to make the yearly results representative, all combine to make it impracticable for the Bureau itself to do a great deal directly to improve these conditions. In general, owners and private testing agencies must be relied upon for this.

However, the Bureau does not overlook any opportunity to increase the number of accurate scales in service and it does upon occasion reduce the errors on accurate scales, when these objects can be accomplished without decreasing the effectiveness of the work in other regards. Especially when a scale is found upon test to be inaccurate, it is highly desirable that its weighing error be reduced as soon as possible and if this can be done at once by the Bureau representative in charge of the testing equipment, the

procedure is efficient and the contribution toward improvement of conditions is worth while. Consequently upon occasion the Bureau, at the request of the owner, will undertake to make minor corrections and to adjust scales, either or both, to decrease their weighing error. However, the Bureau believes that such work should be attempted only upon scales the errors of which are due wholly to faulty adjustment or to slight mechanical faults which can readily be remedied. Very frequently faulty mechanical conditions which cannot readily be corrected, primarily cause or seriously contribute toward the error of a scale. In such a case it is felt that the Bureau should make no attempt to adjust the scale. It is indefensible to endeavor by adjustment to overcome an error which is caused by a mechanical fault. While no permanent improvement will thus be effected, the owner, relying upon the supposition of improved accuracy, may be tempted to postpone repairs which should be made, to the eventual detriment of the installation. The above facts should be borne in mind when the following figures are considered.

During the year 175 railway track scales were the subject of adjustment, of the correction of slight mechanical faults, or of both these measures. It resulted that 87 scales, originally inaccurate, were found to be accurate upon retest, 87 scales originally accurate, were left with a smaller error than before, and 1 scale, originally inaccurate, had a reduced error.

Table 6, which follows, summarizes the condition of all railroad-owned and industry-owned scales as they were encountered by the Bureau and as they were left following the Bureau test.

TABLE 6. SUMMARY OF CONDITION OF RAILWAY TRACK SCALES AS ENCOUNTERED AND AFTER ADJUSTMENTS AND CORRECTIONS MADE FISCAL YEAR 1938

| Scale Ownership | Number of scales tested | Within tolerance | | Not within tolerance | | Mean numerical error -- percent of applied load |
|---|---|---|---|---|---|---|
| | | Number | Percent | Number | Percent | |
| RAILROAD | | | | | | |
| As found | 592 | 490 | 82.8 | 102 | 17.2 | 0.17 |
| As left | 592 | 546 | 92.2 | 46 | 7.8 | 0.12 |
| INDUSTRY | | | | | | |
| As found | 568 | 450 | 79.2 | 118 | 20.8 | 0.17 |
| As left | 568 | 481 | 84.7 | 87 | 15.3 | 0.15 |
| TOTALS | | | | | | |
| As found | 1160 | 940 | 81.0 | 220 | 19.0 | 0.17 |
| As left | 1160 | 1027 | 88.5 | 133 | 11.5 | 0.13 |

## ANALYSIS OF ERRORS OF INACCURATE SCALES

As has been noted heretofore, 220 scales tested during the year were found not to be within the allowable tolerance. An analysis of the errors of these scales is made in Table 7, which will follow. The data are arranged in the usual form. The railroad-owned and industry-owned scales are grouped by districts, and totals are also given. The total numbers of inaccurate scales and the mean numerical percentage errors are shown, following which the various data are separately presented for those scales having errors in excess (+) and for those having errors in deficiency (-).

TABLE 7. ANALYSIS OF ERRORS OF INACCURATE SCALES

FISCAL YEAR 1938

| District and scale ownership | Total number of inaccurate scales | Mean numerical error -- percent of applied load | Errors in excess (+) | | | Errors in deficiency (-) | | |
|---|---|---|---|---|---|---|---|---|
| | | | Number of scales | Percent of inaccurate scales | Mean numerical percentage error | Number of scales | Percent of inaccurate scales | Mean numerical percentage error |
| EASTERN | | | | | | | | |
| Railroad | 39 | 0.55 | 22 | 56.4 | 0.32 | 17 | 43.6 | 0.86 |
| Industry | 45 | 0.41 | 16 | 35.6 | 0.28 | 29 | 64.4 | 0.48 |
| Totals | 84 | 0.48 | 38 | 45.2 | 0.30 | 46 | 54.8 | 0.62 |
| SOUTHERN | | | | | | | | |
| Railroad | 28 | 0.49 | 17 | 60.7 | 0.41 | 11 | 39.3 | 0.61 |
| Industry | 21 | 0.49 | 6 | 28.6 | 0.30 | 15 | 71.4 | 0.56 |
| Totals | 49 | 0.49 | 23 | 46.9 | 0.39 | 26 | 53.1 | 0.58 |
| WESTERN | | | | | | | | |
| Railroad | 35 | 0.45 | 21 | 60.0 | 0.40 | 14 | 40.0 | 0.54 |
| Industry | 52 | 0.44 | 23 | 44.2 | 0.33 | 29 | 55.8 | 0.52 |
| Totals | 87 | 0.44 | 44 | 50.6 | 0.36 | 43 | 49.4 | 0.53 |
| ALL DISTRICTS | | | | | | | | |
| Railroad | 102 | 0.50 | 60 | 58.8 | 0.38 | 42 | 41.2 | 0.69 |
| Industry | 118 | 0.44 | 45 | 38.1 | 0.31 | 73 | 61.9 | 0.51 |
| GRAND TOTALS | 220 | 0.47 | 105 | 47.7 | 0.35 | 115 | 52.3 | 0.58 |
| 1937 Totals | 265 | 0.52 | 160 | 60.4 | 0.45 | 105 | 39.6 | 0.63 |

The mean numerical percentage error of inaccurate railroad-owned scales was found to be 0.50 percent, an increase of 0.11 percent over last year's mean error of 0.39 percent. On the contrary the inaccurate industry-owned scales had a considerably smaller mean error than last year, the two figures being 0.44 percent and 0.58 percent, respectively. The mean error on all inaccurate scales was 0.47 percent; last year the corresponding figure was 0.52 percent. About 48 percent of the scales found inaccurate had errors in excess, and 52 percent had errors in deficiency, a remarkably even distribution. The mean error on the scales having plus errors was 0.35 percent; the mean error on the scales having minus errors was, as usual, a larger figure, 0.58 percent. Both of these means were smaller than were found last year.

ERROR FREQUENCY DISTRIBUTION

Data have been arranged in Table 8 to disclose the frequency distribution of the errors developed on railway track scales tested during fiscal year 1938. The figures for the railroad-owned group and for the industry-owned group are shown for each district and for the country as a whole. This table follows:

TABLE 8. FREQUENCY DISTRIBUTION OF RAILWAY TRACK SCALE ERRORS -- FISCAL YEAR 1938

| Errors -- percent of applied load | EASTERN DISTRICT | | SOUTHERN DISTRICT | | WESTERN DISTRICT | | ALL DISTRICTS | |
|---|---|---|---|---|---|---|---|---|
| | Railroad 178 scales | Industry 185 scales | Railroad 141 scales | Industry 138 scales | Railroad 273 scales | Industry 245 scales | Railroad 592 scales | Industry 568 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 |
| Accurate scales | | | | | | | | |
| 0.00 to 0.05 incl. | 12.9 | 14.1 | 22.7 | 11.6 | 31.9 | 20.0 | 24.0 | 16.0 |
| 0.06 to 0.10 " | 36.5 | 23.8 | 29.1 | 41.3 | 29.3 | 33.4 | 31.4 | 32.2 |
| 0.11 to 0.15 " | 16.9 | 18.9 | 19.1 | 18.8 | 16.5 | 11.9 | 17.2 | 15.9 |
| 0.16 to 0.20 " | 11.8 | 18.9 | 9.2 | 13.1 | 9.5 | 13.5 | 10.2 | 15.1 |
| Inaccurate scales | | | | | | | | |
| 0.21 to 0.25 incl. | 7.9 | 5.4 | 1.4 | 2.9 | 2.9 | 6.1 | 4.0 | 5.1 |
| 0.26 to 0.30 " | 3.9 | 5.4 | 4.3 | 1.5 | 2.2 | 4.1 | 3.2 | 3.9 |
| 0.31 to 0.35 " | 2.3 | 6.4 | 3.6 | 2.2 | 1.8 | 2.1 | 2.4 | 3.5 |
| 0.36 to 0.40 " | 2.2 | 1.1 | 3.5 | 2.2 | 1.1 | 2.0 | 2.0 | 1.8 |
| 0.41 to 0.45 " | 1.1 | 1.1 | 1.4 | 2.2 | 0.8 | 1.2 | 1.0 | 1.4 |
| 0.46 to 0.50 " | 0.0 | 1.1 | 0.7 | 1.4 | 1.1 | 0.8 | 0.7 | 1.0 |
| 0.51 to 1.00 " | 3.4 | 2.7 | 4.3 | 1.4 | 1.8 | 2.9 | 2.9 | 2.5 |
| Over 1.00 | 1.1 | 1.1 | 0.7 | 1.4 | 1.1 | 2.0 | 1.0 | 1.6 |
| Mean numerical errors | | | | | | | | |
| Accurate scales | 0.10 | 0.11 | 0.10 | 0.11 | 0.09 | 0.10 | 0.09 | 0.10 |
| Inaccurate scales | 0.55 | 0.41 | 0.49 | 0.49 | 0.45 | 0.44 | 0.50 | 0.44 |
| All scales | 0.22 | 0.18 | 0.18 | 0.16 | 0.14 | 0.17 | 0.17 | 0.17 |
| Mean errors, 1937 | | | | | | | | |
| All scales | 0.14 | 0.30 | 0.17 | 0.25 | 0.13 | 0.20 | 0.14 | 0.27 |

Discussion of Data. The preceding table discloses that 55.4 percent of all railroad-owned scales were accurate within ±0.10 percent, one-half the allowable tolerance; 48.2 percent of the industry-owned scales were in this category. This is a very slightly better record than that found in the preceding year as to railroad-owned scales; the figure for industry-owned scales shows a great improvement over last year's figure, which was 36.5 percent. When the records for the individual districts are considered, the highest figure (61.2 percent) is found on the railroad-owned group in the Western District; the lowest figure (37.9 percent) represents the condition of industry-owned scales in the Eastern District. The most substantial gains over the figures for fiscal year 1937 are registered in the Southern District. Here 51.8 percent for railroad-owned scales represents an advance of 16.8 percent over the former figure of 35 percent; the industry-owned group is bettered by 24.7 percent, from 28.2 percent to 52.9 percent.

Turning now to the opposite end of the table, it will be noted that the percentage of scales seriously in error is larger this year than was the case last year for railroad-owned scales, the corresponding figures for scales in error by more than 0.50 percent being 3.9 percent and 2.6 percent; the reverse is the case for industry-owned scales, the 1938 and 1937 figures for this class being 4.1 percent and 11.5 percent, representing a sharp decrease.

When the individual districts are considered, it is found that the percentage of railroad-owned scales seriously inaccurate increases in the Eastern District by 2.3 percent, in the Southern District by 1.4 percent, while the figure in the Western District remains unchanged. The improvement in the industry-owned scales is shared by each of the three districts; thus the figures decrease in the Eastern, Southern, and Western Districts by 10.1 percent, 6.6 percent, and 0.9 percent, respectively.

The foregoing does much to explain the increase in mean error on railroad-owned scales of 0.03 percent and the decrease in mean error on industry-owned scales of 0.10 percent, noted earlier in this report.

## 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 9. 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 9. STANDARDIZATION OF RAILWAY TRACK SCALE TEST-WEIGHT CARS ON NATIONAL BUREAU OF STANDARDS MASTER TRACK SCALE, CLEARING, ILLINOIS -- FISCAL YEAR 1938

| Designation of test car | Bureau Report No. | Nominal weight in pounds | Period since last preceding standardization in months | Error in pounds | |
|---|---|---|---|---|---|
| | | | | (Plus) | (Minus) |
| A | 505 | 92 500 | 6 | | 44* |
| | 532 | | 5 | 54* | |
| | 553 | | 5 | 28 | |
| (B) | 506 | 40 000 | 24 | | 4 |
| (C) | 507 | 80 000 | 24 | | 7 |
| D | 508 | 61 400 | 1 | | 62* |
| | 522 | | 4 | 9* | |
| | 537 | | 3 | 12* | |
| | 552 | | 3 | | 36* |
| E | 509 | 75 000 | 2 | | 210* |
| | 529 | | 4 | 283* | |
| | 541 | | 3 | 13* | |
| | 554 | | 3 | | 45* |
| (F) | 510 | 80 000 | 11 | 24* | |
| | 542 | | 8 | 21 | |
| G | 511 | 60 000 | 5 | | 42 |
| (H) | 512 | 80 000 | 11 | | 11 |
| | 545 | | 8 | | 11* |
| I | 513 | 80 000 | 9 | | 113* |
| J | 514 | 80 000 | 9 | 107* | |
| (K) | 515 | 83 000 | 13 | | 362* |
| L | 516 | 60 000 | 7 | | 52* |
| | 548 | | 6 | 40* | |
| M | 517 | 80 000 | 6 | 33 | |
| | 549 | | 7 | | 147* |

TABLE 9 (Continued)

| Designation of test car | Bureau Report No. | Nominal weight in pounds | Period since last preceding standardization in months | Error in pounds (Plus) | Error in pounds (Minus) |
|---|---|---|---|---|---|
| (N) | 518 | 80 000 | 10 | | 6 |
| (O) | 519 | 40 000 | 5 | | 2 |
| (P) | 520 | 80 000 | 5 | 29* | |
| (Q) | 521 | 80 000 | 4 | 19* | |
| | 538 | | 4 | | 39* |
| (R) | 523 | 80 000 | 12 | | 19* |
| (S) | 524 | 80 000 | 5 | 9 | |
| | 544 | | 5 | 10* | |
| T | 525 | 60 000 | 12 | 69* | |
| (U) | 526 | 80 000 | 13 | | 24* |
| V | 527 | 50 000 | 12 | 61* | |
| W | 528 | 60 000 | 12 | 48* | |
| X | 530 | 53 600 | 6 | | 4 |
| (Y) | 531 | 61 600 | 5 | 73* | |
| | 555 | | 6 | | 29 |
| (Z) | 533 | 30 000 | 7 | 14* | |
| (AA) | 534 | 80 000 | 14 | | 26* |
| (BB) | 535 | 30 000 | 7 | | 8* |
| | 556 | | 5 | | 14 |
| CC | 536 | 60 000 | 10 | | 16 |
| | 551 | | 3 | | 4* |
| DD | 539 | 80 000 | - | 6 | |
| (EE) | 540 | 80 000 | 12 | | 174* |
| FF | 543 | 50 000 | 69 | 12 | |
| (GG) | 546 | 80 000 | 12 | | 88* |
| (HH) | 547 | 80 000 | 10 | | 4* |
| (II) | 550 | 80 300 | 33 | 3* | |
| 35 cars | 52 standardizations | | | 23 heavy | 29 light |
| 1937 | | | | | |
| 31 cars | 58 standardizations | | | 20 heavy | 1 zero 37 light |

Summary of Standardization Results. During the year 35 railway track scale test-weight cars were submitted for standardization one or more times on the National Bureau of Standards Master Track Scale at Clearing, Ill. In all, 52 standardizations of these cars were made. The total number of standardizations was 6 less than was the case last year, although 4 more cars were standardized. The cars involved ranged in nominal weight from 30,000 pounds to 92,500 pounds; 20 of them are considered as conforming to modern specifications in essential respects.

One car submitted this year had not formerly been standardized by the Bureau. As to the others, the periods elapsing since the date of the last preceding standardization on the Bureau master scale range from a minimum of 1 month to a maximum of 69 months. The periods were 6 months or less in 25 cases and between 6 months and 12 months in 19 cases; 7 cars had not been standardized for more than 12 months.

Omitting one car not standardized for more than 5 years, the average period elapsing since the last preceding standardization was 8.3 months. Twenty-three of the cars were submitted only once during the year, 9 cars were standardized twice each, 1 car 3 times, and 2 cars 4 times. On the whole, cars were not submitted as frequently as was the case last year and a greater average period elapsed since prior standardization.

As submitted, 23 cars were heavier while 29 were lighter than their nominal weight.

Fifteen cars were submitted which, so far as it was ascertained, had not been repaired since their last preceding standardization by the Bureau. Five of these averaged 21 pounds heavy and 10 averaged 14 pounds light; all had a mean numerical error of 16 pounds. Of these cars, 9 were "specification" cars and 6 were "non-specification" cars. The mean numerical error on the former class was 11 pounds, on the latter class 22 pounds, although in general longer periods had elapsed since the last preceding standardization in the case of the cars of the former class. While these data are so meagre that it is considered that it would not be safe to draw any firm conclusion from them, it is probably significant that they bear out former conclusions reached in relation to the relative stability of these two types of cars.

## WEIGHING OF TEST-WEIGHT CARS IN THE FIELD

The previous subdivision indicates that there are a large number of railway track scale test-weight cars accessible to the Bureau master track scale at Clearing and that many cars are regularly calibrated there. However, it will be understood that it cannot be expected that the great majority of the test-weight cars in the country will be submitted for calibration at Clearing because the hauls involved would be too long and too expensive.

Probably the majority of the short-wheel base test-weight cars in use which are not calibrated at Clearing are calibrated

on some other master track scale to which they are accessible. However, there are a number of short-wheel base test-weight cars which operate in territories distant from a master scale and there are also many test-weight cars in use which are of too long a wheelbase to be accommodated on a regulation master scale. To assist in the maintenance of the accuracy of such cars the Bureau is always prepared to weigh them in the field by a method of substitution against standard loads on a satisfactory railway track scale under test. While it is not to be supposed that such a method will produce results as accurate as those obtained by calibration on a master scale, nevertheless when proper safeguards are observed, this method is a reasonable one.

The Bureau weighed 22 test-weight cars during the year in the manner outlined above. Four of these cars were found to be heavier than their nominal weight, 10 were light, while 8 were accurate within the degree inherent in the method employed. The cars found heavy had a mean error of 19 pounds, the mean error on the light cars was 62 pounds, and the mean numerical error of all cars, including those substantially accurate, was 32 pounds. Last year the corresponding error was 41 pounds.

DISTRIBUTION OF TESTS BY DISTRICTS

The Bureau tested in fiscal year 1938:

In All Districts

| | | | | | |
|---|---|---|---|---|---|
| 592 | or 17 | percent | of | some 3450 | railroad-owned scales |
| 568 | " 16 | " | " | " 3500 | industry-owned scales |
| 1160 | " 17 | " | " | " 6950 | total scales |

In Eastern District

| | | | | | |
|---|---|---|---|---|---|
| 178 | or 14 | percent | of | some 1300 | railroad-owned scales |
| 185 | " 13 | " | " | " 1400 | industry-owned scales |
| 363 | " 13 | " | " | " 2700 | total scales |

In Southern District

| | | | | | |
|---|---|---|---|---|---|
| 141 | or 19 | percent | of | some 750 | railroad-owned scales |
| 138 | " 18 | " | " | " 750 | industry-owned scales |
| 279 | " 19 | " | " | " 1500 | total scales |

In Western District

| | | | | | |
|---|---|---|---|---|---|
| 273 | or 20 | percent | of | some 1400 | railroad-owned scales |
| 245 | " 18 | " | " | " 1350 | industry-owned scales |
| 518 | " 19 | " | " | " 2750 | total scales |

A somewhat smaller percentage of the scales were tested in the Eastern District than in the other two districts. In the Western District the number of tests was somewhat increased on account of special requests for tests which caused a lengthening

of one of the planned itineraries. In any event the distribution this year is reasonable since last year the percentage of scales tested in the Eastern District was abnormally high.

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

In the annual report for fiscal year 1934 the Bureau announced that special efforts would thereafter be made in the planning of itineraries so to route the testing equipments that a maximum number of scales would be encountered which had not formerly been tested by the Bureau or which had not been tested by the Bureau for a considerable period of time. It was felt that by so doing the most equitable distribution of tests would be assured and anything in the nature of routine operation would be avoided. The ultimate desideratum was the eventual testing by the Bureau of practically all of the railway track scales in use in the United States.

Progress along these lines was reported in fiscal years 1936 and 1937. In the same connection, this year it may be noted that 22 percent of the railroad-owned scales tested had not heretofore been tested by the Bureau. The date of the last former test by the Bureau was 10 years or more ago for 17 percent of these scales, and 5 to 9 years ago for 26 percent.

In the case of the industry-owned scale group, the Bureau records as to former tests are complete only from July 1, 1928. Forty percent of the industry-owned scales tested this year do not appear on the records to have been formerly tested by the Bureau; 22 percent were last tested 5 or more years ago.

It will be apparent from the above that scales not formerly tested are rapidly being brought into the tested group. Although the present policy in relation to the routing of equipments will be continued in the future, the number in the not-formerly-tested category, encountered and tested in future fiscal years will necessarily decrease progressively, and it will not be long before a time arrives when only a small percentage of the total tests can be made on such scales. Proper distribution of tests will then be evidenced when scales not tested for five or more years constitute a large percentage of the scales tested; this year 65 percent of the railroad-owned scales and 62 percent of the industry-owned scales were in this category.

CONCLUSION

As each new annual report of the Railway Track Scale Testing Service of the National Bureau of Standards adds to the data formerly gathered the results obtained during an additional fiscal year, it seems worth while to review the results achieved in the period elapsing from the inauguration of the investigation. Over the years tremendous strides toward accuracy have been made. A brief résumé of these advances, by disclosing the magnitude of

the difficulties which have formerly been faced and overcome, should encourage owners of railway track scales and agencies interested in or charged with the maintenance and improvement of their condition, to consolidate the gains made and to press on toward higher ground.

This service of the Bureau was inaugurated in fiscal year 1914 but 1915 was the first complete fiscal year of operation. Consolidating the data of 1914-1915 it was found that only some 33 percent of all scales tested were within the tolerance; that is, two scales out of each three encountered proved to be inaccurate. The mean numerical percentage error of all scales tested was 0.57 percent, a figure almost three times the value of the tolerance. These were the original conditions which cried out for remedy and challenged the best efforts of those interested in accuracy of these facilities.

Year by year new data were gathered and reported. From these it was discerned that conditions were gradually improving despite the fact that the advances were somewhat erratic and seemed not to be consistently maintained. In retrospect it appears that this was in part at least due to the fact that the early figures were not so representative as those of later years. The numbers of scales tested at first was smaller and the tests were not so well distributed either geographically or by railroads. However, when the year 1922 was reached it was disclosed that some 48 percent of all scales tested were accurate; the mean numerical percentage error was 0.38 percent. Thus it was indicated that in a period of seven years there had been an increase in the percentage of accurate scales of some 15 percent, accompanied by a decrease in mean error of some 0.19 percent. This advance was certainly a substantial one. However, in 1922 less than half of the scales being encountered were accurate and the mean error was almost twice the tolerance.

Fiscal year 1922 was destined to mark a turning point in respect to the accuracy of railway track scales in the United States. In 1923 an improvement was noted and conditions continued materially to improve almost without interruption for eleven years -- until 1933, when a peak was realized. In that year 80.6 percent of the scales tested were found accurate with a mean numerical error for all of 0.17 percent. This was a far cry from the figures, set out above, found at the beginning of the Bureau's work in this field.

In fiscal year 1934 the effects of the depression which had been gripping the country became evident. For some time economy programs had been in effect; routine tests were being made less frequently by the testing agencies, maintenance measures were being severely curtailed, the replacement of scales was practically at a standstill. These things began to take their toll. For three successive years there was a downward trend in the figures published annually by the Bureau.

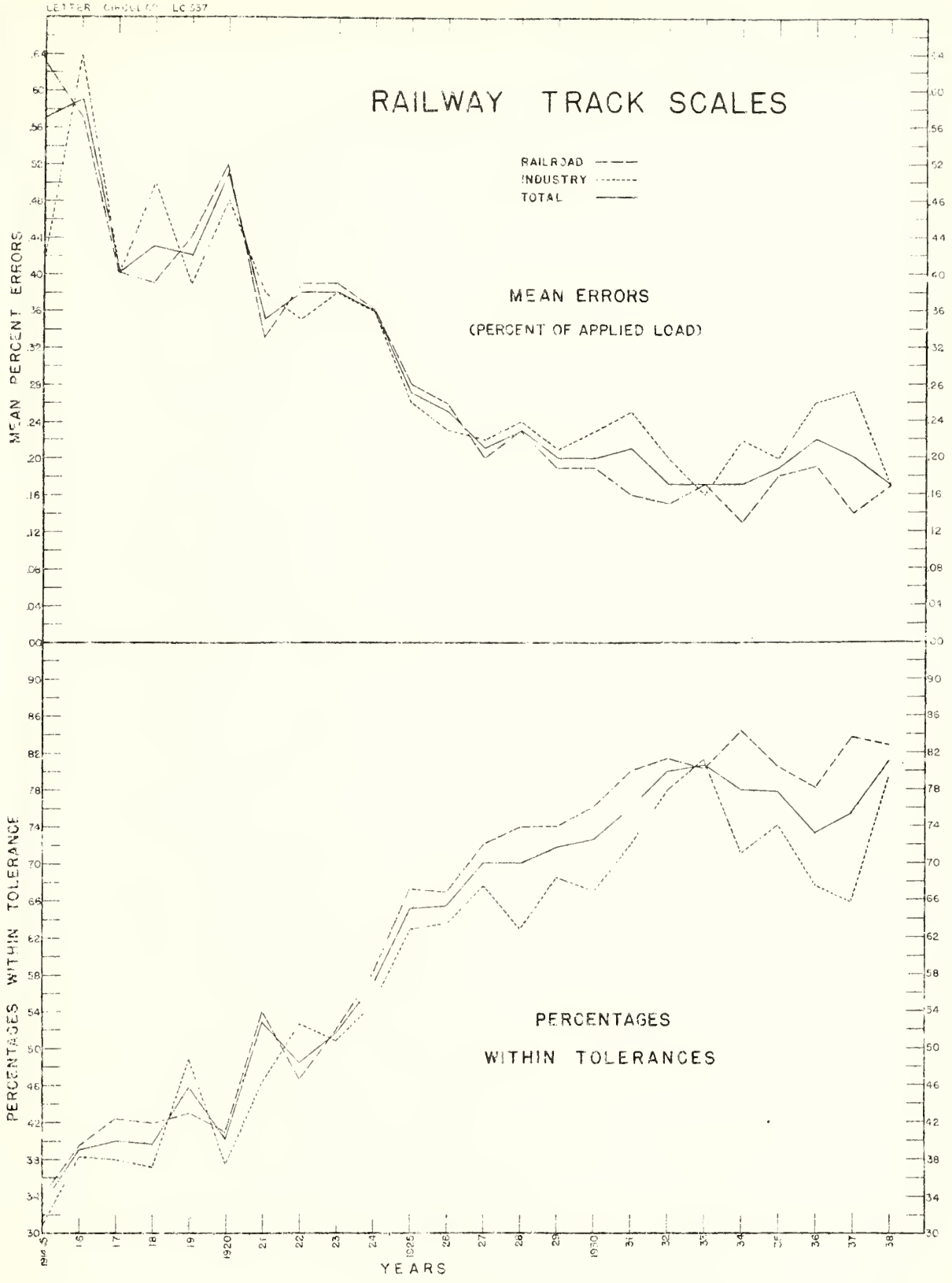
Last year the report gave occasion for renewed optimism since the downward trend was halted and the figures were better than those gathered in the preceding year for the first time since 1933. This year, as has been noted heretofore in this report, a still greater improvement is noted. Now the figure for percentage of tested scales found accurate is higher than in any preceding year and the figure representing the mean numerical error of all scales tested equals the best figure found heretofore.

The task which the owners of scales and agencies interested in their increased accuracy should set for themselves is the continuation of the present trend. This can only be accomplished, however, if proper measures can be pursued. Some suggestions along these lines have been made earlier in this report. Thus scales at coal mines furnish a fertile field of endeavor; the condition of these scales should be improved until they are brought abreast of other industry scales. Again scales in grain-weighing service should have some special attention in an endeavor to make these more generally comply with the more rigorous tolerance applicable to them. Finally all scales, both railroad-owned and industry-owned, must be adequately and frequently tested and they must be properly maintained; also, since even this attention will be insufficient to cause many obsolete or obsolescent scales to weigh accurately, steps should be taken looking to the retirement of such scales, and their replacement, when necessary.

If the measures outlined can be generally pursued there is no reason why the condition of the railway track scales throughout the country can not shortly be made better than ever before. The Bureau is not unmindful of the difficulties which will be encountered in putting such a program into effect at this time but it is strongly urged that the objective is worthy of the best efforts of the agencies concerned with the accuracy of railway track scales and of the weights determined thereon.

APPENDIX: GRAPHICAL REPRESENTATION OF CONDITIONS

On the following page there will be found graphs which present the results developed by the railway track scale testing service of the National Bureau of Standards for successive years from its inauguration to the present time. In the lower graph are plotted the percentages of railway track scales found to be within tolerance, in the upper the mean numerical percentage errors of the scales tested.


RAILWAY TRACK SCALES
RAILROAD
INDUSTRY
TOTAL
MEAN ERRORS
(PERCENT OF APPLIED LOAD)
MEAN PERCENT ERRORS
PERCENTAGES
WITHIN TOLERANCES
PERCENTAGES WITHIN TOLERANCE
YEARS