





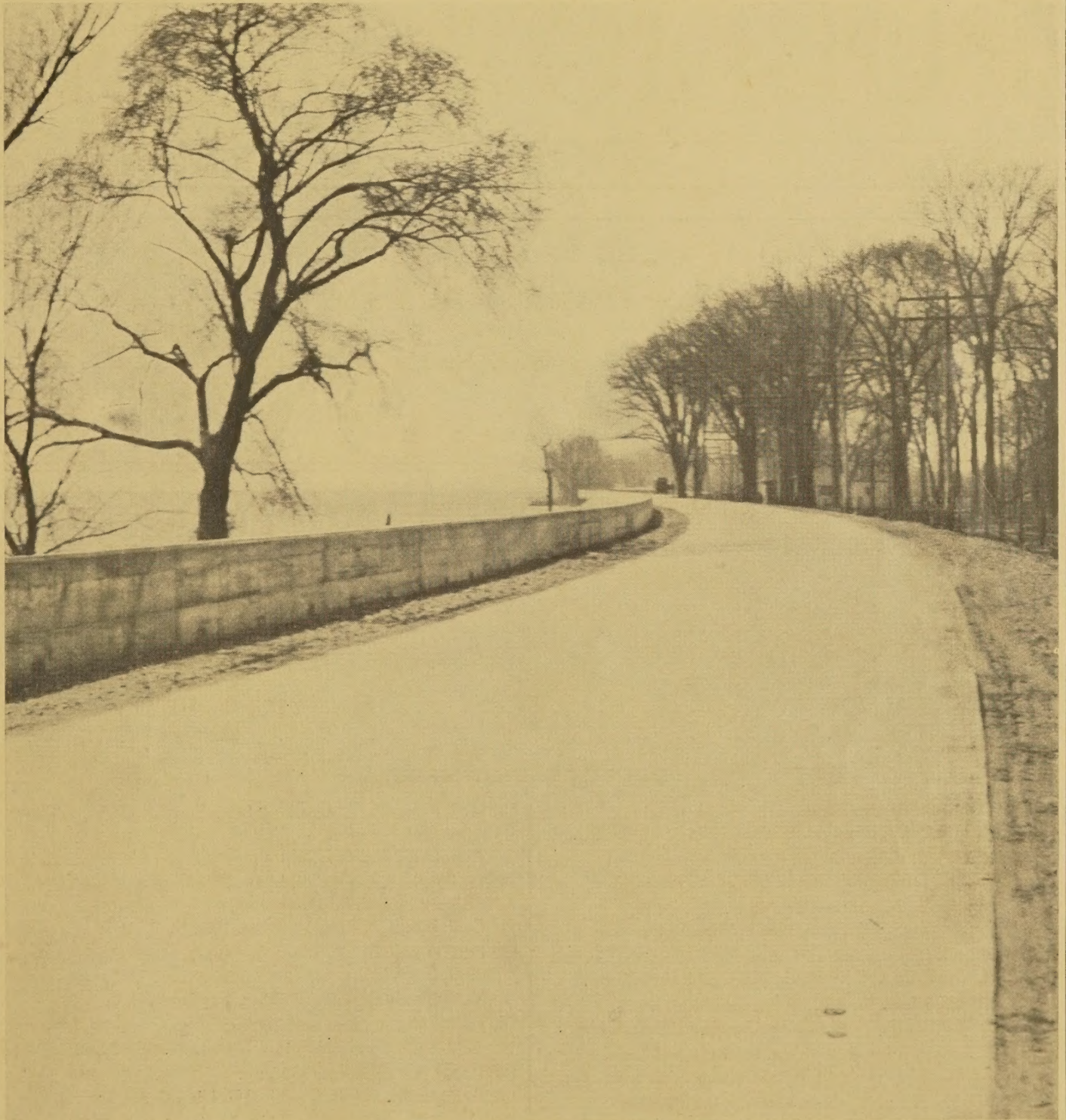
U.S. DEPARTMENT OF AGRICULTURE  
BUREAU OF PUBLIC ROADS

# Public Roads

VOL. 4, NO. 8

WASHINGTON, D. C.

DECEMBER, 1921



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U. S. DEPARTMENT OF AGRICULTURE  
BUREAU OF PUBLIC ROADS

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H. S. FAIRBANK, Editor

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## THE U. S. BUREAU OF PUBLIC ROADS

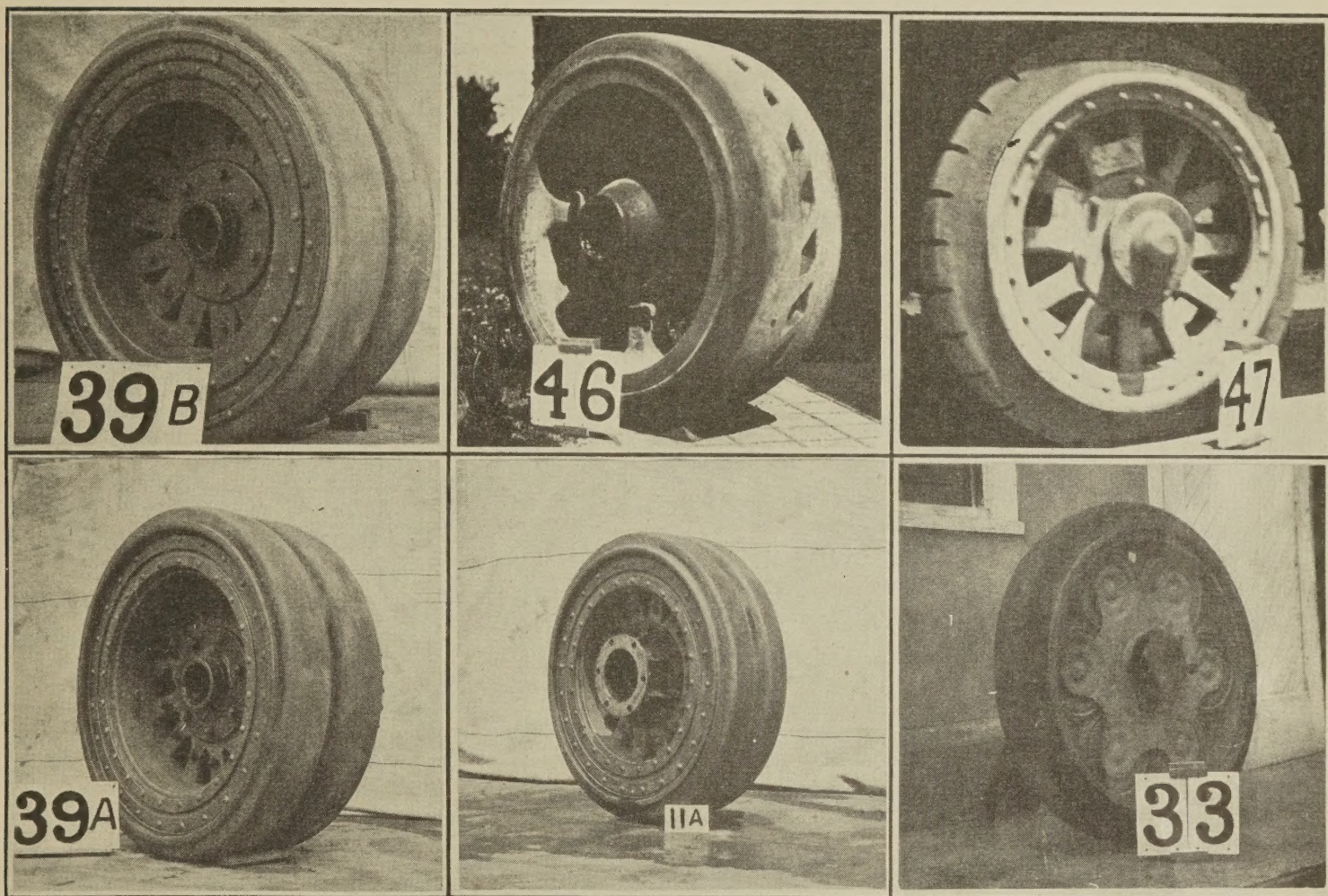
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# THE MOTOR TRUCK IMPACT TESTS OF THE BUREAU OF PUBLIC ROADS

By EARL B. SMITH, Senior Assistant Testing Engineer, Bureau of Public Roads



TYPES OF TIRES AND WHEELS USED IN THE EXPERIMENTS.

IN the former report<sup>1</sup> concerning the investigation of this subject the data and information aimed to show the magnitude of the impact forces developed by motor trucks passing over roads at different speeds and under different loading conditions. It was shown that the type of the truck, that is, whether it had a heavy or light unsprung weight, had considerable influence on the resulting impact. It was also shown that the type and condition of the tire had an even larger influence on the results. Most of the tires used in the former investigation were of solid rubber; these were compared with cushion tires and pneumatic tires, showing the cushioning effect of each and the relative impact forces resulting from the use of either type. Since the publication of the former report the investigation has been continued to include more cushion tires in comparison with solid rubber tires, and also a series of tests to determine the relative cushioning effect of different kinds of cushion wheels. The present report concerns

only the results of comparisons between solid rubber tires, cushion tires, and cushion wheels.

The copper cylinder method was used to measure the force of impact and the results are given in terms of the static load which will produce an equal deformation of a standard copper cylinder. The details of this method of measuring impact are given in the former report. Other details and methods of procedure were identical with those used in the former series of tests.

The curves and data shown in figure 1 give the static deformation values under different loadings for the different tires mounted on solid wheels and on cushion wheels. The photographs perhaps give a better idea as to the types of tires and wheels used.

The experimental data as obtained during the test for each different condition are shown in charts Nos. 134 to 207, inclusive. The sizes, weights, and loadings of various trucks used are shown in Table I. The tables under the graphical charts Nos. 134 to 207, inclusive, show the data and constants with reference to the charts above.

<sup>1</sup>The Motor Truck Impact Tests of the Bureau of Public Roads, Public Roads, March, 1921.

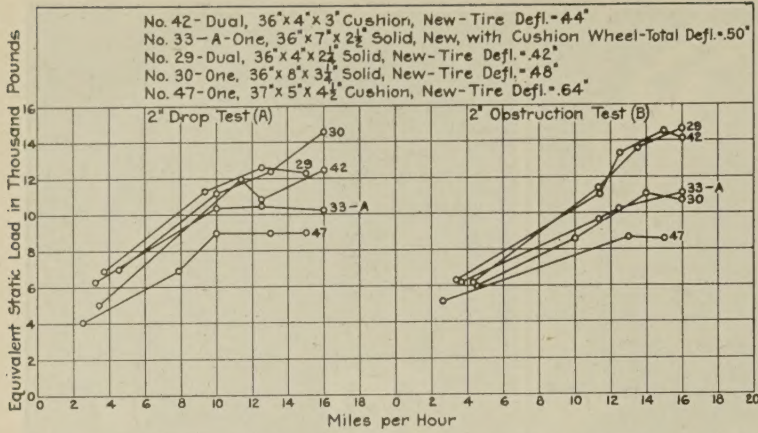


FIG. 2.—COMPARISON OF TIRES AND CUSHION WHEEL, 2-TON TRUCK A WITH 2-TON LOAD.

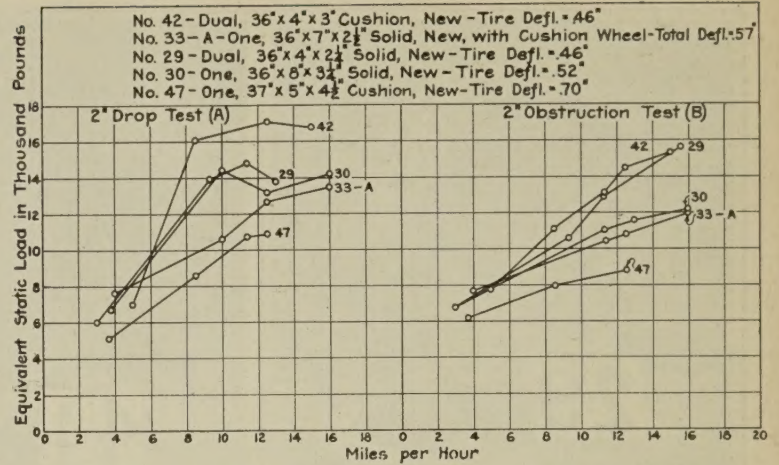


FIG. 3.—COMPARISON OF TIRES AND CUSHION WHEEL, 2-TON TRUCK A WITH 3-TON LOAD.

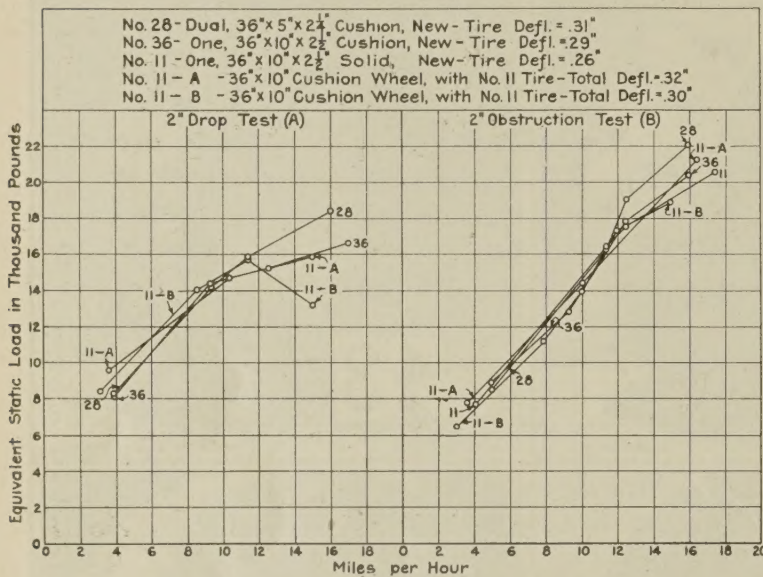


FIG. 4.—COMPARISON OF TIRES AND CUSHION WHEEL, 3-TON TRUCK P WITH 2½-TON LOAD.

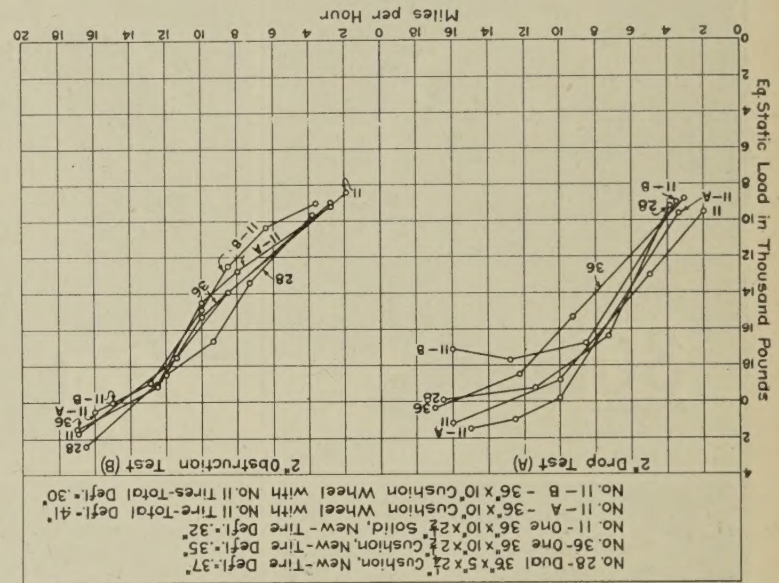


FIG. 5.—COMPARISON OF TIRES AND CUSHION WHEEL, 3-TON TRUCK P WITH 4½-TON LOAD.

TABLE 1.—Showing size, weights, and loadings of trucks.

Truck.	Rated capacity.	Empty weight.			Unsprung weight.		Distribution of load (cargo only).				Total sprung weight on 1 rear wheel (cargo and truck).	Spring deflection for total sprung weight.	Total load on road under 1 rear wheel.
		Total.	Front.	Rear.	On 2 rear wheels.	On 1 rear wheel.	Total weight.	To front axle.	To rear axle.	Per cent of load on rear axle.			
P	3-3½	9,500	3,800	5,700	3,400	1,700	2½	400	4,600	92	1,150	0.48	2,850
P	3-3½	9,500	3,800	5,700	3,400	1,700	4½	700	8,300	92	3,450	1.44	5,150
P	3-3½	9,500	3,800	5,700	3,400	1,700	4½	700	8,300	92	5,300	2.25	7,000
A	2	7,800	3,300	4,500	2,000	1,000	2	—100	4,100	102	1,250	1.02	2,250
A	2	7,800	3,300	4,500	2,000	1,000	2	—100	4,100	102	3,300	2.70	4,300
A	2	7,800	3,300	4,500	2,000	1,000	3	400	5,600	93	3,900	3.19	4,900
A	5	9,850	3,900	5,950	3,900	1,950	5	50	9,950	100	1,050	0.38	3,000
A	5	9,850	3,900	5,950	3,900	1,950	7½	—	15,150	100	5,950	2.12	7,900
A	5	9,850	3,900	5,950	3,900	1,950	7½	—	15,150	100	8,650	3.09	10,600
K	7½	15,000	5,180	9,820	3,000	1,500	7½	80	15,090	100	3,410	1.06	4,910
K	7½	15,000	5,180	9,820	3,000	1,500	7½	80	15,090	100	10,950	3.25	12,455
K	7½	15,000	5,180	9,820	3,000	1,500	10	150	20,650	103	13,235	3.86	14,735

**STATIC DEFORMATION OF TIRES A POSSIBLE MEASURE OF CUSHIONING VALUE.**

In figures 2 to 7, inclusive, are shown the impact forces delivered by the trucks under the different conditions and using the different tire and wheel equipment. The best cushioning effect and the least impact force developed in this series of tests was observed when using tire No. 47, figures 2 and 3. This was a new cushion tire, 36 by 5 inches, with a total depth of 4½

inches, and having a complete annular opening in the center of the tire. This tire, when tested under different static loads, showed almost uniform deflection in proportion to the loading, and a somewhat greater deflection than a pneumatic tire under the same static loading. Compared for cushioning effect under impact forces, other conditions being constant, the pneumatic tire was found to be much the better of the two.

It was observed in these tests that the deflection of different tires under different static loads was a fairly reliable indication of their cushioning effect under impact forces only when the tires compared were of the same type; that is, when comparing solid rubber tires with each other, or pneumatic tires with pneumatics. It is not a proper basis of comparison between solid rubber tires and pneumatic tires, probably for the reason that the deflection of the solid rubber tires is dependent largely upon the shape of the tire and the quality of the rubber, and that the resistance to deformation is not proportional to the loads applied, but increases at a greater rate than the increment of loading, thus causing an increase in the unit load on the rubber. The deflection of pneumatic tires is practically directly pro-

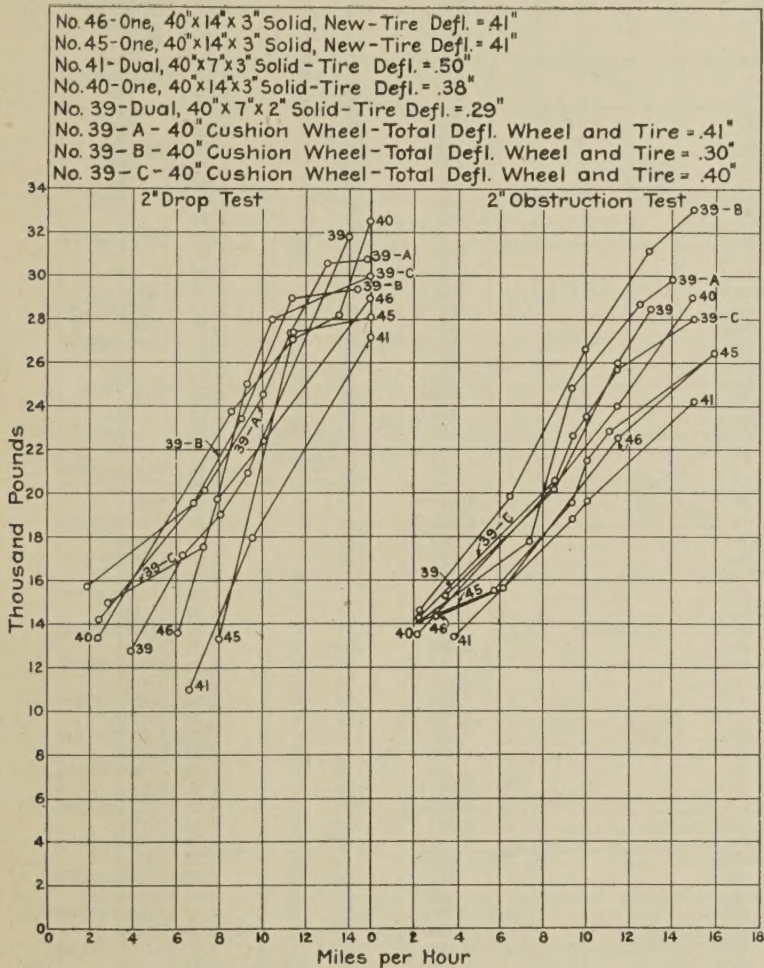


FIG. 6.—COMPARISON OF TIRES AND CUSHION WHEELS. 7½-TON TRUCK K WITH 2½-TON LOAD.

portional to the load applied, or according to a straight-line law, and the resistance to deflection is not dependent upon the material of the tire but mainly upon the air within. The unit load remains practically constant, but, by virtue of the increase in the area of contact as deflection proceeds, the tire offers a uniformly increasing resistance. The cushioning properties of the pneumatic tire remain in proportion to the load and still function at the end of the blow. This is in contradistinction to the cushioning effect produced by solid rubber tires, in which the rubber increases in density under increasing loads and deforms in such a

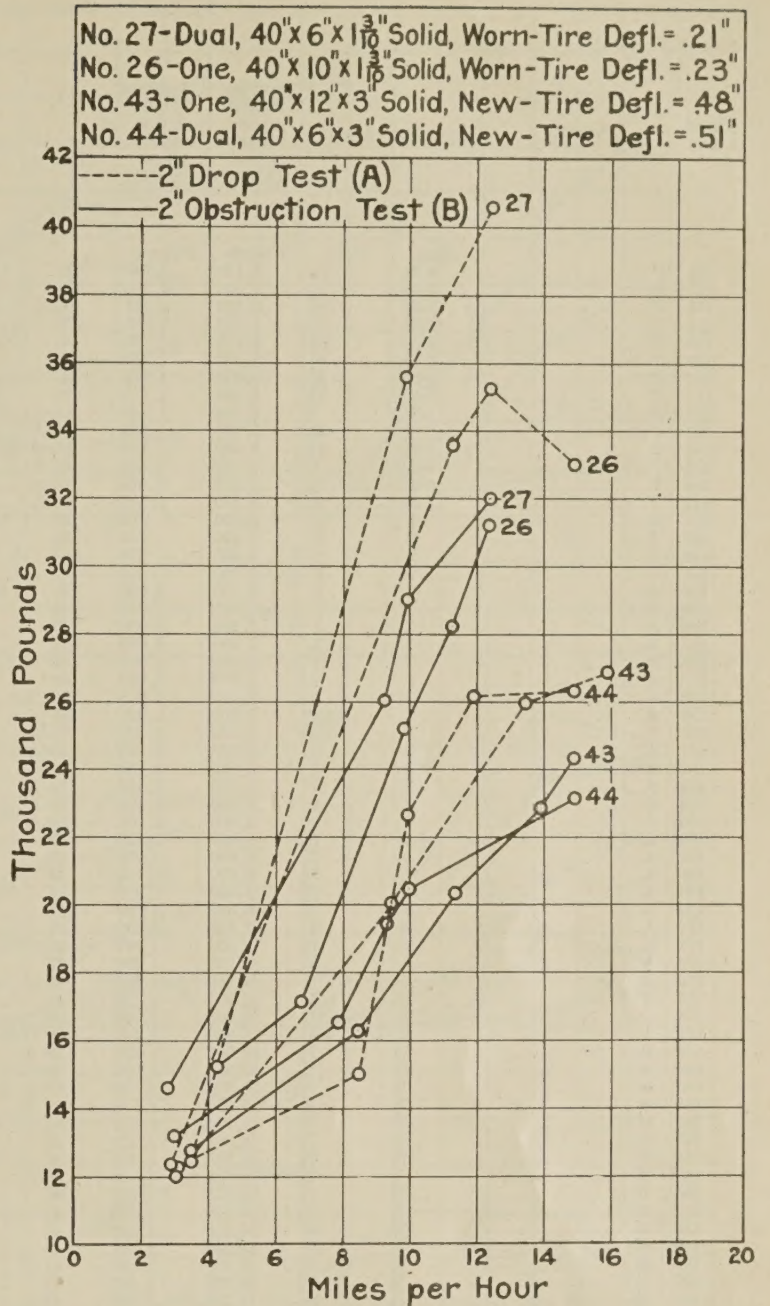


FIG. 7.—COMPARISON OF TIRES. 5-TON TRUCK A WITH 7½-TON LOAD.

manner that the unit intensity of loading at the point of contact is very greatly increased, thus offering less cushioning to the load as it is brought to rest, with the result that the deceleration at the end of the impact may be very greatly increased. This difference explains the more complete and effective cushioning of the pneumatic tire.

**TESTS OF CUSHION WHEELS.**

The development of cushion wheels has come about as a result of the attempt to combine the rugged dependability of the solid rubber tire with the cushioning and shock-absorbing qualities of the pneumatic tire. Three different makes of cushion wheels were used in these tests, two of them being very similar in construction. Their main feature was a corrugated rubber cushion interposed between the base rim on the outside of the wheel and an inner rim or felloe. On this wheel was mounted an ordinary solid rubber tire, the idea





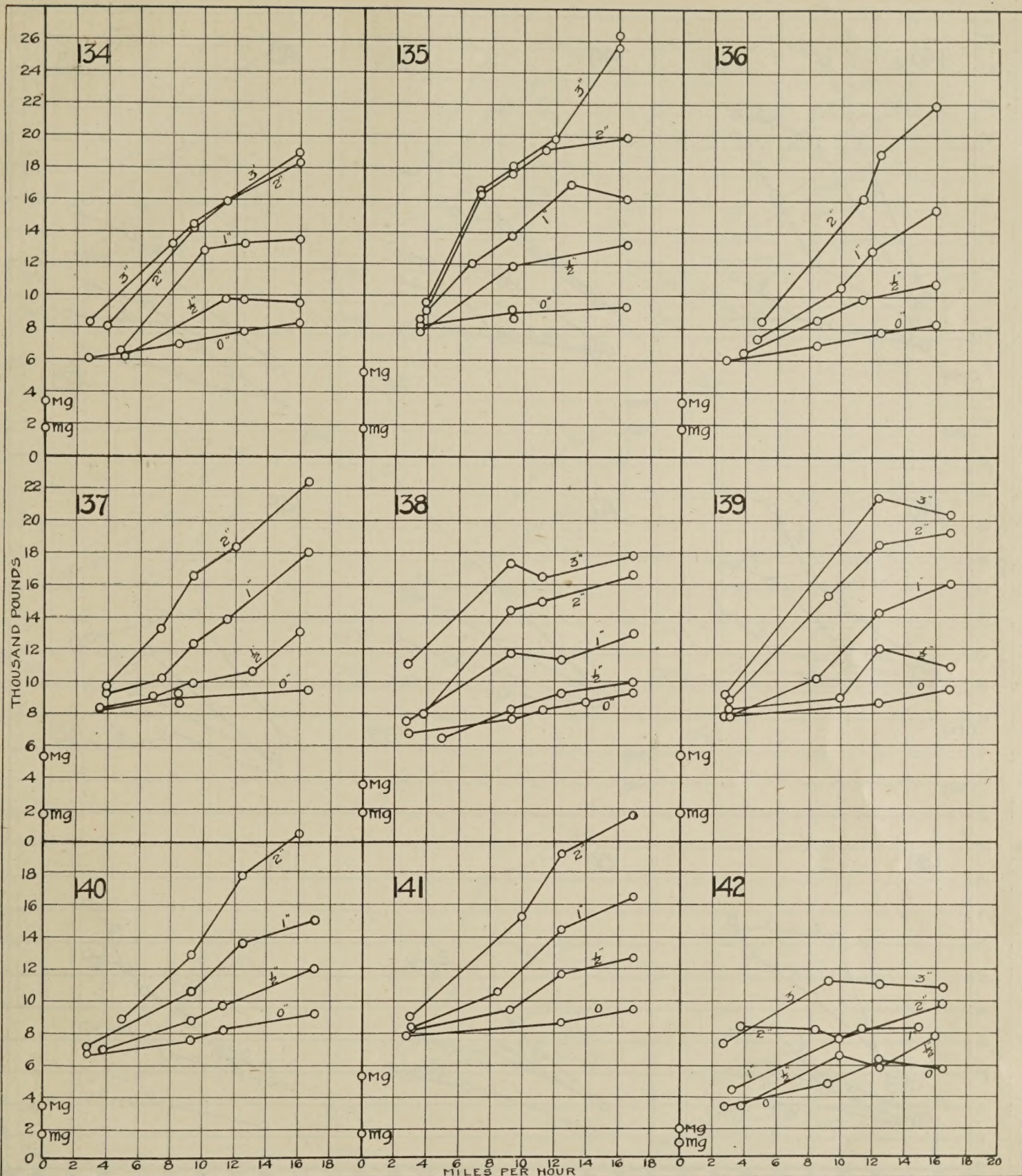


Chart No.	Truck.	Capacity.	Load.	Sprung weight on one rear wheel (Mg.).	Unsprung weight on one rear wheel (mg.).	Tires.		Springs.		Type of test.		
						No.	Kind.	Weight of one rear wheel with tires.	Deformation due to wheel load.		No.	Deflection due to sprung weight.
		Tons.	Tons.	Pounds.	Pounds.			Pounds.	Inches.	No.	Inches.	
134	P.....	3-3½	2½	3,450	1,785	28	Cushion.....	610	0.31	D	1.44	Drop.
135	P.....	3-3½	4½	5,300	1,785	28	do.....	610	.37	D	2.20	Do.
136	P.....	3-3½	2½	3,450	1,785	28	do.....	610	.31	D	1.44	Obstruction.
137	P.....	3-3½	4½	5,300	1,785	28	do.....	610	.37	D	2.20	Do.
138	P.....	3-3½	2½	3,450	1,770	36	do.....	591	.29	D	1.44	Drop.
139	P.....	3-3½	4½	5,300	1,770	36	do.....	591	.35	D	2.20	Do.
140	P.....	3-3½	2½	3,450	1,770	36	do.....	591	.29	D	1.44	Obstruction.
141	P.....	3-3½	4½	5,300	1,770	36	do.....	591	.35	D	2.20	Do.
142	P.....	3-3½	0	1,150	1,840	11-A	Solid.....	664	.20	D	.48	Drop.

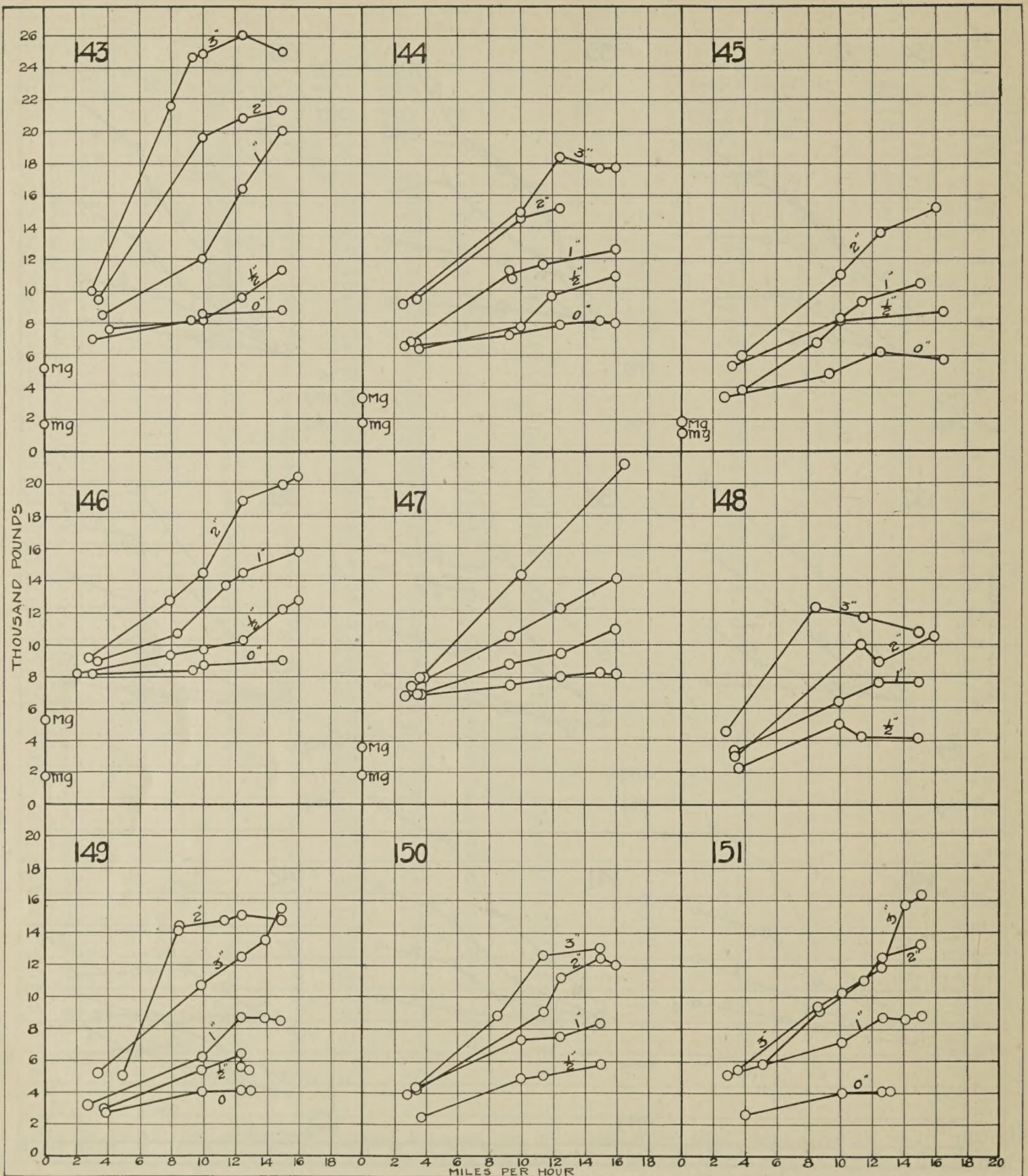


Chart No.	Truck.	Capacity.	Load.	Sprung weight on one rear wheel (Mg.).	Unsprung weight on one rear wheel (mg.).	Tires.		Springs.		Type of test.		
						No.	Kind.	Weight of one rear wheel with tires. Pounds.	Deformation due to wheel load. Inches.		No.	Deflection due to sprung weight. Inches.
143	P.....	3-3½	4½	5,300	1,840	11-A	Solid.....	664	0.41	D	2.20	Drop.
144	P.....	3-3½	2½	3,450	1,840	11-A	do.....	664	.32	D	1.44	Do.
145	P.....	3-3½	0	1,150	1,840	11-A	do.....	664	.20	D	.48	Obstruction.
146	P.....	3-3½	4½	5,300	1,840	11-A	do.....	664	.41	D	2.20	Do.
147	P.....	3-3½	2½	3,450	1,840	11-A	do.....	664	.32	D	1.44	Do.
148	A.....	2	2	3,300	970	42	Cushion.....	395	.44	E	2.70	Drop.
149	A.....	2	3	3,900	970	42	do.....	395	.46	E	3.19	Do.
150	A.....	2	2	3,300	970	42	do.....	395	.44	E	2.70	Obstruction.
151	A.....	2	3	3,900	970	42	do.....	395	.46	F	3.19	Do.

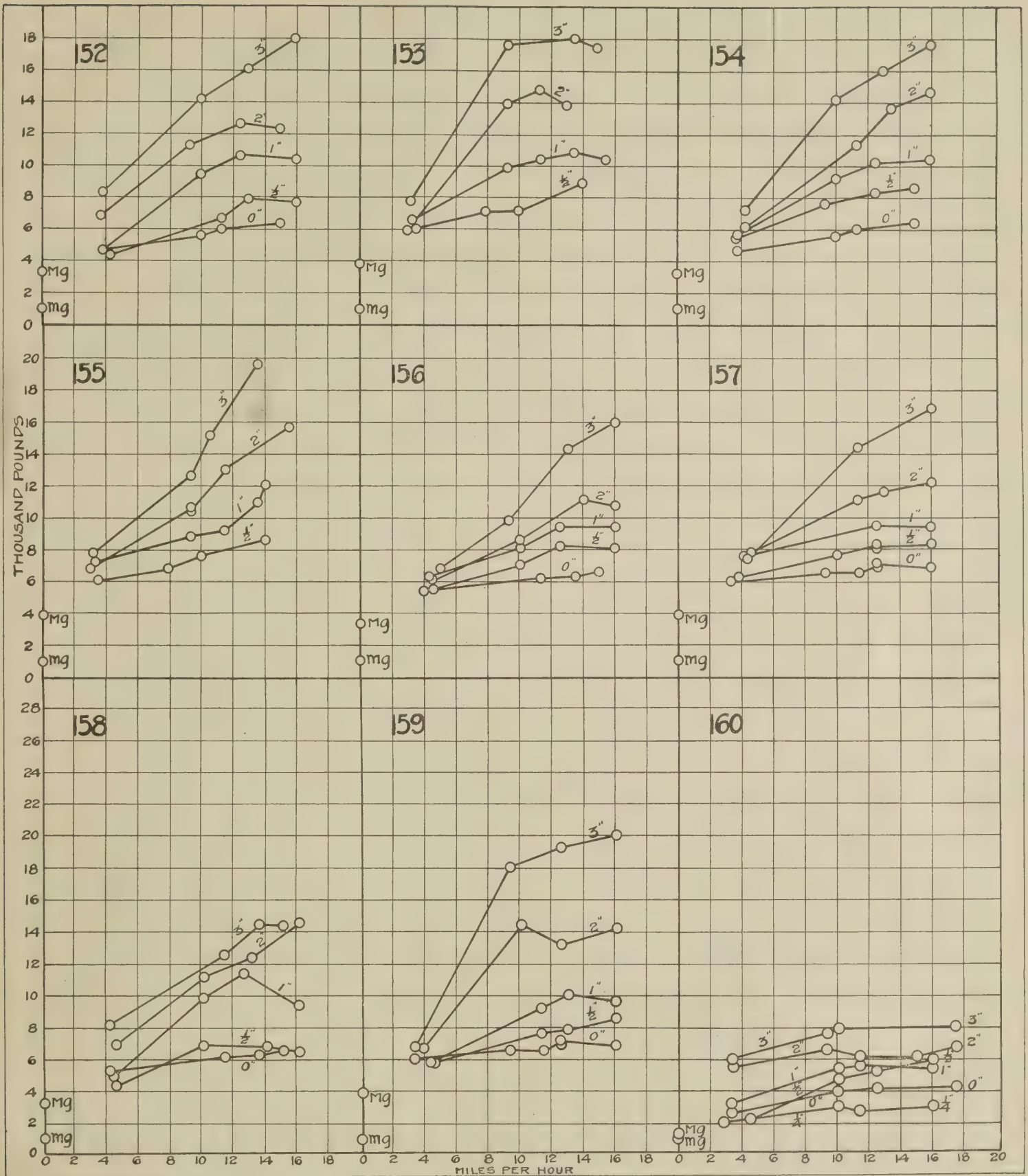


Chart No.	Truck.	Capacity.		Sprung weight on one rear wheel (Mg.).	Unsprung weight on one rear wheel (mg.).	No.	Tires.		No.	Springs.		Type of test.
		Tons.	Tons.				Kind.	Weight of one rear wheel with tires.		Deformation due to wheel load.	Inches.	
152	A.....	2	2	3,300	1,000	29	Solid.....	420	.42	E	2.70	Drop.
153	A.....	2	3	3,900	1,000	29	do.....	420	.46	E	3.19	Do.
154	A.....	2	2	3,300	1,000	29	do.....	420	.42	E	2.70	Obstruction.
155	A.....	2	3	3,900	1,000	29	do.....	420	.46	E	3.19	Do.
156	A.....	2	2	3,300	1,025	30	do.....	457	.48	E	2.70	Do.
157	A.....	2	3	3,900	1,025	30	do.....	457	.52	E	3.19	Do.
158	A.....	2	2	3,300	1,025	30	do.....	457	.48	E	2.70	Drop.
159	A.....	2	3	3,900	1,025	30	do.....	457	.52	E	3.19	Do.
160	A.....	2	0	1,250	1,100	33-A	do.....	516	.27	E	1.02	Do.

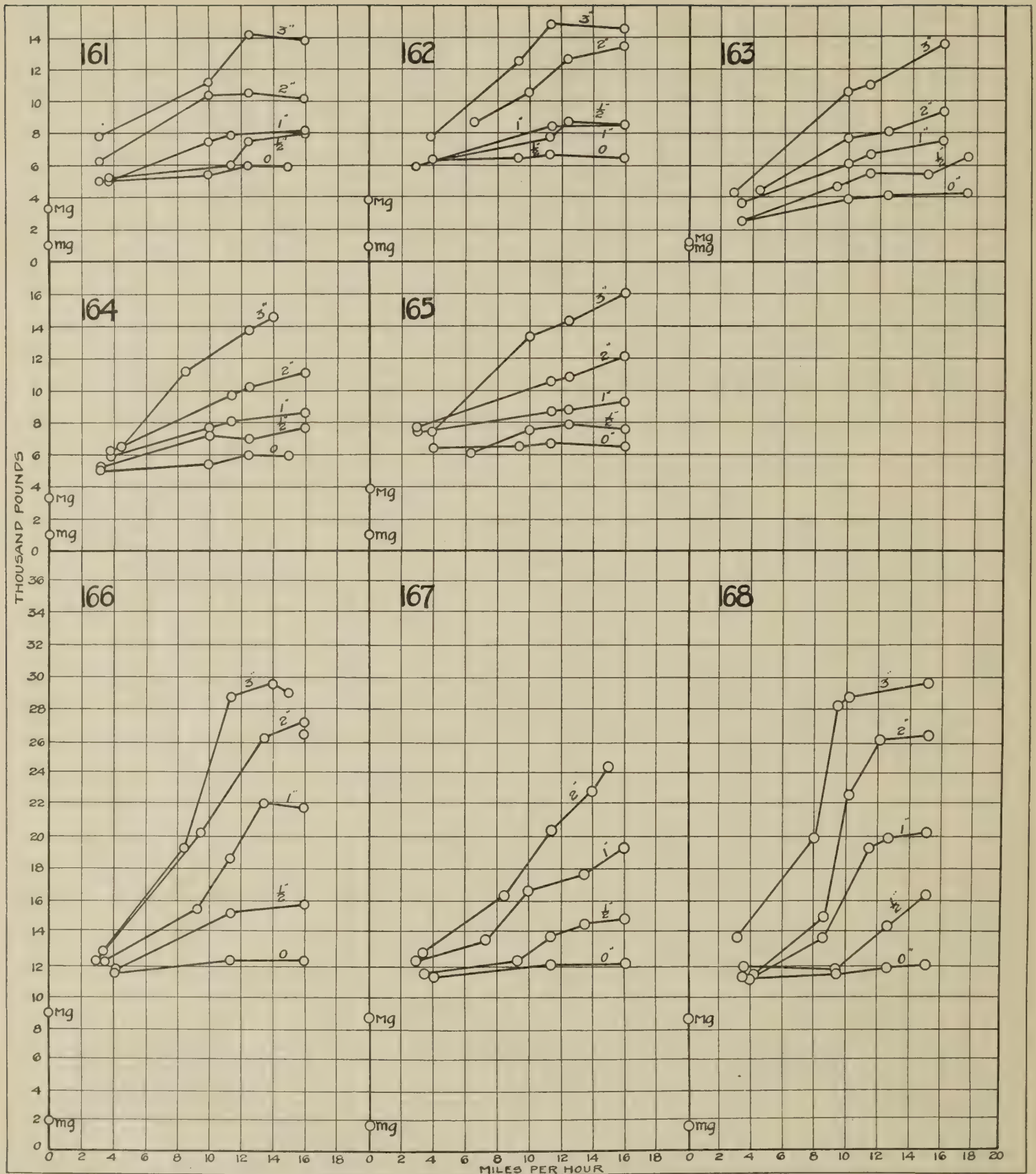


Chart No.	Truck.	Capacity.	Load.	Sprung weight on one rear wheel (Mg.).	Unsprung weight on one rear wheel (mg.).	Tires.			Springs.		Type of test.	
						No.	Kind.	Weight of one rear wheel with tires.	Deformation due to wheel load.	No.		Deflection due to sprung weight.
		Tons.	Tons.	Pounds.	Pounds.			Pounds.	Inches.		Inches.	
161	A.....	2	2	3,300	1,100	33-A	Solid.....	516	.50	E	2.70	Drop.
162	A.....	2	3	3,900	1,100	33-A	do.....	516	.57	E	3.19	Do.
163	A.....	2	0	1,250	1,100	33-A	do.....	516	.27	E	1.02	Obstruction.
164	A.....	2	2	3,300	1,100	33-A	do.....	516	.50	E	2.70	Do.
165	A.....	2	3	3,900	1,100	33-A	do.....	516	.57	E	3.19	Do.
166	A.....	5	7 1/2	8,650	1,920	43	do.....	812	.48	F	3.19	Drop.
167	A.....	5	7 1/2	8,650	1,920	43	do.....	812	.48	F	3.19	Obstruction.
168	A.....	5	7 1/2	8,650	1,920	44	do.....	800	.51	F	3.19	Drop.

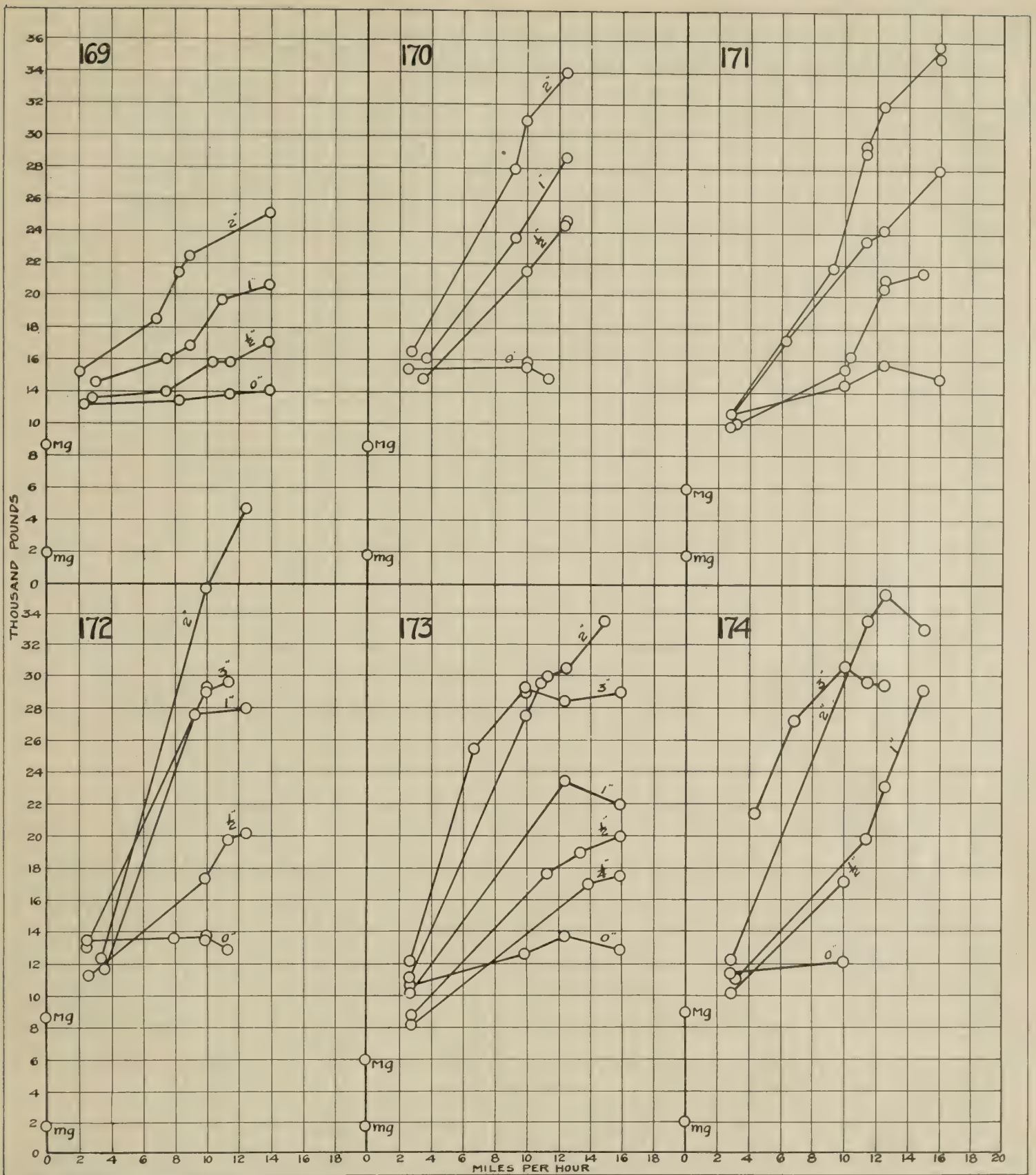


Chart No.	Truck.	Capacity.	Load.	Sprung weight on one rear wheel (Mg.).	Unsprung weight on one rear wheel (mg.).	Tires.		Springs.		Type of test.		
						No.	Kind.	No.	Deflection due to sprung weight.			
		Tons.	Tons.	Pounds.	Pounds.		Weight of one rear wheel with tires.	Deformation due to wheel load.		Inches.		
169	A.....	5	7½	8,650	1,920	44	Solid.....	800	.51	F	3.19	Obstruction.
170	A.....	5	7½	8,650	1,790	27	.....do.....	680	.21	F	3.19	Do.
171	A.....	5	5	5,950	1,790	27	.....do.....	680	.18	F	2.12	Do.
172	A.....	5	7½	8,650	1,790	27	.....do.....	680	.21	F	3.19	Drop.
173	A.....	5	5	5,950	1,790	27	.....do.....	680	.18	F	2.12	Do.
174	A.....	5	7½	8,650	1,740	26	.....do.....	635	.23	F	3.19	Do.

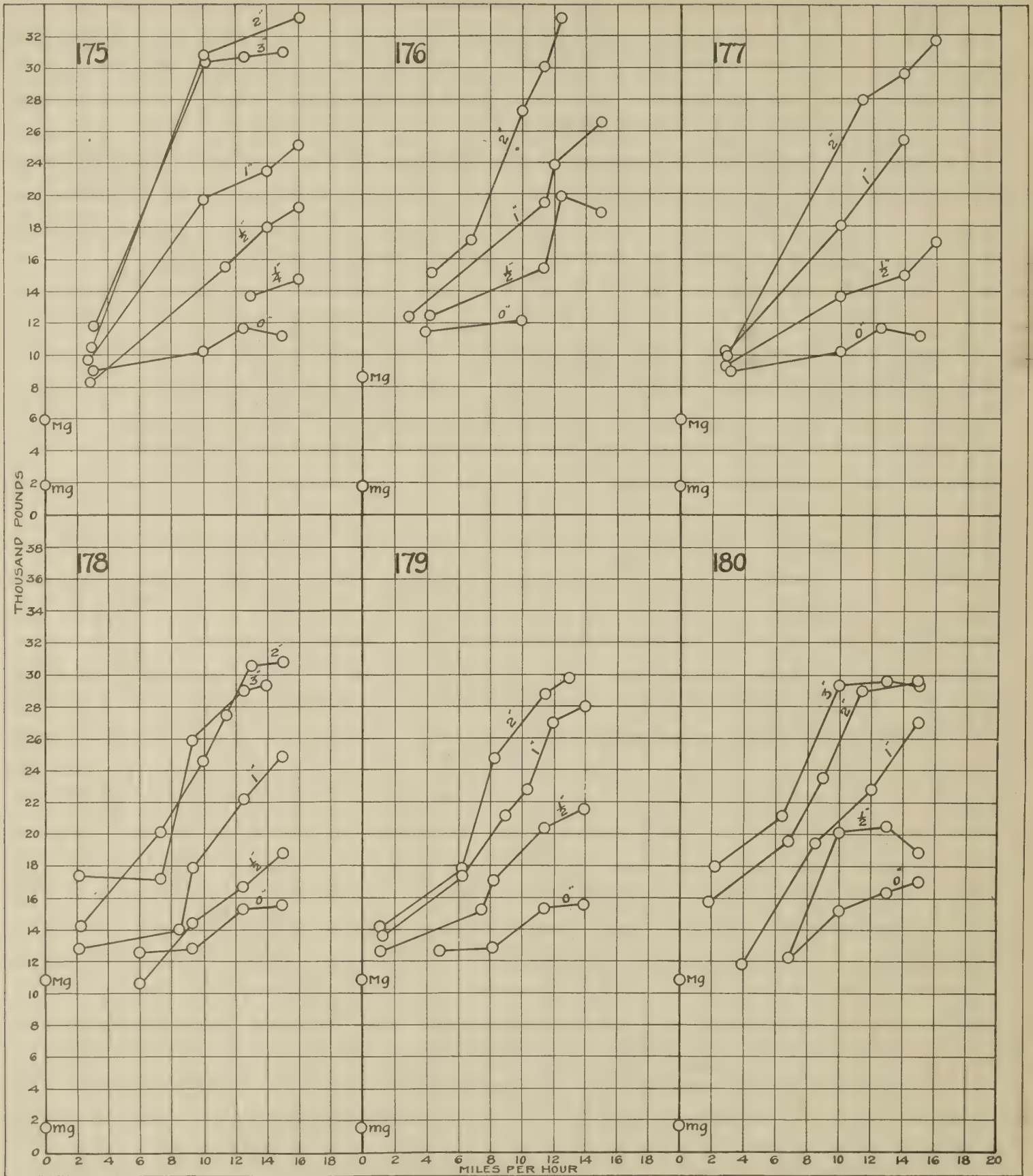


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						No.	Kind.	Weight of one rear wheel with tires.	Deformation due to wheel load.		No.	Deflection due to sprung weight.
		Tons.	Tons.	Pounds.	Pounds.			Pounds.	Inches.	F	Inches.	
175	A	5	5	5,950	1,740	26	Solid	635	.20	F	2.12	Drop.
176	A	5	7 1/2	8,650	1,740	26	do.	635	.23	F	3.19	Obstruction.
177	A	5	5	5,950	1,740	26	do.	635	.20	F	2.12	Do.
178	M	7 1/2	7 1/2	10,950	1,525	39-A	do.	1,045	.41	V	3.20	Drop.
179	M	7 1/2	7 1/2	10,950	1,525	39-A	do.	1,045	.41	V	3.20	Obstruction.
180	M	7 1/2	7 1/2	10,950	1,710	39-B	do.	1,225	.30	V	3.20	Drop.

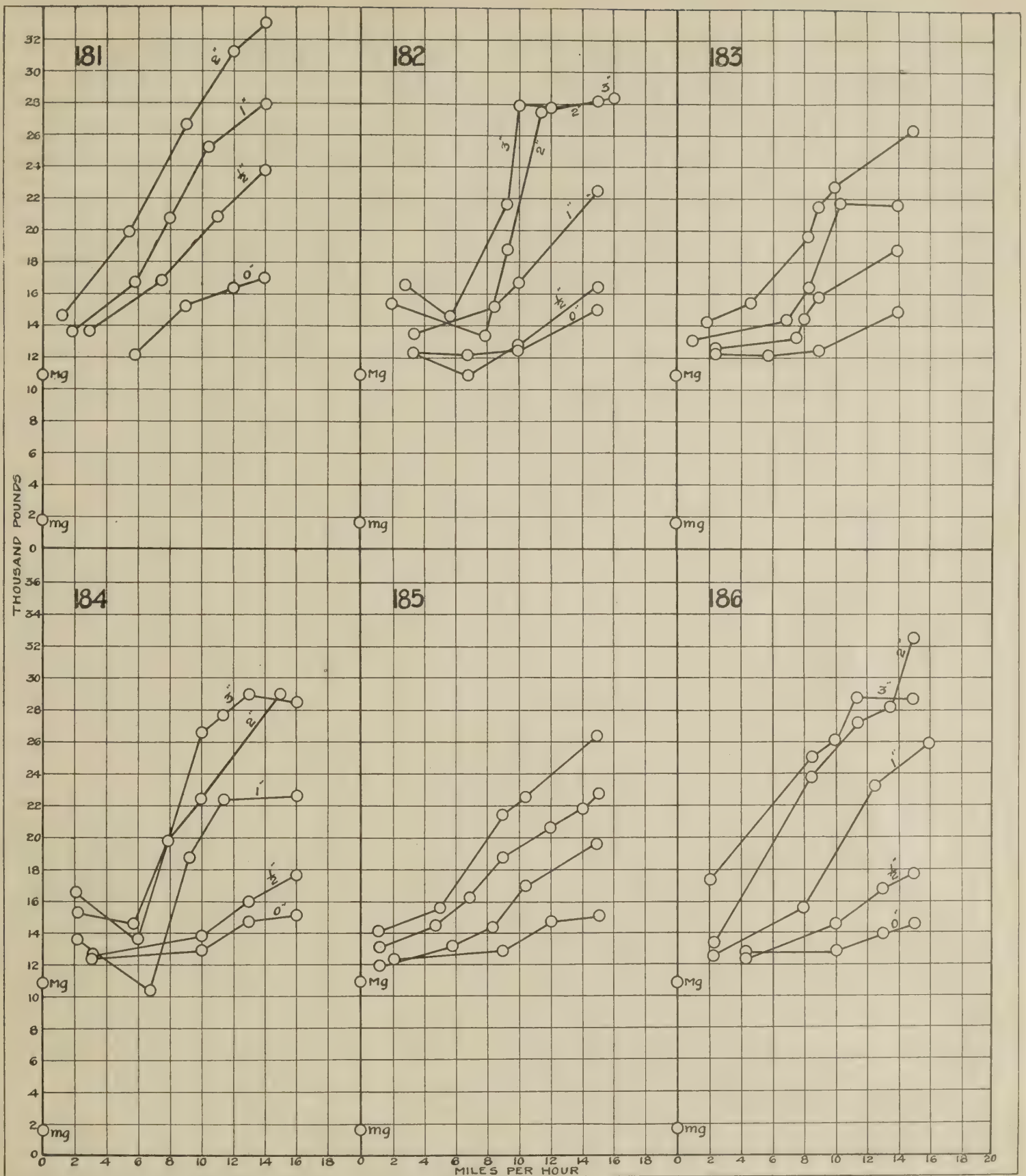


Chart No.	Truck.	Capacity.	Load.	Sprung weight on one rear wheel (Mg.).	Unsprung weight on one rear wheel (mg.).	Tires.				Springs.		Type of test.
						No.	Kind.	Weight of one rear wheel with tires.	Deformation due to wheel load.	No.	Deflection due to sprung weight.	
		Tons.	Tons.	Pounds.	Pounds.			Pounds.	Inches.		Inches.	
181	M.....	7½	7½	10,950	1,710	39-B	Solid.....	1,225	.30	V	3.20	Obstruction.
182	M.....	7½	7½	10,950	1,672	45	Cushion.....	1,190	.41	V	3.20	Drop.
183	M.....	7½	7½	10,950	1,672	45	do.....	1,190	.41	V	3.20	Obstruction.
184	M.....	7½	7½	10,950	1,606	46	Solid.....	1,123	.41	V	3.20	Drop.
185	M.....	7½	7½	10,950	1,606	46	do.....	1,123	.41	V	3.20	Obstruction.
186	M.....	7½	7½	10,950	1,720	40	do.....	1,235	.33	V	3.20	Drop.

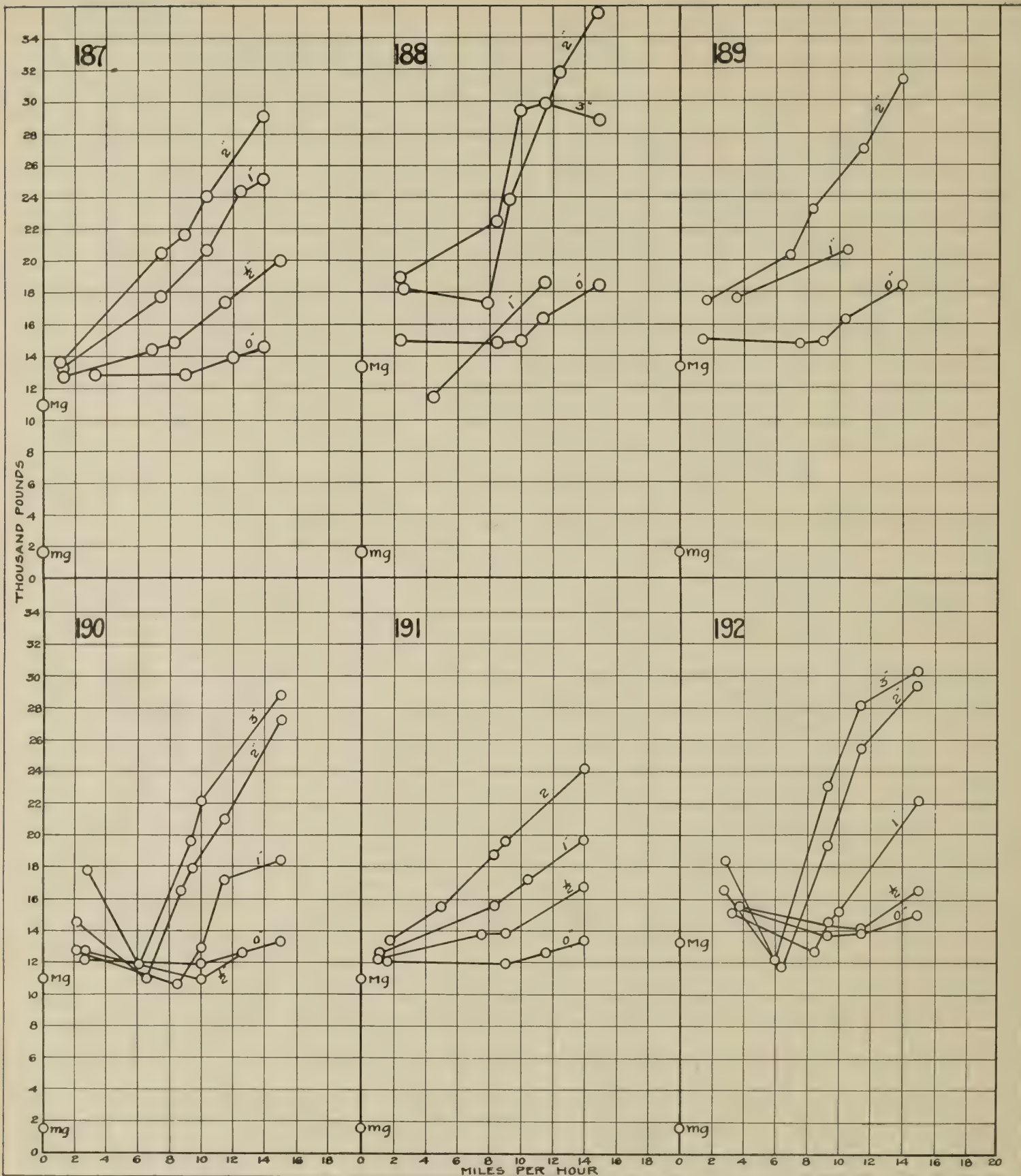


Chart No.	Truck.	Capacity.	Load.	Sprung weight on one rear wheel (Mg.).	Unsprung weight on one rear wheel (mg.).	Tires.			Springs.		Type of test.	
						No.	Kind.	Weight of one rear wheel with tires.	Deformation due to wheel load.	No.		Deflection due to sprung weight.
		Tons.	Tons.	Pounds.	Pounds.			Pounds.	Inches.		Inches.	
187	M.....	7½	7½	10,950	1,720	40	Solid.....	1,235	.33	V	3.20	Obstruction.
188	M.....	7½	10	13,250	1,720	40	do.....	1,235	.38	V	3.64	Drop.
189	M.....	7½	10	13,250	1,720	40	do.....	1,235	.38	V	3.64	Obstruction.
190	M.....	7½	7½	10,950	1,590	41	do.....	1,109	.50	V	3.20	Drop.
191	M.....	7½	7½	10,950	1,590	41	do.....	1,109	.50	V	3.20	Obstruction.
192	M.....	7½	10	13,250	1,590	41	do.....	1,109	.56	V	3.64	Drop.



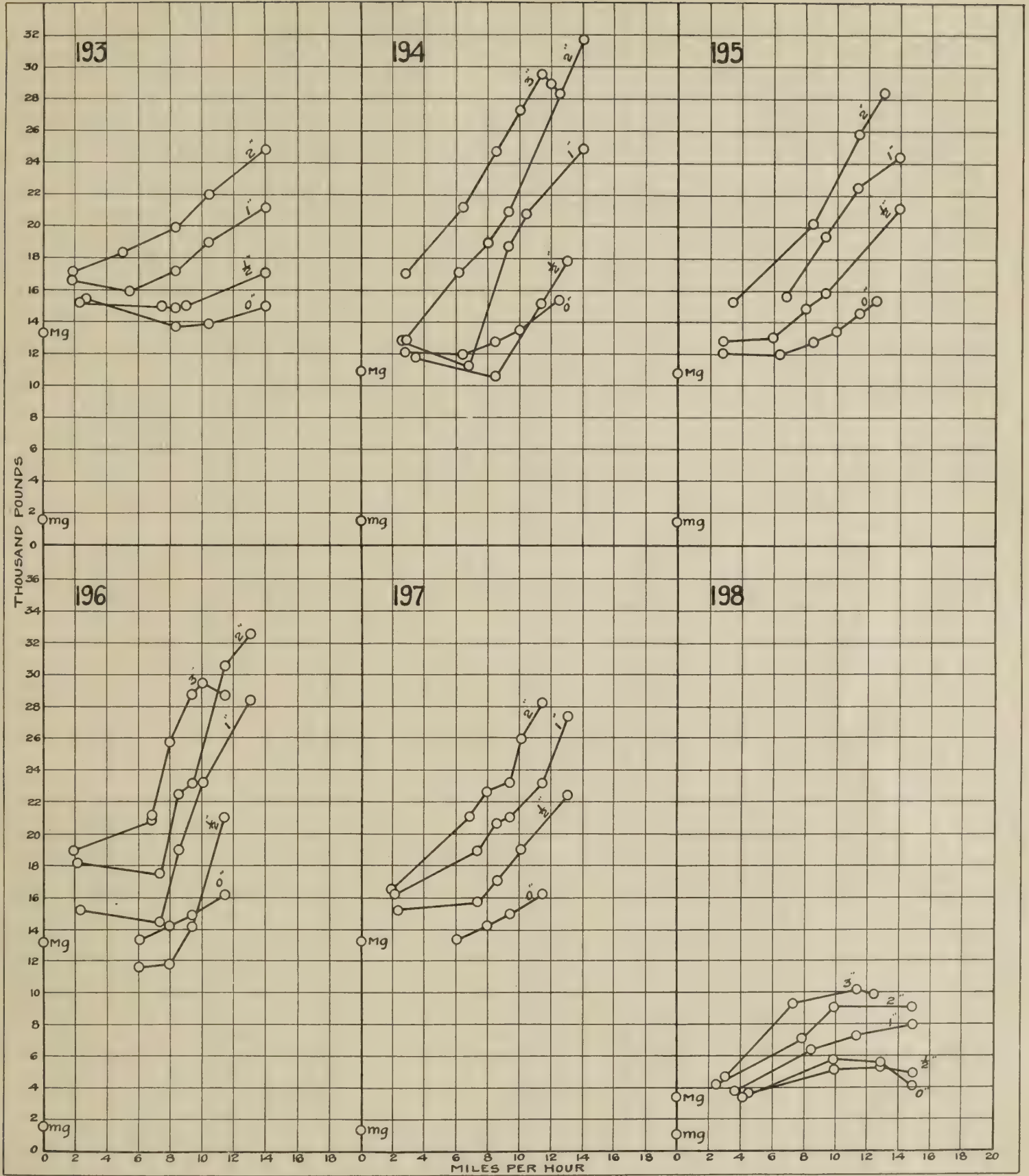


Chart No.	Truck.	Capacity.	Load.	Sprung weight on one rear wheel (Mg.).	Unsprung weight on one rear wheel (mg.).	Tires.		Springs.		Type of test.		
						No.	Kind.	Weight of one rear wheel with tires.	Deformation due to wheel load.		No.	Deflection due to sprung weight.
		Tons.	Tons.	Pounds.	Pounds.			Pounds.	Inches.	V	Inches.	
193	M.....	7½	10	13,250	1,590	41	Solid.....	1,109	0.56	V	3.64	Obstruction.
194	M.....	7½	7½	10,950	1,500	39	do.....	1,017	.29	V	3.20	Drop.
195	M.....	7½	7½	10,950	1,500	39	do.....	1,017	.29	V	3.20	Obstruction.
196	M.....	7½	10	13,250	1,500	39	do.....	1,017	.32	V	3.64	Drop.
197	M.....	7½	10	13,250	1,500	39	do.....	1,017	.32	V	3.64	Obstruction.
198	A.....	2	2	3,300	910	47	Cushion.....	340	.64	E	2.70	Drop.

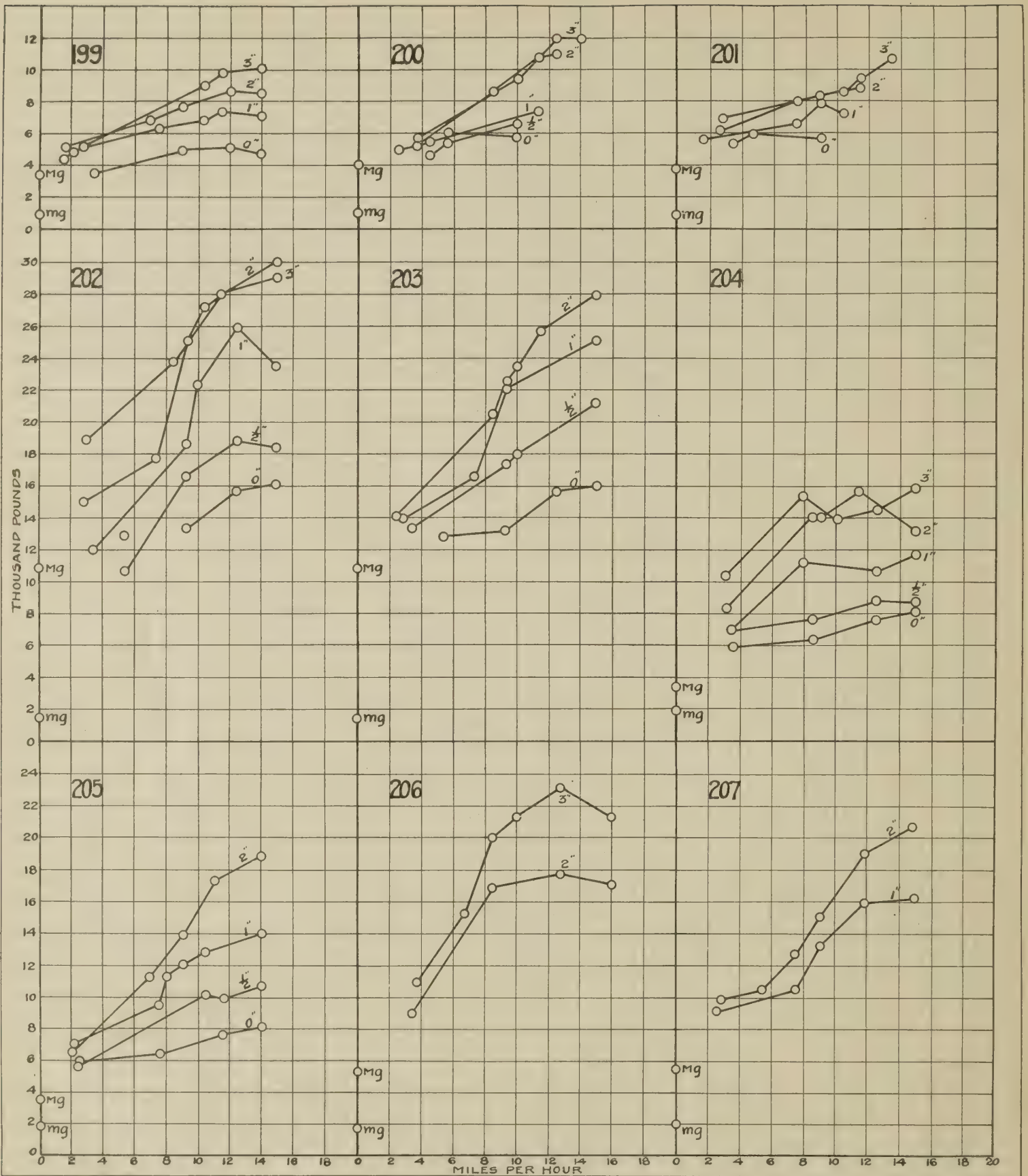


Chart No.	Truck.	Capacity.	Load.	Sprung weight on one rear wheel (Mg.).	Unsprung weight on one rear wheel (mg.).	Tires.			Springs.		Type of test.	
						No.	Kind.	Weight of one rear wheel with tires.	Deformation due to wheel load.	No.		Deflection due to sprung weight.
		Tons.	Tons.	Pounds.	Pounds.			Pounds.	Inches.		Inches.	
199	A	2	2	3,300	910	47	Cushion	340	0.64	E	2.70	Obstruction.
200	A	2	3	3,900	910	47	do.	340	.70	E	3.19	Drop.
201	A	2	3	3,900	910	47	do.	340	.70	E	3.19	Obstruction.
202	M	7½	7½	10,950	1,528	39-C	Solid <sup>1</sup>	1,045	.37	V	3.20	Drop.
203	M	7½	7½	10,950	1,528	39-C	do.	1,045	.37	V	3.20	Obstruction.
204	P	3-3½	2½	3,450	1,822	11-B	do.	646	.41	D	1.44	Drop.
205	P	3-3½	2½	3,450	1,822	11-B	do.	646	.41	D	1.44	Obstruction.
206	P	3-3½	4½	5,300	1,822	11-B	do.	646	.50	D	2.20	Drop.
207	P	3-3½	4½	5,300	1,822	11-B	do.	646	.50	D	2.20	Obstruction.

<sup>1</sup> With cushion wheel.

# THE FEDERAL HIGHWAY ACT.

THE Federal Highway Act, approved by President Harding November 9, appropriates \$75,000,000 as Federal aid for road construction in the various States, and \$15,000,000 for the construction of roads and trails in and adjacent to the national forests. The sum of \$25,000,000 is made available immediately for Federal-aid roads and the balance of \$50,000,000 becomes available on January 1, 1922. Of the forest road appropriation \$5,000,000 becomes available immediately and \$10,000,000 on July 1, 1922, the beginning of the next fiscal year.

Under the terms of the act the Federal-aid money will be available to the States for two years after the close of the fiscal year for which the money is appropriated. This provision is made to apply to the money appropriated under the previous act and its amendment as well as to the new appropriation. According to this provision the new appropriation must be ex-

pendent by June 30, 1924, and the time allowed for the expenditure of the balance of the previous appropriation which remains in some States is extended to June 30, 1923. The forest road appropriation is available until expended.

## METHOD OF DISTRIBUTION SLIGHTLY CHANGED.

Not more than 2½ per cent of the appropriation for Federal aid may be deducted by the Secretary of Agriculture for the purpose of administering the provisions of the act and for highway research.

The balance of the appropriation is to be apportioned among the States in a manner similar to that which was prescribed by the Federal aid act of 1916. The three factors governing the distribution remain as before—area, population, and mileage of rural delivery and star routes. Dividing the net appropriation into three parts one-third is to be apportioned in the ratio

*Apportionment of Federal aid under new and old acts.*

State.	New apportionment available immediately available.	Apportionment available Jan. 1, 1922.	Total apportionment under new act.	Total apportionment under old acts.	Total apportionment under new and old acts.
Alabama.....	\$517,806.89	\$1,035,613.78	\$1,553,420.67	\$5,776,552.58	\$7,329,973.25
Arizona.....	351,093.81	702,187.63	1,053,281.44	3,771,351.69	4,824,633.13
Arkansas.....	418,047.40	836,094.80	1,254,142.20	4,619,929.47	5,874,071.67
California.....	820,699.51	1,641,399.02	2,462,098.53	8,384,354.57	10,846,453.10
Colorado.....	447,058.56	894,117.13	1,341,175.69	4,780,064.14	6,121,239.83
Connecticut.....	160,299.26	320,598.52	480,897.78	1,689,324.70	2,170,222.48
Delaware.....	121,875.00	243,750.00	365,625.00	447,654.83	813,279.83
Florida.....	295,608.56	591,217.13	886,825.69	3,150,112.48	4,036,938.17
Georgia.....	665,985.86	1,331,971.72	1,997,957.58	7,407,578.62	9,405,536.20
Idaho.....	312,845.56	625,691.12	938,536.68	3,360,388.86	4,298,925.54
Illinois.....	1,082,093.69	2,164,187.38	3,246,281.07	12,024,266.97	15,270,548.04
Indiana.....	652,951.80	1,305,903.61	1,958,855.41	7,415,292.61	9,374,148.02
Iowa.....	700,957.58	1,401,915.16	2,102,872.74	7,939,343.14	10,042,215.88
Kansas.....	700,760.50	1,401,521.01	2,102,281.51	7,895,309.07	9,997,590.58
Kentucky.....	472,392.89	944,785.79	1,417,178.68	5,370,064.79	6,787,243.47
Louisiana.....	332,329.88	664,659.76	996,989.64	3,742,524.57	4,739,514.21
Maine.....	231,720.08	463,440.17	695,160.25	2,645,963.57	3,341,123.82
Maryland.....	213,543.00	427,086.01	640,629.01	2,390,749.07	3,031,378.08
Massachusetts.....	365,392.01	730,784.03	1,096,176.04	4,052,565.09	5,148,741.13
Michigan.....	749,844.14	1,499,688.29	2,249,532.43	7,961,295.55	10,210,827.98
Minnesota.....	707,865.69	1,415,731.38	2,123,597.07	7,815,383.02	9,938,980.09
Mississippi.....	431,635.41	863,270.81	1,294,906.22	4,951,542.29	6,246,448.51
Missouri.....	816,042.87	1,632,085.75	2,448,128.62	9,322,075.71	11,770,204.33
Montana.....	515,628.61	1,031,257.21	1,546,885.82	5,498,827.31	7,045,713.13
Nebraska.....	527,063.17	1,054,126.33	1,581,189.50	5,866,761.66	7,447,951.16
Nevada.....	317,812.26	635,624.52	953,436.78	3,527,276.18	4,480,712.96
New Hampshire.....	121,875.00	243,750.00	365,625.00	1,143,088.99	1,508,713.99
New Jersey.....	314,290.32	628,580.63	942,870.95	3,265,299.02	4,208,169.97
New Mexico.....	396,607.78	793,215.56	1,189,823.34	4,389,794.61	5,579,617.95
New York.....	1,232,149.32	2,464,298.65	3,696,447.97	13,688,801.67	17,385,249.64
North Carolina.....	569,777.97	1,139,555.93	1,709,333.90	6,270,690.68	7,980,024.58
North Dakota.....	388,238.14	776,476.28	1,164,714.42	4,222,487.70	5,387,202.12
Ohio.....	941,001.35	1,882,002.70	2,823,004.05	10,202,947.71	13,025,951.76
Oklahoma.....	584,113.15	1,168,226.29	1,752,339.44	6,338,245.60	8,090,585.04
Oregon.....	394,221.30	788,442.60	1,182,663.90	4,332,178.26	5,514,842.16
Pennsylvania.....	1,132,984.66	2,265,969.31	3,398,953.97	12,632,644.29	16,031,598.26
Rhode Island.....	121,875.00	243,750.00	365,625.00	641,166.13	1,006,791.13
South Carolina.....	353,745.78	707,491.56	1,061,237.34	3,946,617.50	5,007,854.84
South Dakota.....	401,353.44	802,706.87	1,204,060.31	4,452,883.04	5,656,943.35
Tennessee.....	549,230.75	1,098,461.49	1,647,692.24	6,228,137.98	7,875,830.22
Texas.....	1,475,057.47	2,950,114.94	4,425,172.41	16,100,404.77	20,525,577.18
Utah.....	283,139.07	566,278.14	849,417.21	3,117,206.38	3,966,623.59
Vermont.....	121,875.00	243,750.00	365,625.00	1,242,103.73	1,607,728.73
Virginia.....	485,609.49	971,218.98	1,456,828.47	5,451,730.28	6,908,558.75
Washington.....	367,903.26	735,806.51	1,103,709.77	3,971,675.83	5,075,385.60
West Virginia.....	267,453.26	534,906.51	802,359.77	2,922,504.45	3,724,864.22
Wisconsin.....	631,605.29	1,263,210.57	1,894,815.86	7,004,280.67	8,899,096.53
Wyoming.....	311,589.21	623,178.42	934,767.63	3,378,558.17	4,313,325.80
Total.....	24,375,000.00	48,750,000.00	73,125,000.00	266,750,000.00	339,875,000.00

which each of these factors in each State bears to their total for the United States.

A new provision is that no State shall receive less than one-half of one per cent of the year's appropriation. This stipulation will increase the amount which would otherwise be received by 4 of the smaller States—Delaware, New Hampshire, Rhode Island, and Vermont.

#### THE APPORTIONMENT TO THE STATES.

After deducting the administrative allowance the amount available for immediate apportionment is \$24,375,000; that which becomes available on January 1 is \$48,750,000 making a total of \$73,125,000. The apportionment of these sums to the several States and the amounts apportioned under the previous acts are given in the table.

#### UNITED STATES' SHARE LIMITED TO 50 PER CENT EXCEPT IN PUBLIC LAND STATES.

The participation of the United States in any one road project is limited to 50 per cent of the total estimated cost except in those States containing unappropriated public lands in excess of 5 per cent of all lands in the State. For these States the special provision is made that the Government may participate to the extent of 50 per cent plus a percentage of the total estimated cost equal to one-half of the percentage which the area of the public lands bears to the total of the State. As a general rule the Governments participation is limited to \$20,000 per mile, but for the public-land States this amount may be increased in proportion to the increased percentage of Federal aid authorized. The provisions with respect to these States are made to apply to all unobligated funds appropriated by the previous acts and also to payments for approved projects upon which actual construction had not begun June 30, last. The States which benefit from these provisions are given in the table below, together with the maximum limit of Government participation allowed by the act.

*Proportion of cost of projects to be paid by Government.*

State.	Paid by Government.	State.	Paid by Government.
Arizona.....	61.11	Nevada.....	87.23
California.....	57.37	New Mexico.....	61.51
Colorado.....	56.13	Oregon.....	61.14
Idaho.....	58.02	Utah.....	74.85
Montana.....	53.04	Wyoming.....	64.65

#### FEDERAL FUNDS MUST BE MATCHED BY FUNDS UNDER STATE CONTROL.

The funds to match the Government's contribution may be raised by the States or by any political or other subdivision of the States, but if the funds of a country or other local subdivision are to be used the new act requires that they shall be paced under the direct con-

trol of the State highway department. No project is to be approved in any State until the State has made provision for the money required to match the State's share of the Federal appropriation and to maintain the roads built with the joint fund, except that where the laws of the State will not permit it to make such provision, the Secretary of Agriculture may continue to approve projects for three years.

#### MONEY TO BE SPENT ON A CONNECTED SYSTEM.

The new appropriation is to be expended upon a definite connected system of highways in each State limited in extent to 7 per cent of the total mileage of highways in the State. This system is to be divided into two parts; the first, to include the more important roads which are to be known as the primary or interstate highways, is to contain not more than three-sevenths of the mileage in the system. The second part will include the secondary or intercounty highways which will make up the balance of the system.

These systems are to be designated by the State highway departments, but the Secretary of Agriculture is given authority to require modifications or revisions of the systems as selected. Until the States have had an opportunity to select their systems the Secretary will continue to approve new projects submitted if there is ground for reasonable anticipation that the projects submitted will become a part of the system when it is selected.

When a State has made provision for the completion and maintenance of a system equal to 7 per cent of its total highway mileage the act provides that an addition may be made to the mileage of the primary and secondary systems which will give such States finally a system which will include more than 7 per cent of their total road mileage.

The act contemplates that the primary or interstate system and the secondary or intercounty system will be built up concurrently. One of its sections provides that not more than 60 per cent of the Federal aid allotted to a State may be expended upon the interstate system except with the joint approval of the State highway department and the Secretary of Agriculture.

#### TYPE AND WIDTH REQUIREMENTS.

New phraseology is introduced into the bill in the section which defines the requisite character of the Federal aid roads. Instead of the term "substantial" used in the first act the new act requires explicitly that only durable types of surface and kinds of material shall be adopted as will meet the existing and probable future traffic needs and conditions, consideration being given to peculiar local conditions.

This provision will not alter the policy heretofore followed by the Department of Agriculture. Its effect is to strengthen the position wisely taken by the Secre-

tary several years ago in the construction which he placed upon the word "substantial" in the previous act.

An entirely new provision, however, is contained in the requirement as to width. After stating in general terms that the highways to be constructed hereafter must have right of way and surface of adequate width, the act lays down the definition of adequacy for the surface by requiring that it shall not be less than 18 feet wide. Exceptions to this rule may be made if, in the opinion of the Secretary of Agriculture, it is impracticable to construct an 18-foot pavement by reason of physical conditions, excessive costs, probable traffic requirements, or legal obstacles.

#### HEAVY PENALTY FOR FAILURE TO MAINTAIN.

In harmony with the spirit of President Harding's first message to Congress, in which he deprecated the failure to give proper attention to the roads after the construction is completed so as to keep them constantly in condition to render service, the new act lays a heavy penalty upon failure to maintain the roads which are to be constructed under it. It defines "maintenance" in its broadest sense as "the constant making of needed repairs to preserve a smooth-surfaced highway." To insure that each highway aided by the Government will receive that kind of maintenance it provides that the Secretary of Agriculture shall serve notice upon any State which allows a road to suffer for lack of maintenance. If within 90 days after the notice is served the proper attention has not been given to the road, the Secretary is authorized to proceed to maintain it himself and to charge the cost against the Federal funds allotted to the State. What is more, he is ordered to refuse to approve any other project in the State until the amount spent for maintenance of the project in question has been reimbursed by the State. When the money is paid back it is not to be returned to the State's allotment of the appropriation, but is to be reapportioned among all the States, so that the delinquent State will lose all but a small portion.

#### THE TERMS OF THE ACT.

The terms of the act are as follows:

AN ACT To amend the Act entitled "An Act to provide that the United States shall aid the States in the construction of rural post roads, and for other purposes," approved July 11, 1916, as amended and supplemented, and for other purposes.

*Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That this Act may be cited as the Federal Highway Act.*

SEC. 2. That, when used in this Act, unless the context indicates otherwise—

The term "Federal Aid Act" means the Act entitled "An Act to provide that the United States shall aid the States in the construction of rural post roads, and for other purposes," approved July 11, 1916, as amended by sections 5 and 6 of an Act entitled "An Act making appropriations for the service of the Post Office Department for the fiscal year ending June 30, 1920, and for other purposes," approved February 28, 1919, and all other Acts amendatory thereof or supplementary thereto.

The term "highway" includes rights of way, bridges, drainage structures, signs, guard rails, and protective structures in connec-

tion with highways, but shall not include any highway or street in a municipality having a population of two thousand five hundred or more as shown by the last available census, except that portion of any such highway or street along which within a distance of one mile the houses average more than two hundred feet apart.

The term "State highway department" includes any State department, commission, board, or official having adequate powers and suitably equipped and organized to discharge to the satisfaction of the Secretary of Agriculture the duties herein required.

The term "maintenance" means the constant making of needed repairs to preserve a smooth-surfaced highway.

The term "construction" means the supervising, inspecting, actual building, and all expenses incidental to the construction of a highway except locating, surveying, mapping, and costs of rights of way.

The term "reconstruction" means a widening or a rebuilding of the highway or any portion thereof to make it a continuous road, and of sufficient width and strength to care adequately for traffic needs.

The term "forest roads" means roads wholly or partly within or adjacent to and serving the national forests.

The term "State funds" includes for the purposes of this Act, funds raised under the authority of the State, or any political or other subdivision thereof, and made available for expenditure under the direct control of the State highway department.

SEC. 3. All powers and duties of the Council of National Defense under the Act entitled "An Act making appropriations for the support of the Army for the fiscal year ending June 30, 1917, and for other purposes," approved August 29, 1916, in relation to highway or highway transport, are hereby transferred to the Secretary of Agriculture, and the Council of National Defense is directed to turn over to the Secretary of Agriculture the equipment, material, supplies, papers, maps, and documents utilized in the exercise of such powers. The powers and duties of agencies dealing with highways in the national parks or in military or naval reservations under the control of the United States Army or Navy, or with highways used principally for military or naval purposes, shall not be taken over by the Secretary of Agriculture, but such highways shall remain under the control and jurisdiction of such agencies.

The Secretary of Agriculture is authorized to cooperate with the State highway departments, and with the Department of the Interior in the construction of public highways within Indian reservations, and to pay the amount assumed therefor from the funds allotted or apportioned under this Act to the State wherein the reservation is located.

SEC. 4. That the Secretary of Agriculture shall establish an accounting division, which shall devise and install a proper method of keeping the accounts.

SEC. 5. That the Secretary of War be, and he is hereby, authorized and directed to transfer to the Secretary of Agriculture, upon his request, all war material, equipment, and supplies now or hereinafter declared surplus from stock now on hand and not needed for the purposes of the War Department but suitable for use in the improvement of highways, and that the same shall be distributed among the highway departments of the several States to be used in the construction, reconstruction, and maintenance of highways, such distribution to be upon the same basis as that hereinafter provided for in this Act in the distribution of Federal-aid fund: *Provided*, That the Secretary of Agriculture, in his discretion, may reserve from such distribution not to exceed 10 per centum of such material, equipment, and supplies for use in the construction, reconstruction, and maintenance of national forest roads or other roads constructed, reconstructed, or maintained under his direct supervision.

SEC. 6. That in approving projects to receive Federal aid under the provisions of this Act the Secretary of Agriculture shall give preference to such projects as will expedite the completion of an adequate and connected system of highways, interstate in character.

Before any projects are approved in any State, such State, through its State highway department, shall select or designate a system of highways not to exceed 7 per centum of the total highway mileage of such State as shown by the records of the State highway department at the time of the passage of this Act.

Upon this system all Federal-aid apportionments shall be expended.

Highways which may receive Federal aid shall be divided into two classes, one of which shall be known as primary or interstate highways, and shall not exceed three-sevenths of the total mileage which may receive Federal aid, and the other which shall connect or correlate therewith and be known as secondary or intercounty highways, and shall consist of the remainder of the mileage which may receive Federal aid.

The Secretary of Agriculture shall have authority to approve in whole or in part the systems as designated or to require modifications or revisions thereof: *Provided*, That the States shall submit to the Secretary of Agriculture for his approval any proposed revisions of the designated systems of highways above provided for.

Not more than 60 per centum of all Federal aid allotted to any State shall be expended upon the primary or interstate highways until provision has been made for the improvement of the entire system of such highways: *Provided*, That with the approval of any State highway department the Secretary of Agriculture may approve the expenditure of more than 60 per centum of the Federal aid apportioned to such State upon the primary or interstate highways in such State.

The Secretary of Agriculture may approve projects submitted by the State highway departments prior to the selection, designation, and approval of the system of Federal-aid highways herein provided for if he may reasonably anticipate that such projects will become a part of such system.

Whenever provision has been made by any State for the completion and maintenance of a system of primary or interstate and secondary or inter-county highways equal to 7 per centum of the total mileage of such State, as required by this act, said State, through its State highway department, by and with the approval of the Secretary of Agriculture, is hereby authorized to add to the mileage of primary or interstate and secondary or intercounty systems as funds become available for the construction and maintenance of such additional mileage.

SEC. 7. That before any project shall be approved by the Secretary of Agriculture for any State such State shall make provisions for State funds required each year of such States by this act for construction, reconstruction, and maintenance of all Federal-aid highways within the State, which funds shall be under the direct control of the State highway department.

SEC. 8. That only such durable types of surface and kinds of materials shall be adopted for the construction and reconstruction of any highway which is a part of the primary or interstate and secondary or intercounty systems as will adequately meet the existing and probable future traffic needs and conditions thereon. The Secretary of Agriculture shall approve the types and width of construction and reconstruction and the character of improvement, repair, and maintenance in each case, consideration being given to the type and character which shall be best suited for each locality and to the probable character and extent of the future traffic.

SEC. 9. That all highways constructed or reconstructed under the provisions of this act shall be free from tolls of all kinds.

That all highways in the primary or interstate system constructed after the passage of this act shall have a right of way of ample width and a wearing surface of an adequate width which shall not be less than 18 feet, unless, in the opinion of the Secretary of Agriculture, it is rendered impracticable by physical conditions, excessive costs, probable traffic requirements, or legal obstacles.

SEC. 10. That when any State shall have met the requirements of this act, the Secretary of the Treasury, upon receipt of certification from the governor of such State to such effect, approved by the Secretary of Agriculture, shall immediately make available to such State, for the purpose set forth in this act, the sum apportioned to such State as herein provided.

SEC. 11. That any State having complied with the provisions of this act, and desiring to avail itself of the benefits thereof, shall by its State highway department submit to the Secretary of Agriculture project statements setting forth proposed construction or reconstruction of any primary or interstate, or secondary or intercounty highway therein. If the Secretary of Agriculture approve the project, the State highway department shall furnish to him such surveys, plans, specifications, and estimates therefor as he may require; items included for engineering, inspection, and unforeseen contingencies shall not exceed 10 per centum of the total estimated cost of its construction. That when the Secretary of Agriculture approves such surveys, plans, specifications, and estimates, he shall notify the State highway department and immediately certify the fact to the Secretary of the Treasury. The Secretary of the Treasury shall thereupon set aside the share of the United States payable under this act on account of such projects, which shall not exceed 50 per centum of the total estimated cost thereof, except that in the case of any State containing unappropriated public lands exceeding 5 per centum of the total area of all lands in the State, the share of the United States payable under this act on account of such projects shall not exceed 50 per centum of the total estimated cost thereof plus a percentage of such estimated cost equal to one-half of the percentage which the area of the unappropriated public lands in such State bears to the total area of such State: *Provided*, That the limitation of payments not to exceed \$20,000 per mile, under existing law, which the Secretary of Agriculture may make be, and the same is hereby, increased in proportion to the increased percentage of Federal aid authorized by this section: *Provided further*, That these provisions relative to the public-land States shall apply to all unobligated or unmatched funds appropriated by the Federal aid act and payment for approved projects upon which actual building construction work had not begun on the 30th day of June, 1921.

SEC. 12. That the construction and reconstruction of the highways or parts of highways under the provisions of this act, and all contracts, plans, specifications, and estimates relating thereto, shall be undertaken by the State highway departments subject to the approval of the Secretary of Agriculture. The construction and reconstruction work and labor in each State shall be done in accordance with its laws and under the direct supervision of the State highway department, subject to the inspection and approval of the Secretary of Agriculture and in accordance with the rules and regulations pursuant to this act.

SEC. 13. That when the Secretary of Agriculture shall find that any project approved by him has been constructed or reconstructed in compliance with said plans and specifications, he shall cause to be paid to the proper authorities of said State the amount set aside for said project.

That the Secretary of Agriculture may, in his discretion, from time to time, make payments on such construction or reconstruction as the work progresses, but these payments, including previous payments, if any, shall not be more than the United States pro rata part of the value of the labor and materials which have been actually put into such construction or reconstruction in conformity to said plans and specifications. The Secretary of Agriculture and the State highway department of each State may jointly determine at what time and in what amounts payments as work progresses shall be made under this Act.

Such payments shall be made by the Secretary of the Treasury, on warrants drawn by the Secretary of Agriculture, to such official or officials or depository as may be designated by the State highway department and authorized under the laws of the State to receive public funds of the State.

SEC. 14. That should any State fail to maintain any highway within its boundaries after construction or reconstruction under the provisions of this Act, the Secretary of Agriculture shall then serve notice upon the State highway department of that fact, and if within ninety days after receipt of such notice said highway has not been placed in proper condition of maintenance, the Secretary of Agriculture shall proceed immediately to have such highway placed in a proper condition of maintenance and charge the cost thereof against the Federal funds allotted to such State, and shall refuse to approve any other project in such State, except as herein after provided.

Upon the reimbursement by the State of the amount expended by the Federal Government for such maintenance, said amount shall be paid into the Federal highway fund for reappportionment among all the States for the construction of roads under this Act, and the Secretary of Agriculture shall then approve further projects submitted by the State as in this Act provided.

Whenever it shall become necessary for the Secretary of Agriculture under the provisions of this Act to place any highway in a proper condition of maintenance the Secretary of Agriculture shall contract with some responsible party or parties for doing such work: *Provided, however*, That in case he is not able to secure a satisfactory contract he may purchase, lease, hire, or otherwise obtain all necessary supplies, equipment, and labor, and may operate and maintain such motor and other equipment and facilities as in his judgment are necessary for the proper and efficient performance of his functions.

SEC. 15. That within two years after this Act takes effect the Secretary shall prepare, publish, and distribute a map showing the highways and forest roads that have been selected and approved as a part of the primary or interstate, and the secondary or intercounty systems, and at least annually thereafter shall publish supplementary maps showing his program and the progress made in selection, construction, and reconstruction.

SEC. 16. That for the purpose of this Act the consent of the United States is hereby given to any railroad or canal company to convey to the highway department of any State any part of its right of way or other property in that State acquired by grant from the United States.

SEC. 17. That if the Secretary of Agriculture determines that any part of the public lands or reservations of the United States is reasonably necessary for the right of way of any highway or forest road or as a source of materials for the construction or maintenance of any such highway or forest road adjacent to such lands or reservations, the Secretary of Agriculture shall file with the Secretary of the department supervising the administration of such land or reservation, a map showing the portion of such lands or reservations which it is desired to appropriate.

If within a period of four months after such filing the said Secretary shall not have certified to the Secretary of Agriculture that the proposed appropriation of such land or material is contrary to the public interest or inconsistent with the purposes for which such land or materials have been reserved, or shall have agreed to the appropriation and transfer under conditions which he deems necessary for the adequate protection and utilization of the reserve, then such land and materials may be appropriated and transferred

to the State highway department for such purposes and subject to the conditions so specified.

If at any time the need for any such lands or materials for such purposes shall no longer exist, notice of the fact shall be given by the State highway department to the Secretary of Agriculture, and such lands or materials shall immediately revert to the control of the Secretary of the department from which they had been appropriated.

SEC. 18. That the Secretary of Agriculture shall prescribe and promulgate all needful rules and regulations for the carrying out of the provisions of this Act, including such recommendations to the Congress and the State highway departments as he may deem necessary for preserving and protecting the highways and insuring the safety of traffic thereon.

SEC. 19. That on or before the first Monday in December of each year the Secretary of Agriculture shall make a report to Congress, which shall include a detailed statement of the work done, the status of each project undertaken, the allocation of appropriations, an itemized statement of the expenditures and receipts during the preceding fiscal year under this Act, an itemized statement of the traveling and other expenses, including a list of employees, their duties, salaries, and traveling expenses, if any, and his recommendations, if any, for new legislation amending or supplementing this Act. The Secretary of Agriculture shall also make such special reports as Congress may request.

SEC. 20. That for the purpose of carrying out the provisions of this Act there is hereby appropriated, out of the moneys in the Treasury not otherwise appropriated, \$75,000,000 for the fiscal year ending June 30, 1922, \$25,000,000 of which shall become immediately available and \$50,000,000 of which shall become available January 1, 1922.

SEC. 21. That so much, not to exceed 2½ per centum, of all moneys hereby or hereafter appropriated for expenditure under the provisions of this Act, as the Secretary of Agriculture may deem necessary for administering the provisions of this Act and for carrying on necessary highway research and investigational studies independently or in cooperation with the State highway departments and other research agencies, and for publishing the results thereof, shall be deducted for such purposes, available until expended.

Within sixty days after the close of each fiscal year the Secretary of Agriculture shall determine what part, if any, of the sums theretofore deducted for such purposes will not be needed and apportion such part, if any, for the fiscal year then current in the same manner and on the same basis as are other amounts authorized by this Act apportioned among all the States, and shall certify such apportionment to the Secretary of the Treasury and to the State highway departments.

The Secretary of Agriculture, after making the deduction authorized by this section, shall apportion the remainder of the appropriation made for expenditure under the provision of the Act for the fiscal year among the several States in the following manner: One-third in the ratio which the area of each State bears to the total area of all the States; one-third in the ratio which the population of each State bears to the total population of all the States, as shown by the latest available Federal census; one-third in the ratio which the mileage of rural delivery routes and star routes in each State bears to the total mileage of rural delivery and star routes in all the States at the close of the next preceding fiscal year, as shown by certificate of the Postmaster General, which he is directed to make and furnish annually to the Secretary of Agriculture: *Provided*, That no State shall receive less than one-half of 1 per centum of each year's allotment. All moneys herein or hereafter appropriated for expenditure under the provisions of this Act shall be available until the close of the second succeeding fiscal year for which apportionment was made: *Provided further*, That any sums apportioned to any State under the provisions of the Act entitled "An Act to provide that the United States shall aid the States in the construction of rural post roads, and for other purposes," approved July 11, 1916, and all Acts amendatory thereof and supplemental thereto, shall be available for expenditure in that State for the purpose set forth in such Acts until two years after the close of the respective fiscal years for which any such sums become available, and any amount so apportioned remaining unexpended at the end of the period during which it is available for expenditure under the terms of such Acts shall be reapportioned according to the provisions of the Act entitled "An Act to provide that the United States shall aid the States in the construction of rural post roads, and for other purposes," approved July 11, 1916: *And provided further*, That any amount apportioned under the provisions of this Act unexpended at the end of the period during which it is available for expenditure under the terms of this section shall be reapportioned within sixty days thereafter to all the States in the same manner and on the same basis, and certified to the Secretary of the Treasury and the State highway departments in the same way as if it were being apportioned under this Act for the first time.

SEC. 22. That within sixty days after the approval of this Act the Secretary of Agriculture shall certify to the Secretary of the Treasury and to each of the State highway departments the sum he has estimated to be deducted for administering the provisions of this Act and the sums which he has apportioned to each State for the fiscal year ending June 30, 1922, and on or before January 20 next preceding the commencement of each succeeding fiscal year, and shall make like certificates for each fiscal year.

SEC. 23. That out of the moneys in the Treasury not otherwise appropriated, there is hereby appropriated for the survey, construction, reconstruction, and maintenance of forest roads and trails the sum of \$5,000,000 for the fiscal year ending June 30, 1922, available immediately and until expended, and \$10,000,000 for the fiscal year ending June 30, 1923, available until expended.

(a) Fifty per centum, but not to exceed \$3,000,000 for any one fiscal year, of the appropriation made or that may hereafter be made for expenditure under the provisions of this section shall be expended under the direct supervision of the Secretary of Agriculture in the survey, construction, reconstruction, and maintenance of roads and trails of primary importance for the protection, administration, and utilization of the national forests, or, when necessary, for the use and development of resources upon which communities within or adjacent to the national forests are dependent, and shall be apportioned among the several States, Alaska, and Porto Rico by the Secretary of Agriculture, according to the relative needs of the various national forests, taking into consideration the existing transportation facilities, value of timber, or other resources served, relative fire danger, and comparative difficulties of road and trail construction.

The balance of such appropriations shall be expended by the Secretary of Agriculture in the survey, construction, reconstruction, and maintenance of forest roads of primary importance to the State, counties, or communities within, adjoining, or adjacent to the national forests, and shall be prorated and apportioned by the Secretary of Agriculture for expenditures in the several States, Alaska, and Porto Rico, according to the area and value of the land owned by the Government within the national forests therein as determined by the Secretary of Agriculture from such information, investigation, sources, and departments as the Secretary of Agriculture may deem most accurate.

(b) Cooperation of Territories, States, and civil subdivisions thereof may be accepted but shall not be required by the Secretary of Agriculture.

(c) The Secretary of Agriculture may enter into contracts with any Territory, State, or civil subdivision thereof for the construction, reconstruction, or maintenance of any forest road or trail or part thereof.

(d) Construction work on forest roads or trails estimated to cost \$5,000 or more per mile, exclusive of bridges, shall be advertised and let to contract.

If such estimated cost is less than \$5,000 per mile, or if after proper advertising no acceptable bid is received, or the bids are deemed excessive, the work may be done by the Secretary of Agriculture on his own account; and for such purpose the Secretary of Agriculture may purchase, lease, hire, rent, or otherwise obtain all necessary supplies, materials, tools, equipment, and facilities required to perform the work.

The appropriation made in this section or that may hereafter be made for expenditure under the provisions of this section may be expended for the purpose herein authorized and for the payment of wages, salaries, and other expenses for help employed in connection with such work.

SEC. 24. That in any State where the existing constitution or laws will not permit the State to provide revenues for the construction, reconstruction, or maintenance of highways, the Secretary of Agriculture shall continue to approve projects for said State until three years after the passage of this Act, if he shall find that said State has complied with the provisions of this Act in so far as its existing constitution and laws will permit.

SEC. 25. That if any provision of this Act, or the application thereof to any person or circumstances, shall be held invalid, the validity of the remainder of the Act and of the application of such provision to other persons or circumstances shall not be affected thereby.

SEC. 26. That all Acts or parts of Acts in any way inconsistent with the provisions of this Act are hereby repealed, and this Act shall take effect on its passage.

F. H. GILLETT,  
*Speaker of the House of Representatives.*  
CALVIN COOLIDGE,  
*Vice President of the United States and  
President of the Senate.*

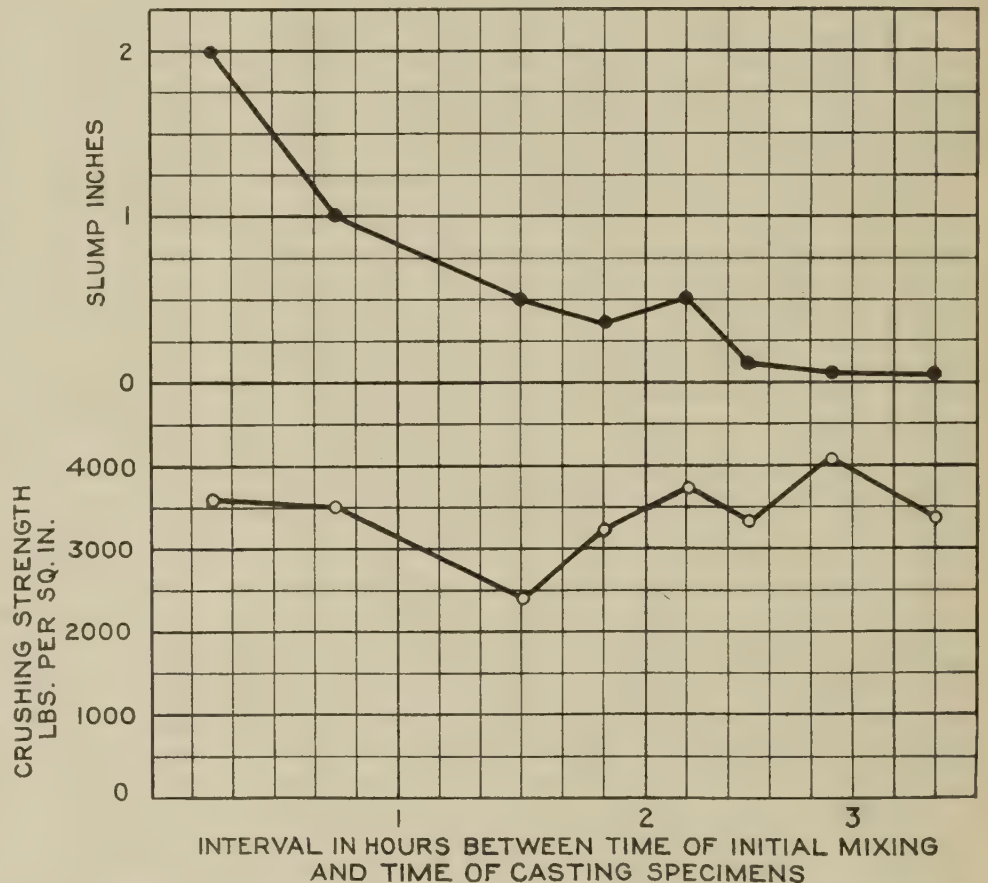
Approved November 9, 1921.

WARREN G. HARDING.

# CENTRAL-PLANT-MIXED CONCRETE TESTED FOR MAXIMUM SAFE HAUL

THE tests were made primarily for the purpose of determining the probable safe maximum length of haul for central-plant-mixed concrete to be used in the construction of a proposed experimental concrete road near Washington, D. C. The results are interesting, however, in a general way in that they show the relative strength and consistency of gravel concrete when hauled in a wet batch and tested at various periods of time up to three hours after initial mixing. The experiment was made in the following manner: Two batches of concrete in the proportion of 1:1½:3 were mixed in a stationary concrete mixing plant of 1 cubic yard capacity. Potomac River sand and gravel were used as aggregates, the latter graded from 1½ inches to ¼ inch in size. An effort was made to mix each batch to a consistency having a slump of about 2 inches as measured by the truncated cone.

After mixing, the concrete was dumped directly into a 3-ton truck, the wooden body of which had previously been divided into six compartments by means of transverse boards equally spaced and each about 1 foot high. The concrete in the two batches was dumped so that each of these six compartments contained approximately one-third of a cubic yard. After making a slump test and casting 6 inch by 12 inch cylindrical specimens for compression test, the truck was run for 30 minutes, when the contents of the first compartment were sampled for consistency and strength. The concrete in compartment No. 1 was not dumped at this time but was sampled in the truck, every effort being made to secure average samples. The truck was then run to the Arlington Experimental Station, a distance of 3 miles, where the contents of compartment No. 1 were dumped. Inasmuch as a dump body was not available for this experiment it was necessary to shovel out the concrete by hand. Its consistency at this point, however, was such that it came out readily and would probably have dumped easily from a regulation dump body. After removing the concrete from compartment No. 1, the truck was run about the station roads for 15 minutes, returned to the starting point and the contents of the second compartment deposited. Samples for both consistency and strength were likewise taken of this material, after which the operation of driving 15 minutes, dumping and sampling was repeated until all of the concrete had been deposited.



RESULT OF TESTS FOR CONSISTENCY AND CRUSHING STRENGTH OF CENTRAL-PLANT-MIXED CONCRETE.

The concrete had been mixed 3 hours and 10 minutes when the last section was removed. By this time it had become so hard that it was necessary to break it up with a pick. Up to section 6, however, it was possible to remove the concrete with shovels, and, although very dry, segregation had not become especially marked. This may probably be accounted for by the fact that the concrete was mixed fairly dry in the first place, the initial slump being only about 2 inches. It has been noted frequently that wet concrete will segregate more quickly and pack more readily during hauling than dry concrete.

### STRENGTH NOT AFFECTED SO LONG AS CONCRETE IS WORKABLE.

The results of the tests for consistency as well as the 28-day crushing strength tests are given in Table 1. They are also shown in figure 1, in which the slump in inches and the crushing strength in pounds per square inch at 28 days are plotted against the length of haul in hours. It will be noted that, whereas the concrete became very dry after about one hour's haul, the strength of the cylinders prepared from the various batches was about the same. In only one case was the strength much below the general average of 3,500 pounds per square inch. This was noted in the case of



TABLE 1.—Results of tests of central plant mixed concrete.

Compart- ment number.	Total elapsed time. <sup>2</sup>	Slump. <sup>3</sup>	Crushing strength, pounds per square inch. <sup>4</sup>		
			(1)	(2)	Average.
(1)	Hrs. min.	Inches.			
	15	2	3,620	3,510	3,565
1	45	1	3,460	3,550	3,505
1	1 30	1	2,670	2,200	2,435
2	1 50	1	3,510	2,960	3,235
3	2 10	1	3,820	3,580	3,700
4	2 25	1	3,110	3,550	3,330
5	2 45	1/5	3,840	4,230	4,035
6	3 10	1/6	3,300	3,370	3,335

<sup>1</sup> Test made at plant.<sup>2</sup> Time between initial mixing and sampling.<sup>3</sup> Test made with truncated cone 12 inches high and with top and bottom diameters of 4 and 8 inches, respectively.<sup>4</sup> Tests made on 6-inch by 12-inch cylinders of 1:1:3 concrete at age of 28 days.

the cylinders made from the concrete in compartment No. 1. Nothing in the appearance of the concrete at the time these cylinders were cast would account for the difference in strength. All of the specimens were made as nearly as possible in accordance with the recommended practice of the American Society for Testing Materials for taking field specimens of concrete, but as the concrete in the last three compartments was so dry as to show practically no slump it was necessary to use considerably more pressure in preparing the cylinders representing these sections.

The appearance of the concrete during the experiment would indicate that it could have been handled by a concrete pavement finishing machine at any period up to two hours after mixing. It became too dry for hand finishing, however, 45 minutes after mixing. Assuming that a wetter mixture would have segregated more quickly, especially with a gravel aggregate, the experiment indicates that the most practical way to utilize the central mixing plant in concrete road construction is in connection with a machine finisher. It also indicates that so long as the concrete is workable after a period of hauling, the strength will not be affected.

As previously noted, this experiment was made simply in order to obtain some idea of the behavior of certain aggregates when handled as central-plant-mixed concrete. It is the intention of the Bureau of Public Roads to make a somewhat extended investigation of this subject in the near future, using a variety of aggregates and consistencies.

(Continued from page 6.)

tire shown on the curve marked 39. In fact, the cushioning they show against impact is not as good as that shown by the dual solid tire equipment on the regular solid wheel, in curve No. 41. Referring, also, to the test results shown in figures 4 and 5, by curves marked 11-A and 11-B, it will be seen that there is no particular advantage in the cushion wheel. The wheels tested do not seem to offer cushioning that is of any practical advantage over the single solid-tire equipment on the ordinary rigid wheel, a test

of which is shown in curve No. 11. These results are not very surprising when considered in the light of the factors which enter into impact forces. To secure the proper strength and lateral rigidity, all parts of the cushion wheels must be made rather heavy. This, of course, adds to the value for mass in the impact formulæ and the addition is so great that it nearly or completely overcomes the effect of the added rubber cushion in the wheel. Under heavy loads, however, they do tend to show a slight advantage over the regular rigid-wheel equipment.

#### SOME SOLID AND CUSHION TIRES BETTER THAN CUSHION WHEELS.

The cushion wheel constructed with the six rubber cushions, tests of which are shown by the curves marked 33-A in figures 2 and 3, shows considerably more advantage than the other type of cushion wheel. These wheels with the tires mounted on them showed considerably more total static deflection than any other type of equipment except the pneumatic tire, and their construction was such that the weight of the wheel was not unduly increased. Though these wheels were rather flexible laterally no trouble was experienced in the operation of the truck.

In the light of the tests on these particular cushion wheels, it is seen that certain solid and cushion tires offer considerably more cushioning than the cushion wheel equipment. It should be remembered, however, that these tests refer to the impact delivered to the road surface and have no reference to the effect of the impact or vibration on the truck itself. No attempt was made to determine this; but several persons riding on the truck seemed to observe less severe shocks and vibration in the truck body.

The results presented in this and the former report are given solely for the purpose of making a comparison between the impact of trucks under different loads and with different tire and wheel equipment, taking into account the type of construction of the truck and its speed. The values shown give an idea of the maximum impact forces which may be expected under given conditions of truck traffic. No attempt is made to show the effect of these forces on different road surfaces. This effect has been studied in another investigation, a preliminary report of which has been made.<sup>1</sup>

#### INTERESTING FACTS ABOUT FOREST ROADS.

On the Klamath River road in California the average curvature amounts to six complete circles to the mile. Few tangents are as long as 200 feet. The contractor found the cheapest method of delivering culvert pipe a distance of 100 miles from the railroad to be by parcel post.

The Berthoud Pass road in Colorado crosses the Front Range at an elevation of 11,300 feet. A steam shovel was moved 15 miles under its own power up 15 per cent grades to start work at the highest point.

<sup>1</sup> Tests of Impacts on Pavements by the Bureau of Public Roads, Public Roads, October and November, 1921.

# STATUS OF FEDERAL AID OCTOBER 31, 1921.

WHAT the new Federal highway appropriation will mean to the country can be judged by the use to which the \$275,000,000 previously appropriated has been put. The report of the status of this fund on October 31 shows that practically \$200,000,000 had been put to work in projects which were either entirely completed or under construction. The exact amount was \$199,823,427. To match that amount the States have appropriated \$265,567,696, making a total of \$465,391,123.

The roads to be paid for by this money, if placed end to end, would encircle the earth at the Equator and extend as far as from New York to San Francisco on the second lap. The total mileage of roads under construction and completed was reported as 27,000 miles. Of

this mileage 9,555 miles was in projects which were entirely completed and the contractors discharged. The balance of 17,445 miles was in projects which were still under construction, but which were 69 per cent complete on October 31. In these projects there is the equivalent of 12,000 miles of completed road, so that the completed road to date totals over 21,000 miles, or nearly enough to encircle the globe.

Prior to five years ago the Federal Government took no active part in the road construction of the country. To-day about one-half of all roads that are being built are being aided by the Government financially, and the construction is subject to the inspection and approval of Federal engineers.

TABLE 1.—Financial statement as of October 31, 1921.

State.	Total apportionment of Federal aid.	Federal aid in work under construction and completed. <sup>1</sup>	Federal aid available for new contracts.	Federal aid in completed work. <sup>2</sup>	Federal aid in uncompleted work on projects under construction.	Amounts Federal aid paid States.	Balance Federal aid earned by States.
Alabama.....	\$5,776,552.58	\$2,740,986	\$3,035,567	\$1,916,875	\$824,111	\$1,539,411	\$377,464
Arizona.....	3,771,351.69	2,984,862	786,490	2,629,885	354,977	1,387,725	1,242,160
Arkansas.....	4,619,929.47	3,755,468	864,461	2,707,875	1,047,593	1,673,078	1,034,797
California.....	8,384,354.57	6,055,398	2,328,956	3,567,240	2,488,158	2,351,478	1,215,762
Colorado.....	4,780,064.14	3,351,641	1,428,423	2,424,576	927,065	1,921,340	503,236
Connecticut.....	1,689,324.70	1,059,823	629,502	697,366	362,457	479,267	218,099
Delaware.....	447,654.83	447,654	.....	439,554	8,100	414,022	25,532
Florida.....	3,150,112.48	2,715,064	435,048	1,362,508	1,352,556	600,055	762,453
Georgia.....	7,407,578.62	3,718,939	217,740	6,177,719	1,012,120	5,317,098	860,621
Idaho.....	3,360,388.86	3,272,145	88,244	3,030,488	241,657	2,332,307	698,181
Illinois.....	12,024,266.97	11,707,018	317,249	11,299,195	407,823	9,182,059	2,117,136
Indiana.....	7,415,292.61	2,914,125	4,501,168	2,291,935	622,190	2,254,141	37,794
Iowa.....	7,939,343.14	7,313,329	626,014	6,321,129	992,200	3,935,792	2,385,337
Kansas.....	7,895,309.07	5,718,479	2,176,830	3,956,453	1,762,026	3,038,079	918,374
Kentucky.....	5,370,064.79	3,678,927	1,691,138	2,595,789	1,083,138	2,122,253	473,536
Louisiana.....	3,742,524.57	3,643,982	98,543	3,121,154	522,828	2,712,205	408,949
Maine.....	2,645,963.57	2,579,528	66,436	1,938,527	641,001	925,779	1,012,748
Maryland.....	2,390,749.07	2,249,349	141,400	2,145,616	103,733	1,717,162	428,454
Massachusetts.....	4,052,565.09	2,407,847	1,644,718	2,109,088	298,759	1,082,214	1,026,874
Michigan.....	7,961,295.55	5,480,018	2,481,277	3,937,826	1,542,192	3,493,632	444,194
Minnesota.....	7,815,383.02	7,356,120	459,263	5,967,058	1,389,062	5,291,604	675,454
Mississippi.....	4,951,542.29	3,448,515	1,503,027	2,387,099	1,061,416	1,725,962	661,137
Missouri.....	9,322,075.71	4,951,728	4,370,348	3,054,675	1,897,053	2,031,031	1,023,644
Montana.....	5,498,827.31	3,823,260	1,675,558	3,277,147	546,122	2,594,649	682,498
Nebraska.....	5,866,761.66	3,881,287	1,985,475	3,641,145	240,142	2,627,594	1,013,551
Nevada.....	3,527,276.18	1,449,213	2,078,063	1,351,077	98,136	1,019,465	331,612
New Hampshire.....	1,143,088.99	1,102,480	40,609	1,001,010	101,470	861,007	140,003
New Jersey.....	3,265,299.02	1,746,819	1,518,480	1,448,867	297,952	1,014,133	434,734
New Mexico.....	4,389,794.61	2,349,347	2,040,448	1,622,365	726,982	1,493,287	129,078
New York.....	13,688,801.67	6,525,191	7,163,611	3,009,856	3,515,335	1,820,333	1,189,523
North Carolina.....	6,270,690.68	6,157,917	112,774	5,308,212	849,705	4,218,306	1,089,906
North Dakota.....	4,222,487.70	3,111,932	1,110,556	2,408,522	703,410	1,675,549	732,973
Ohio.....	10,202,947.71	7,057,920	3,145,028	6,364,354	693,566	5,015,063	1,349,291
Oklahoma.....	6,338,245.60	3,743,464	2,594,782	2,210,548	1,532,916	1,854,622	355,926
Oregon.....	4,332,178.26	4,268,076	64,102	4,054,679	213,397	3,440,004	614,675
Pennsylvania.....	12,632,644.29	11,463,738	1,168,906	10,553,739	909,999	6,978,628	3,575,111
Rhode Island.....	641,166.13	637,411	3,755	556,858	80,553	428,321	128,537
South Carolina.....	3,946,617.50	3,181,812	764,805	2,324,629	857,183	1,658,713	665,916
South Dakota.....	4,452,883.04	3,831,633	621,250	2,297,440	1,534,193	1,619,304	678,136
Tennessee.....	6,228,137.98	4,491,555	736,583	2,306,453	3,185,102	1,148,217	1,158,236
Texas.....	16,100,404.77	11,479,044	4,621,361	7,878,005	3,601,039	5,953,592	1,924,413
Utah.....	3,117,206.38	1,924,761	1,192,445	1,510,465	414,296	835,193	675,272
Vermont.....	1,242,103.73	674,908	567,196	599,178	75,730	432,354	166,824
Virginia.....	5,451,730.28	3,797,876	1,653,854	3,303,793	494,083	2,041,449	1,262,344
Washington.....	3,971,675.83	3,936,886	34,790	3,826,622	110,264	3,665,391	161,241
West Virginia.....	2,922,504.45	2,776,840	145,664	2,284,864	491,976	1,765,286	519,578
Wisconsin.....	7,004,280.67	5,532,666	1,471,615	4,215,648	1,317,018	2,961,960	1,253,688
Wyoming.....	3,378,558.17	2,855,537	523,021	2,188,174	667,363	1,835,003	353,171
Total.....	266,750,000.00	199,823,427	66,926,573	155,623,280	44,200,147	116,485,107	39,138,173

<sup>1</sup> Includes projects entirely completed and paid for.

<sup>2</sup> Includes completed portions of projects under construction.

<sup>3</sup> Reduction due to payment of final vouchers.

<sup>4</sup> Correction.

<sup>5</sup> Difference due to revision of project statement or agreement estimates.

<sup>6</sup> Reduction due to withdrawal or cancellation of projects.



## ROAD PUBLICATIONS OF BUREAU OF PUBLIC ROADS.

*Applicants are urgently requested to ask only for those publications in which they are particularly interested. The Department can not undertake to supply complete sets, nor to send free more than one copy of any publication to any one person. The editions of some of the publications are necessarily limited, and when the Department's free supply is exhausted and no funds are available for procuring additional copies, applicants are referred to the Superintendent of Documents, Government Printing Office, this city, who has them for sale at a nominal price, under the law of January 12, 1895. Those publications in this list, the Department supply of which is exhausted, can only be secured by purchase from the Superintendent of Documents, who is not authorized to furnish publications free.*

### REPORTS

- Report of the Director of the Bureau of Public Roads for 1918.
- Report of the Chief of the Bureau of Public Roads for 1919.
- Report of the Chief of the Bureau of Public Roads for 1920.
- Report of the Chief of the Bureau of Public Roads for 1921.

### DEPARTMENT BULLETINS.

- Dept. Bul. \*105. Progress Report of Experiments in Dust Prevention and Road Preservation, 1913. 5c.
- \*136. Highway Bonds. 25c.
- 220. Road Models.
- \*249. Portland Cement Concrete Pavements for Country Roads. 15c.
- 257. Progress Report of Experiments in Dust Prevention and Road Preservation, 1914.
- 314. Methods for the Examination of Bituminous Road Materials.
- 347. Methods for the Determination of the Physical Properties of Road-Building Rock.
- \*370. The Results of Physical Tests of Road-Building Rock. 15c.
- \*373. Brick Roads. 15c.\*
- 386. Public Road Mileage and Revenues in the Middle Atlantic States, 1914.
- 387. Public Road Mileage and Revenues in the Southern States, 1914.
- 388. Public Road Mileage and Revenues in the New England States, 1914.
- \*389. Public Road Mileage and Revenues in the Central, Mountain, and Pacific States, 1914. 15c.
- 390. Public Road Mileage in the United States, 1914. A summary.
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- \*537. The Results of Physical Tests of Road-Building Rock in 1916, Including all Compression Tests. 5c.
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- 586. Progress Reports of Experiments in Dust Prevention and Road Preservation, 1916.
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- \*691. Typical Specifications for Bituminous Road Materials. 15c.
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- \*724. Drainage Methods and Foundations for County Roads. 20c.
- 949. Standard and Tentative Methods of Sampling and Testing Highway Materials.
- \*Public Roads, Vol. II, No. 23. Tests of Road-Building Rock in 1919. 15c.
- Public Roads, Vol. IV, No. 11. Tests of Road-Building Rock in 1920.

### DEPARTMENT CIRCULAR.

- No. 94. TNT as a Blasting Explosive.

\*Department supply exhausted.

### FARMERS' BULLETINS.

- F. B. 338. Macadam Roads.
- 505. Benefits of Improved Roads.
- 597. The Road Drag.

### SEPARATE REPRINTS FROM THE YEARBOOK.

- Y. B. Sep.\*727 Design of Public Roads. 5c.
- 739. Federal Aid to Highways.
- 849. Roads.

### OFFICE OF PUBLIC ROADS BULLETINS.

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