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Vehicles and its effects on their
Design and operation.

By

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Printed in U.S.A.

PREPRINT.-- Paper to be presented at the Transportation Meeting of the Society of Automotive Engineers at Toronto, Canada, October 4 to 6, 1932. Printed to stimulate written or oral discussion. Subject to revision for errors before final publication. All papers presented at meetings of the Society are the exclusive property of the Society, from which permission to publish this paper, in full or in part, after its presentation and with credit to the author and the Society, can be obtained upon request.

Legislative Regulation of Motor Vehicles and
Its Effect on Their Design and Operation

By

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Abstract

The dangers of excessive taxation and drastic regulations as affecting the design and operating practice of motor vehicles is brought out in this paper. With constantly mounting tax burdens placed on motor vehicles, will excessive gasoline taxes eventually affect the design of passenger cars following European practice?

However, this paper deals primarily with restrictive regulations concerning sizes and weights of commercial vehicles. Through recent enactment of state regulations four million dollars worth of truck equipment has been outlawed in the State of Texas, and Kentucky operators are facing a loss of over two million dollars brought about by enforcement of the new length and weight law.

A Uniform Code, when and if adopted by all states, would simplify manufacturers and operators problems. However, the nationwide anti-truck propaganda will result in additional shuffling and juggling of state regulatory measures with 44 state legislatures scheduled to convene in 1933.

Recent laws passed in Indiana and Illinois are of great influence in bringing about radical changes in design of motor trucks in order to enable operators to carry maximum payload within the new length and weight restrictions.

LEGISLATIVE REGULATION OF MOTOR VEHICLES AND
 ITS EFFECT ON THEIR DESIGN AND OPERATION

The trend of legislative regulation and its effect on design and operation of motor vehicles presents a problem for manufacturers and operators more acute at this time than at any time in the history of the automotive industry.

Regardless of engineering research and efficient development in highway transport vehicles from the standpoint of performance ability and reduction in the cost of operation, and regardless of the great achievements in improving the methods and reducing the cost of building good highways, legal regulations prevent the general public from deriving the utmost benefits from the progress which has been made by these two branches of engineering.

While legislative regulations have not as yet affected the design of passenger cars, curtailment of usage is already in evidence in those states where gasoline taxes have reached exorbitant levels. United States vehicle registrations show that in 1931 the use of passenger cars was reduced by 711,462 vehicles as compared with 1930 figures. No doubt our depression period has been partly responsible for this loss in registrations, yet official statistics show that in those states imposing a low tax on gasoline, vehicle registrations actually increased regardless of the depression. It is also interesting to note that the percentage of vehicle registrations gradually decreased in the states with higher gasoline taxes.

Fig. No. 1

U. S. VEHICLE REGISTRATIONS 1931

State Gas Tax	Vehicle Registrations	
	Increase	Decrease
2 ¢.....	1.8 %	
3 ¢.....		1.0 %
4 ¢.....		2.3 %
5 ¢.....		7.5 %
6 ¢.....		13.2 %

High cost of gasoline has exerted a strong influence on design of passenger cars in European countries and while the average tax on gasoline for the United States at this time is approximately 5-1/7 cents per gallon, in certain localities this particular tax has become an unbearable burden to many people. In Mobile, Alabama, for instance, motorists pay a tax on gasoline amounting to 11 cents per gallon.

Fig. No. 2

1932 GASOLINE TAXES IN MOBILE, ALABAMA

Federal Tax.....	1 ¢
State Tax.....	5 ¢
County Tax.....	3 ¢
City Tax.....	2 ¢
TOTAL TAX....	11 ¢

1932 U.S. Average Gas Tax For All States..... ¢.0514

The frantic search by our governmental bodies for new sources of taxation may eventually affect the design of passenger cars in this country, the same as high taxes have forced European manufacturers to produce light weight cars with higher gasoline mileage.

We are concerned here primarily, however, with existing regulations and their effects on design and operation of the heavier vehicles, namely, buses, trucks and trailers, and while this is not the time nor the place to discuss the motives prompting the proposals of drastic restrictive regulations with which our state legislatures are being flooded, it is an opportune time to state that, unless the activities of the selfish propagandists behind this nationwide movement are curbed, the year of 1933 with 44 state legislatures scheduled to be in session will bring about the most critical situation ever faced by the automotive industry.

Based on legislative enactments during 1932, no one can foretell at this time to what extent the juggling and shuffling of state motor vehicle laws will affect our industry, both manufacturers and operators. Bills are being written by railroad lawyers for regulating highway transport to the extent of confiscation and elimination of a competitor in the transportation business, and these bills are being supported by the organized forces of twenty-one railroad labor unions actively engaged in circulating petitions to present in every state legislature scheduled to meet next year. Regardless of facts and figures established by the U.S. Bureau of Public Roads on highway construction and regardless of facts developed showing the value of highway transportation to our industries, our farmers and the consumer, the proponents of drastic regulations have so far exhibited the utmost disregard for uniformity in size and weight regulations, and as the actual picture stands today, we have forty-nine different sets of state regulations differing in some manner from neighboring states.

If a uniform code controlling sizes and weights, along the lines as submitted by the U.S. Bureau of Public Roads, could be put into effect in all states, existing design and operating practices would be simplified, resulting in lower manufacturing costs and greater economies in operation.

WIDTH REGULATIONS

Fig. No. 3

In dealing with legal limitations prescribing maximum sizes of vehicles, we find that a fair degree of uniformity is apparent in the width regulations, the 96" width limit being in effect in the majority of states.

Massachusetts has the most practical law with a basic 96" vehicle limit, but permits 102" width from outside to outside of dual pneumatic tires.

Enforcement of the 96" law frequently results in complications for the operator, regardless of the fact that the manufacturing limits complied with the 96" legal regulation. This is due to the peculiarity of a balloon tire growing with age and also the low air pressure causing bulging at the bottom. Unless a provision is made in the legal regulations wherein a slight increase over the legal limit caused by INFLATION, DEFLECTION, WEAR or BULGING of balloon tires shall not be considered an infraction of the law, the manufacturers of motor buses and trucks will be compelled to provide a maximum width limit of less than 96" on new vehicles when measured from outside to outside of balloon tires.

Fig. No. 4

Important changes in vehicle design are necessary to permit dualling the larger sizes of balloon tires. If the 96" width limit is strictly enforced, we must either reduce the width of the frame to impractical dimensions, or locate the rear springs into a position partially under the frame. If we move the springs to an under-frame position and the top of frame is to be kept within practical height from the ground, the rear springs must be placed under the axle. In any event this change in design requires a special axle housing design and the distance from center to center of spring saddles is reduced from 40" to 34", decreasing the stability of the vehicle in relative proportion.

Changes in rear spring suspension brackets for attachment to frame also must be made in order to provide adequate vertical clearance between frame and axle housing when springs are deflected.

Fig. No. 5

1931 U.S. ACCIDENT STATISTICS PER 100,000 POPULATION

<u>STATES</u>	<u>ACCIDENTS</u>	<u>LEGAL VEHICLE WIDTH</u>
Florida	34.4	84 In.
Rhode Island	16.7	102 In.
<u>CITIES</u>	<u>ACCIDENTS</u>	<u>LEGAL VEHICLE WIDTH</u>
Miami (Fla.)	52.4	84 In.
Toledo (Ohio)	40.4	96 In.
Bridgeport (Conn.)	40.1	102 In.

From the standpoint of safety on the highway, statistics compiled by the Department of Commerce definitely indicate that the width of vehicles does not affect accidents or highway hazards. Florida with an 84" width limit shows a much higher rate of motor vehicle accidents, namely, 34.4 per 100,000 population as against Rhode Island's accident record of 16.7. Rhode Island allows a width of 102".

Accidents in individual Florida cities as compared with Bridgeport, Conn. also show a higher ratio of vehicle accidents: Miami 52.4, Jacksonville 42.5, and Bridgeport, Conn. 40.1. Connecticut also allows 102" width as compared with Florida's 84".

Fig. No. 6

MASSACHUSETTS WIDTH LAW PROVIDES:

The 96" limit may be exceeded by the lateral projection of pneumatic tires beyond the rims of the wheels for such a distance on either side of the vehicle as will not increase its outside width above 102".

From the standpoint of design and operation, the Massachusetts law is the most practical, and in line with the rapid progress made in the general use of the balloon tire.

HEIGHT REGULATIONS

Fig. No. 7

There is a wide variation in height restrictions, but the majority of states permit $12\frac{1}{2}$ feet and over, with only 12 states having laws in effect limiting vehicle height to less than $12\frac{1}{2}$ feet.

While height regulations have not as yet appreciably affected the design of vehicles, yet with a precedent established in Kentucky this year limiting maximum height to $11\frac{1}{2}$ feet, and even more stringent regulations in prospect for 1933, we may have to come to drop frames and other important design changes for certain vocations to keep the overall loading height within the law.

In view of the majority of states allowing heights greater than twelve feet, and in view of certain types of specialized vocational vehicles requiring a height of $12\frac{1}{2}$ feet, it is obvious that a height limitation of $12\frac{1}{2}$ feet or 150 inches would be a more desirable standard to adopt in a uniform code.

Attention is also called to the fact that certain types of road building machinery transported from and to highway construction jobs on trailers of special design require a slightly greater clearance under bridges than the 12 feet height as now recommended in the National Safety Code.

LENGTH REGULATIONS - SINGLE VEHICLE

Fig. No. 8

A 35 foot length as recommended in the proposed Uniform Code is entirely adequate and practical for a single vehicle unit. Present regulations in effect show a wide variation and there is urgent need for arriving at a standard uniform length limit throughout the United States.

With present lack of uniformity and limitations ranging from $26\frac{1}{2}$ feet up to 40 feet, vehicles used for interstate transportation must necessarily be held within the minimum length regulations. Up to the present time, legal length restrictions for single vehicles have not materially affected the design of single unit vehicles but our industry is on the threshold of radical design changes of the single vehicle unit for use in combinations of vehicles.

Fig. No. 9

From a humorous angle, telescoping frames, adjustable wheelbases and accordion type bodies have been suggested as a solution to enable interstate operators crossing our state boundary lines and comply with existing and constantly changing state laws.

TRACTOR-SEMI TRAILER

The first step necessary to clarify the status of the most commonly used combination of vehicles is to determine if a tractor and semi trailer shall be considered as a single unit, or a combination of two units. A typical example of im-

practical regulations in 5 neighboring states is found in the laws of Illinois, Indiana, Michigan, Ohio and Kentucky.

Fig. No. 10 LENGTH REGULATIONS FOR TRACTOR AND SEMI-TRAILER

<u>States</u>	<u>Considered As</u>	<u>Legal Length Limits</u>	
		<u>Semi-Trailer Only</u>	<u>Total Length</u>
Illinois	1 Unit	None	35 Ft.
Indiana	2 Units	35 Ft.	40 Ft.
Ohio	2 Units	50 Ft.	None
Michigan	2 Units	None	60 Ft.
Kentucky	1 Unit	None	30 Ft.

While Illinois and Kentucky classify a tractor and semi trailer as one single unit, in the other 3 states they are considered as a combination of 2 units. For registration and licensing purposes, it is desirable that a tractor and semi trailer be classified as two single units. In transporting certain classes of bulky light weight materials, where loading space is an important factor, the basic 35 foot length as recommended for the single vehicle is also highly desirable and practical for controlling the length of the semi trailer.

Fig. No. 11

Various design changes have been made to fit a tractor semi trailer to the regulations of different state laws, but no standard design practice can be established until the legal situation becomes more definitely clarified. Operators demand maximum loading space within legal limits. With 35 foot single unit basic length, it is obvious that the additional length for the tractor brings the total overall length of the conventional type tractor semi-trailer combination up to 45 feet minimum and up to 50 feet where sleeper cab and spare tire back of cab increase the length of tractor ahead of semi trailer body. Even with reduced cab length, obtained by placing cab over engine, it is impossible to hold the overall length of a tractor semi trailer within 40 feet, if basic 35 feet single unit length is applied to the semi trailer. Forty-five feet is a more practical length for a tractor semi trailer combination.

COMBINATION LENGTHS

Fig. No. 12

A great variation is apparent in legal length limitations for combinations of vehicles ranging from 30 to 85 feet for the different states.

A 65 foot maximum length limit, as recommended for the proposed uniform code, is entirely practical for all ordinary hauling requirements and there is no truck operation that we know of where a length of 85 feet is required except for hauling steel girders, timbers, telephone poles or such commodities as cannot be reasonably transported without being dismantled, and to cover such exceptions, provisions should be made in the laws for a special annual permit for one or more vehicles operated by the same applicant.

Last year, Indiana and Illinois passed laws limiting the length of vehicle combination to 40 feet. Attempting to meet the legal limitations in these two important truck markets, our first problem consists of providing adequate loading

space for a truck and four wheel trailer within the maximum overall length of 40 feet.

Fig. No. 13

Assuming a distance of 9' 3" from bumper to back of cab, plus 3' 9" of space required between the two bodies, there remains a total of only 27' for useful body load space, 14' for truck and 13' for the trailer body.

For tank trucks or hauling heavy materials such as coal, gravel, cement, etc. sufficient load space is available, but for furniture moving and transporting general merchandise, also many other vocations, it is obvious that body lengths are too short to meet practical loading requirements.

To meet this situation, truck manufacturers are compelled to make changes as illustrated in Figure No. 13. In this design, cab is located over the engine within a distance of only 5' 7" from bumper to back of cab. This allows a body length of 16' 4" for the truck and 14' 4" for the trailer within the overall legal limit of 40'.

Design changes involve the following major problems:

- (a) Shortening distance between front bumper and back of cab
- (b) Increasing carrying capacity of front axle and front springs
- (c) Changes in steering gear mounting
- (d) Changes in control levers
- (e) Development of new cab.

This new design not only results in a gain in body load space, but also provides for better load distribution utilizing full carrying capacity of front tires. This phase will be discussed in the "Weight" section.

NUMBER OF VEHICLES IN A COMBINATION

With the modern type of trailer design in which side swaying has been reduced to a minimum, there is no practical reason why 3 units should be considered excessive.

Fig. No. 14

From the standpoint of hazard on the highway, three vehicles coupled together have a shorter turning radius than two long vehicles within the same overall combination length. In certain vocations, it is highly desirable to split the load in a greater number of units, especially in the hauling of milk from the farms to the city. In Michigan, for instance, an average of 2,000,000 pounds of milk per day is brought into the city of Detroit by vehicle combinations of one truck and two trailers.

This milk is being brought in from territories not served by railroads or any other means of transportation. The truck pulling two empty four-wheel trailers on its outbound trip drops the last trailer at the first milk collecting station, continues on its route for another 15 or 20 miles, uncouples the other trailer and proceeds to the collecting station at the extreme end of the route, where it takes on its load of milk and on the return trip picks up the two loaded trailers.

Fig. No. 15

This chart shows how unreasonable restrictions on the length of vehicles will have a serious effect on the dairy farmer. For instance, if the Kentucky law prohibiting trailers were applied in the state of Michigan the cost of transportation would make it prohibitive to transport milk by truck into the city of Detroit from a distance greater than 45 miles, whereas at the present time, milk produced on dairy farms located as far as 125 miles from the city of Detroit is being transported economically by these truck and trailer combinations.

The development of the transportation of milk in the state of Michigan may be an exception to the rule, but in order to cover such exceptions it is obvious that the wording in a recommended uniform code should read: "NOT MORE THAN THREE UNITS" instead of "NOT MORE THAN TWO UNITS".

Fig. No. 16

Highway congestion is affected by length regulations. One truck with two trailers carrying 30 tons payload as allowed by Michigan law would occupy a maximum space on the highway of 65 feet. It would require 15 two-ton trucks to carry this load - each truck 20 feet long and with the necessary intervening space of 200 feet between each two vehicles, these 15 two-ton trucks would occupy a total length of 3,100 feet on the highway, as compared with the one combination 65 feet long.

SPEED REGULATIONS

Fig. No. 17

CONNECTICUT BRAKE LAW

<u>MILES PER HOUR SPEED</u>	<u>SERVICE BRAKES</u>	<u>EMERGENCY BRAKES</u>	<u>EMERGENCY BRAKES ON TRUCKS OVER 2 TON CAP.</u>
20	40 Ft.	60 Ft.	80 Ft.
25	70 Ft.		
30	100 Ft.		
35	140 Ft.		
40	175 Ft.		

Power brakes permit heavy vehicles to decelerate within

SAFE STOPPING DISTANCE

We are entirely in accord with the U.S. Bureau of Public Roads recommendations on legal speed limits and a complete revision of truck speed laws in most states is highly desirable as the majority of laws in effect now for the purpose of controlling speed of commercial vehicles were formulated in the days of solid tires and gravel roads.

With the faster speed of modern commercial vehicles made possible by six cylinder engines, balloon tires, the question of stopping ability is highly im-

portant, and power brakes are now standard equipment on most all heavy duty vehicles. Unless the speed regulation phase of legal activities is carefully watched we may have to contend with impractical regulations such as have been contemplated in at least one state, namely, prescribing by law a minimum number of square inches of braking surface per 1000 pounds of vehicle gross weight. Such regulations would stifle research and progress in the design of brakes.

From the safety standpoint, regulations now in effect in the State of Connecticut, where safe stopping distances are required by law for motor vehicles of various types traveling at various speeds, are very practical.

Under this regulation, vehicles must have braking systems in good working order at all times, and Uniform Speed Regulations must necessarily be based on deceleration ability of vehicles. Sixteen states now require trailers to be equipped with power brakes. It is safe to assume that when the 44 legislatures in 1933 are adjourned, similar legal regulations will be in effect in most all of the states.

Fig. No. 18 Report by the National Safety Council
 on Vehicle Accidents last 4-1/2 years
 show that Fatalities caused by

Passenger Cars INCREASED	-----	59 %
Commercial Vehicles DECREASED		31 %

Efficient Maintenance Methods and Driver
 Training Contribute to Safety of Commer-
 cial Vehicles on the Highway.

Highway safety of commercial vehicles can best be estimated by comparing accident records as reported by National Safety Council for the last 4-1/2 years. While passenger car fatalities increased during this period by 59%, the safety record of trained truck and bus drivers shows a decrease of 31% for commercial cars.

INTERPRETATION OF GROSS WEIGHT REGULATIONS FOR FOUR WHEEL TRUCK AND SINGLE AXLES

Fig. No. 19

A tabulation of four wheel vehicle permissible gross weights and single axle gross weight limitations presents an extremely complicated picture.

Gross weights as shown in Chart are based on the states' interpretations of their laws and on physical limitations of vehicle design and tire capacity. Maximum gross vehicle weights as shown for the four wheel truck have been computed on the basis of front axle weight being not in excess of 1/2 of the rear axle weight, resulting in a 1/3 and 2/3 gross weight distribution.

For instance, while New York allows a gross weight of 36,000 pounds for a four wheel truck, the maximum axle weight is 22,400 pounds for rear axle and one-

half of the axle limitation maximum figures 11,200 pounds for the front axle, or a practical maximum gross weight of 33,600 pounds vehicle gross weight.

The almost universal adaptation of the pneumatic tire and impractical legal weight regulations have created problems for the operators which perhaps have not received sufficient attention from designing engineers and no consideration whatsoever from the legislators.

Uniformity of tire equipment, front and rear, on a four-wheel truck, and carrying maximum payload permissible by law, are demanded by the operators. With dual tires on rear wheels and single tires at the front, it is obvious that with uniformity of tire size a weight distribution of $\frac{2}{3}$ on the rear axle and $\frac{1}{3}$ on the front axle results in the most practical tire equipment and most economical weight distribution from the operator's standpoint.

Basic gross weights for four wheel truck range from 33,600 pounds in New York to 16,000 pounds for Florida. The Texas and Louisiana 7,000 pounds payload law brings the gross weight to 14,000 pounds and even less, depending upon chassis and body weight variations.

Fig.No. 20

GROUP 1

State	Legal Weight Limits		Weight Distribution With $\frac{1}{3}$ Frt. and $\frac{2}{3}$ Rear		
	Max.Gross	Max.Per Axle	Front	Rear	Total
New York	36,000	22,400	11,200	22,400	33,600
Rhode Island	32,000	22,400	10,666	21,334	32,000
Connecticut	32,000	-----	10,666	21,334	32,000
Dist.of Col.	30,800	24,640	10,266	20,534	30,800
Colorado	30,000	20,000	10,000	20,000	30,000
Massachusetts	30,000	-----	10,000	20,000	30,000
New Jersey	30,000	-----	<u>10,000</u>	<u>20,000</u>	<u>30,000</u>
Axle and Gross Weight Averages-----			11,260	20,800	31,200

The nearest we can come to any semblance of uniformity in weight distribution and observe legal restrictions is by grouping those states having somewhat similar gross vehicle and axle weight regulations. According to such an interpretation, the state restrictions fall into six distinct capacity groups and each one of these groups has been tabulated showing the maximum gross vehicle weight of a four wheel truck with rear axle weighing $\frac{2}{3}$ and front axle load being $\frac{1}{3}$ of total gross vehicle weight. It will be noted that in some cases the result of this interpretation shows a lower gross vehicle weight than that allowed by law. In those cases the maximum permissible axle load is the controlling factor, and the gross vehicle weight has been arrived at by allowing a front axle weight equivalent to only $\frac{1}{2}$ of the maximum legal weight applicable to the rear axle. The front axle weights as shown in Group No. 1 may seem excessive for manual steering control, yet these problems have been solved on our large buses where front axle weights frequently range up to 12,000 pounds. In this group of 7 states, average front axle weight is 11,260 pounds, average rear axle weight 20,800 pounds and average gross vehicle weight 31,200 pounds.

Fig. No. 21
GROUP 2

STATE	Legal Weight Limits		Weight Distribution With 1/3 Front and 2/3 Rear		
	Max. Gross	Max. Per Axle	Front	Rear	Total
Kansas	28,000	18,500	9,250	18,500	27,750
Michigan	-----	18,000	9,000	18,000	27,000
Minnesota	36,000	18,000	9,000	18,000	27,000
New Mexico	36,000	18,000	9,000	18,000	27,000
Wyoming	30,000	18,000	9,000	18,000	27,000
Delaware	26,000	18,000	8,666	17,334	26,000
Pennsylvania	26,000	18,000	8,666	17,334	26,000
Utah	26,000	18,000	8,666	17,334	26,000
Oregon	600(L+40)	17,000	8,500	17,000	25,500
Maryland	25,000	-----	8,333	16,667	25,000
Nevada	25,000	-----	8,333	16,667	25,000
Axle and Gross Weight Averages-----			8,765	17,535	26,300

Group No. 2 shows 11 states with fairly uniform regulations, not neighboring states, however, but grouped according to a similarity of vehicles required to best meet existing weight regulations. In these 11 states, average weight for front axle figures 8,765 pounds, average rear axle weight 17,535 pounds and average gross vehicle weight 26,300 pounds.

Fig. No. 22
GROUP 3

STATE	Legal Weight Limits		Weight Distribution With 1/3 Front and 2/3 Rear		
	Max. Gross	Max. Per Axle	Front	Rear	Total
Fla. (Carrier)	24,000		8,000	16,000	24,000
Idaho	24,000	16,000	8,000	16,000	24,000
Illinois	24,000	16,000	8,000	16,000	24,000
Indiana	24,000	16,000	8,000	16,000	24,000
Iowa	24,000	16,000	8,000	16,000	24,000
Maine	24,000	18,000	8,000	16,000	24,000
Missouri	24,000	16,000	8,000	16,000	24,000
Montana	24,000	16,800	8,000	16,000	24,000
Nebraska	-----	16,000	8,000	16,000	24,000
North Dakota	32,000	16,000	8,000	16,000	24,000
Ohio	24,000	18,000	8,000	16,000	24,000
Virginia	24,000	16,000	8,000	16,000	24,000
Washington	24,000	18,500	8,000	16,000	24,000
West Virginia	32,000	16,000	8,000	16,000	24,000
Wisconsin	24,000	19,000	8,000	16,000	24,000
Louisiana	14,000 Lbs. Payload for trucks serving railroads				
Texas	14,000 Lbs.	"	"	"	"
Axle and Gross Weight Averages-----			8,000	16,000	24,000

The third group includes 15 states where either the 24,000 pound gross vehicle limit or the 16,000 pound axle weight limit are dominant factors. Additional states may come within this classification next year, as the legislative trend is toward this class of vehicle. Interpretation shows that weights are uniform in these 15 states - 8,000 pounds front axle and 16,000 pounds rear axle. In addition to these 15 states, Texas and Louisiana, with a 14,000 pound net weight law for trucks serving railroad freight stations, also can be considered to partly belong in this classification, bringing the group up to a total of 17 states.

Fig.No.23

GROUP 4

STATE	Legal Weight Limits		Weight Distribution With 1/3 Front and 2/3 Rear		
	Max.Gross	Max.Per Axle	Front	Rear	Total
South Car.	25,000	15,000	7,500	15,000	22,500
Arkansas	-----	14,820	7,410	14,820	22,230
Arizona	22,000	18,000	7,333	14,667	22,000
California	22,000	17,000	7,333	14,667	22,000
Georgia	22,000	17,600	7,333	14,667	22,000
Axle and Gross Weight Averages-----			7,382	14,764	22,106

Group No. 4 includes only 5 states with 7,382 pounds average front axle capacity and 14,674 pounds rear. Difference between maximum and minimum front axle weights is only 167 pounds - difference for rear axle 333 pounds - and difference in total vehicle gross weight 500 pounds.

Fig.No.24

GROUP 5

STATE	Legal Weight Limits		Weight Distribution With 1/3 Front and 2/3 Rear		
	Max.Gross	Max.Per Axle	Front	Rear	Total
New Hampshire	20,000	15,000	6,666	13,334	20,000
Oklahoma	20,000	16,000	6,666	13,334	20,000
South Dakota	20,000	16,000	6,666	13,334	20,000
Tennessee	20,000	18,000	6,666	13,334	20,000
Vermont	20,000	-----	6,666	13,334	20,000
North Carolina	20,000	-----	6,666	13,334	20,000
Alabama	24,000	12,000	6,000	12,000	18,000
Kentucky	18,000	-----	6,000	12,000	18,000
Mississippi	24,000	12,000	6,000	12,000	18,000
Axle and Gross Weight Averages-----			6,444	12,889	19,333

Group No. 5 includes 9 states with gross vehicle weights from 18 to 20,000 pounds - maximum variation of 666 pounds front axle weight and 1334 pounds difference in rear axle. Average front axle weight 6,444 pounds - average rear axle weight 12,889 pounds and average gross vehicle weight 19,333 pounds.

Fig.No.25
GROUP 6

STATE	Legal Weight Limits		Weight Distribution With 1/3 Front and 2/3 Rear		
	Max.Gross	Max.Per Axle	Front	Rear	Total
Fla.(Private)	16,000	-----	5,333	10,667	16,000
Wisc.(Class B Highways)	15,000	12,000	5,000	10,000	15,000
Texas	7,000 Lbs. Payload		4,500	9,000	13,500
Louisiana	7,000 Lbs. Payload		<u>4,500</u>	<u>9,000</u>	<u>13,000</u>
Axle and Gross Weight Average		-----	4,833	9,667	14,500

In Group No. 6, we only have 4 states. Florida legal restrictions for vehicles privately owned allow 16,000 pounds gross. Wisconsin on Class B highways allows 15,000 pounds gross weight. Texas and Louisiana limit trucks passing more than one railroad station to a 7,000 pound payload. In these 2 states, the gross vehicle weight, of course, will vary according to the type and weight of the body. For these 2 states, we have assumed a chassis and body weight of 6,500 pounds plus the 7,000 pounds legal payload, or a total gross weight of 13,500 pounds.

Fig.No.26

While these problems seem very important for designing engineers and operators, to the humorist the solution is quite simple. A sliding weight over the front and a balloon to reduce the weight at the rear have been suggested as standard equipment for the heavier trucks, so axle loads can be adjusted according to law when crossing our state border lines.

Fig. No.27

The problem of carrying maximum payload on a four wheel truck on pneumatic tires within legal weight regulations, can only be solved by shifting more of the payload toward the front. This results in the same type of design as that required for obtaining adequate body load space with the Indiana and Illinois length regulations of 40 feet for a four wheel truck and a four wheel trailer combination.

As long as solid tires were standard equipment on motor trucks and many of the states allowing 22,400 pounds on the rear axle, a gross weight distribution of 80% on rear and 20% at the front was entirely practical. However, balloon tires, restrictive size and weight regulations demand elimination of waste load space and a more economical load distribution.

With tires of uniform size, single front and dual rear, the logical answer for carrying maximum payload on the most economical tire equipment is a 1/3 and 2/3 load distribution factor incorporated in the design of the vehicle.

Fig. No.28

The major design problem involves the shortening of distance from the front bumper to back of cab with the following modifications of present standard design practice:

- A. Increase carrying capacity of front axle
- B. Increase carrying capacity of front springs
- C. Complete re-designing of steering mechanism
- D. Re-location of all controls
- E. New cab design.

EFFECTS OF VEHICLE TRAVEL ON HIGHWAYS

Digressing for a moment from the subject of legislative effect on vehicle design, it may be of interest to present a few facts on how vehicle travel effects highway construction. Bulletin No. 28 recently issued by the American Road Builders' Association contains a report covering a most exhaustive study of 6,700 miles of concrete pavement in 11 different states.

Particular attention was given in this study to cracking of concrete pavement slabs for the reason that road builders consider cracking as primary evidence of weakness or deterioration. The report states as follows: "THE SUMMARY OF SUCH STUDIES DID NOT SHOW ANY DEFINITE OR CONSISTENT INFLUENCE OF TRAFFIC ON TRANSVERSE CRACKING WHERE THE CROSS SECTIONS USED WERE ADEQUATE TO CARRY THE LOADS IMPOSED ON THEM".

Fig. No. 29

In close proximity to our Factory in Pontiac, we had occasion to make a survey of the effects of vehicle traffic on concrete pavements on U. S. Highway No. 10 between Detroit and Pontiac. Part of this highway was constructed over 7 years ago and due to right-of-way litigation a 500 foot concrete pavement section in this highway has never been subjected to vehicle traffic of any kind for 7 years, yet this particular untravelled section of pavement shows an extremely high percentage in lineal feet of transverse cracks, as compared with the remaining part of this highway bearing the heaviest kind of traffic during these 7 years.

Our Michigan law allows 18,000 pounds per axle on solid tires. Truck trailer trains weighing up to 100,000 pounds gross are travelling this highway day and night, transporting heavy tonnage of castings, forgings and other materials to the manufacturing plants in this highly industrialized area. Regardless of these heavy vehicle weights, a survey of a 1500 foot section shows an average of only 38 lineal feet of transverse cracks in the concrete, while the 500 foot section never subjected to vehicle travel of any kind for over 7 years shows an average of 67 lineal feet of cracks per hundred feet of pavement.

FOUR WHEEL TRAILER AND SINGLE AXLE WEIGHTS

Fig. No. 30

4 WHEEL TRAILER WEIGHTS IN 2 NEIGHBORING STATES

	<u>Vehicle Max. Gross</u>	<u>Max. Per Axle</u>	<u>Legal Gross Weight</u>
Ohio	24,000	18,000	24,000
Michigan	None	18,000	36,000

INTERSTATE OPERATORS CAN CARRY 6 TON ADDITIONAL
PAYLOAD ON THE SAME TRAILER IN MICHIGAN.

Very little consideration has been given by our lawmakers to the basic variations in design between a four wheel truck and a four wheel trailer. With a draw-bar steering device on a four wheel trailer and a 50-50 load distribution, it is standard practice to mount dual tires on the front axle of a four wheel trailer. A typical example of inconsistencies in legal regulation affecting payload capacity is found in 2 important neighboring states, where axle weight regulations are uniform, yet the gross vehicle weight limitation is forcing interstate operators to reduce their payload by 12,000 pounds when crossing the state line from Michigan into Ohio.

Variations in trailer weight regulations are extremely burdensome for interstate operators, but according to legislative records of 1932, the anti-truck propaganda includes complete elimination of trailers through laws similar to that passed in Kentucky this year.

SIX WHEELERS

Fig. No. 31

Legislation controlling six wheel vehicle weights is far in arrear of progress made in the design of six wheel trucks. While a limited number of states have recognized the value of the six wheel vehicle, the majority of states have not as yet taken any action to legalize a higher gross weight on six wheel trucks than that permitted on a four wheel vehicle. The present situation is highly complicated for interstate operation, due to a variety of interpretations on the spacing of axles, gross vehicle weights, axle loads and the "L" Plus Formula, "L" meaning the distance from the first to the last axle.

CONCLUSION

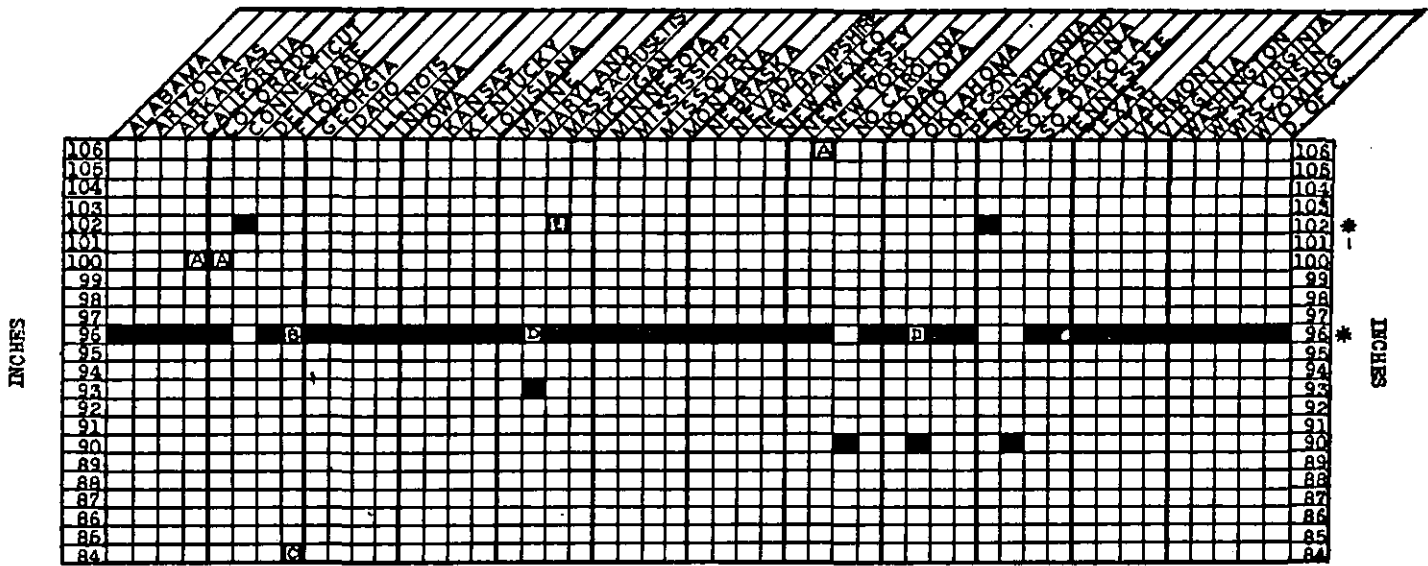
Manufacturers and operators are forced to fit their transportation tools to the legal regulations. Our industry is threatened with even greater complications since open warfare has been declared by the railroads against highway transportation. Not only must we be prepared to meet attempts to place additional burdens on our industry through higher license taxes, public carrier permit fees, ton-mile taxes, gross revenue taxes, higher gasoline taxes, county and municipal privilege taxes, personal property tax, but most stringent regulations will be proposed in the 1933 legislative sessions for further restrictions on sizes and weights affecting not only the design but also the earning capacity of commercial vehicles. In some states, such as Texas and Kentucky, operators had to face losses amounting to millions of dollars worth of trucks, the operation of which had to be discontinued due to enactment of new laws.

We are in full accord with the U.S. Bureau of Public Roads and other national associations that a uniform vehicle code should be recommended to our state legislatures in order to stabilize design and operating practice.

Fig. No. 32

In conclusion, I take pleasure in presenting a picture of police activities at our state boundary lines brought about by the 49 different varieties of state motor vehicle regulations. Unless uniform regulations are eventually adopted, the enforcement of our state laws will require an innumerable force of police officers increasing present burdens of taxation and diverting a good share of the motor taxes for enforcement of impractical laws rather than conserve these funds for construction and maintenance of highways.

INTERPRETATION OF WIDTH REGULATIONS AS OF OCTOBER 1, 1932

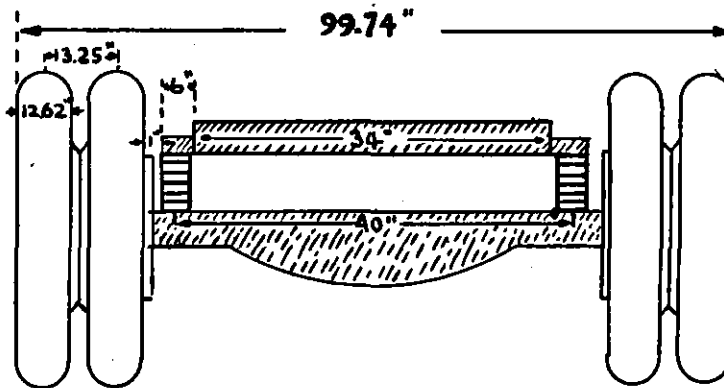


- | | |
|---|--------------------------|
| A - TO FACILITATE CHANGE-OVER FROM SOLID TO PNEUMATIC | D - BY SPECIAL PERMIT |
| B - CONTRACT AND COMMON CARRIERS | E - DUAL PNEUMATIC TIRES |
| C - PRIVATE OPERATORS | |

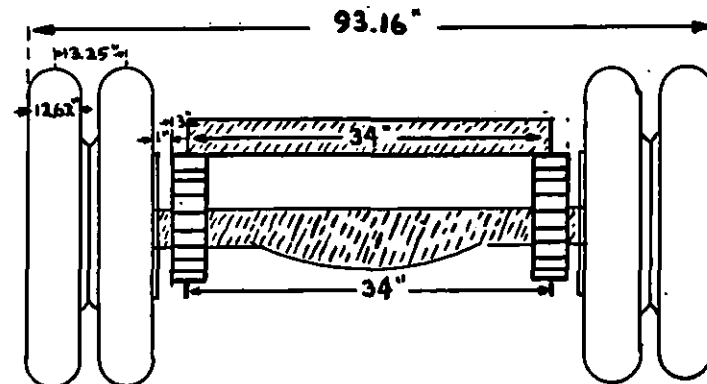
BASIC LAWS

- | | | | |
|-----------|---------|----------|--------|
| 2 States | 102 in. | 1 State | 93 in. |
| 42 States | 96 in. | 3 States | 90 in. |
| | | 1 State | 84 in. |

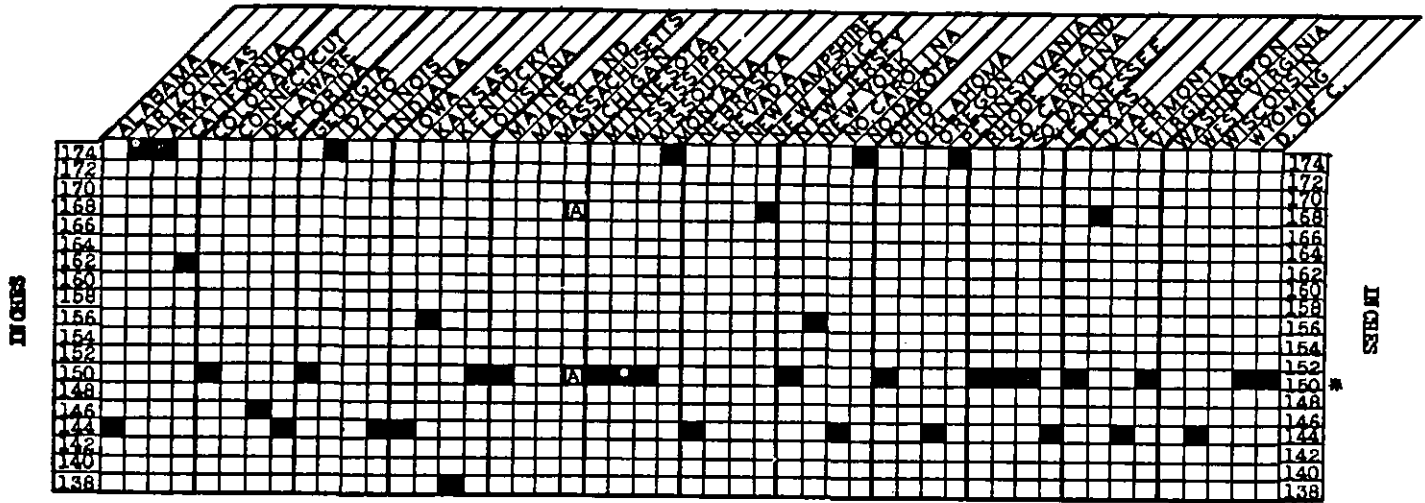
Truck Rear
Axle With
Outboard
Spring
Mounting.
11.25/20
Dual Tires



Under Frame
Underslung
Spring Mounting.
11.25/20
Dual Tires



INTERPRETATION OF HEIGHT REGULATIONS AS OF OCTOBER 1, 1932

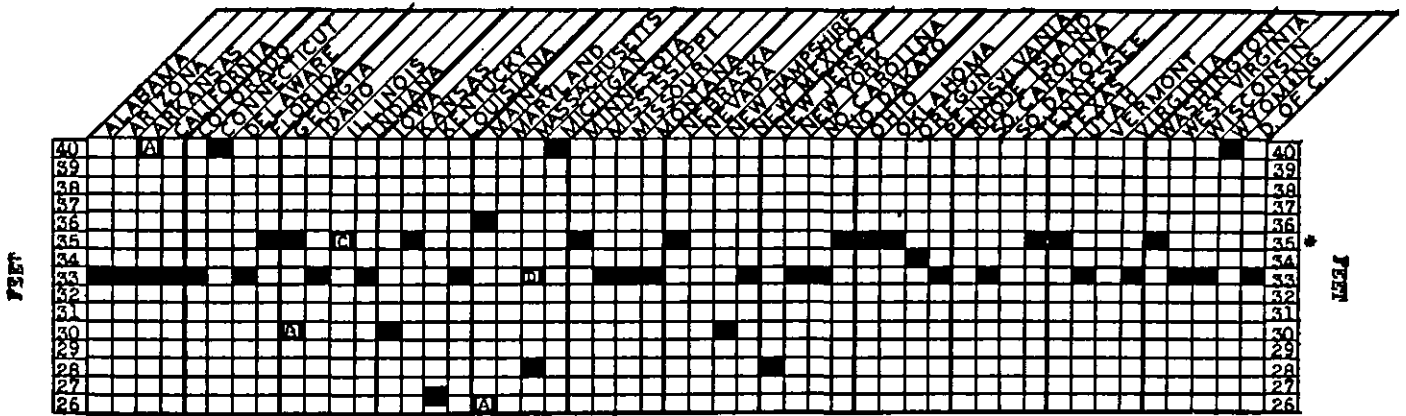


A - TWO CONFLICTING LAWS IN EFFECT

BASIC LAWS

9 States have no regulations	Less than 12½ Ft.
6 States 174 in.	1 State 146 in.
3 States 168 in.	10 States 144 in.
1 State 162 in.	1 State 138 in.
2 States 156 in.	
17 States 150 in.	

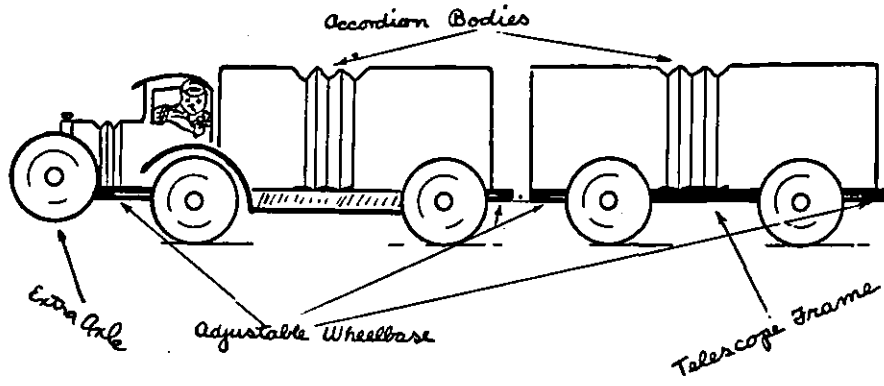
INTERPRETATION OF SINGLE VEHICLE LENGTH REGULATIONS AS OF OCTOBER 1, 1932



A - TRAILER OR SEMI-TRAILER
 B - VEHICLES PRIVATELY OWNED
 C - TRACTOR AND SEMI-TRAILER CONSIDERED ONE UNIT
 D - IN LOCALITIES DESIGNATED BY DEPT. OF PUBLIC WORKS

BASIC LAWS

4 States have no regulations	Less than 35 ft.
3 States 40 ft.	23 States 33 ft.
1 State 36 ft.	3 States 30 ft.
12 States 35 ft.	2 States 28 ft.
	1 State 26½ ft.

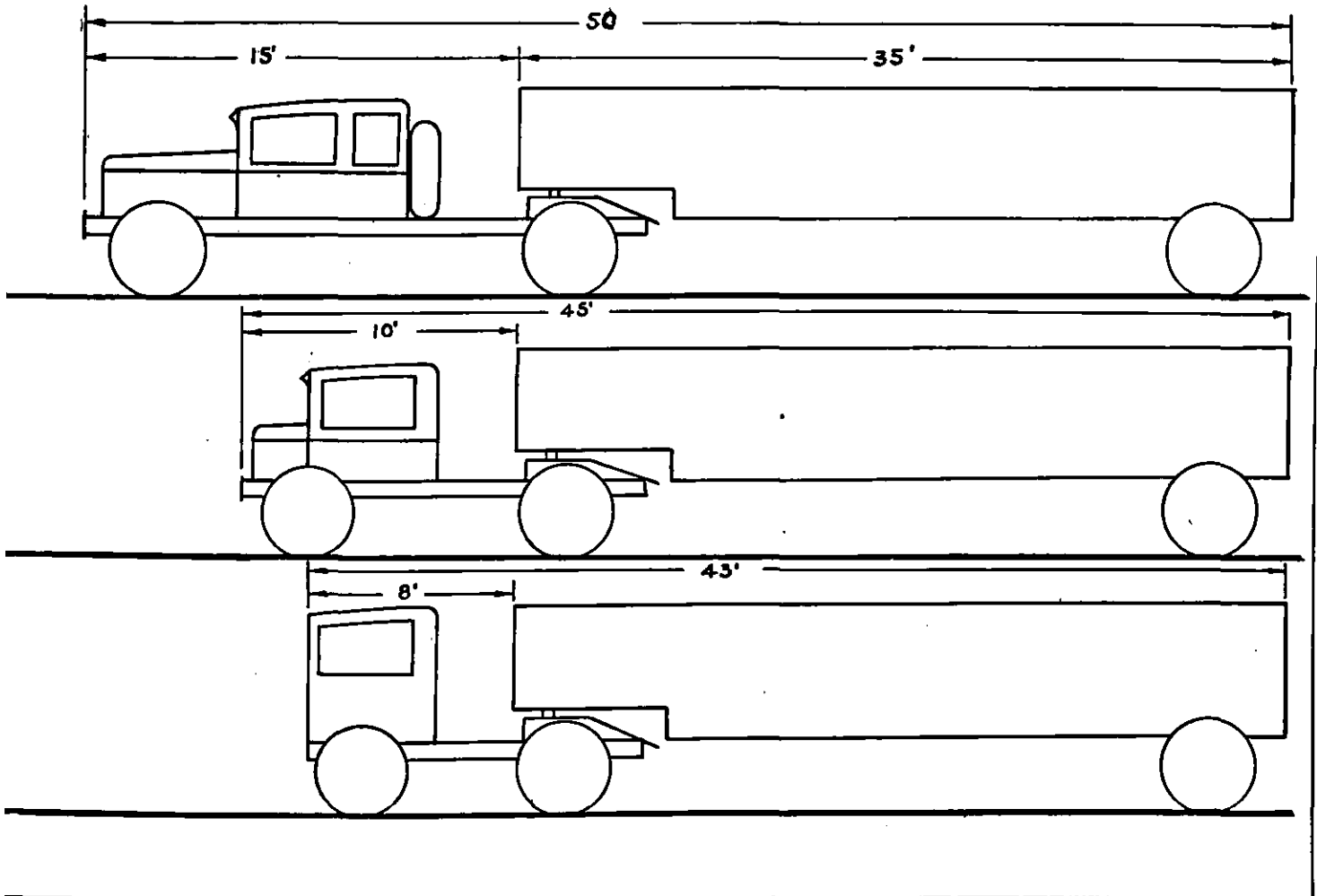


THE PANACEA FOR TRANSPORTATION STRICTURES

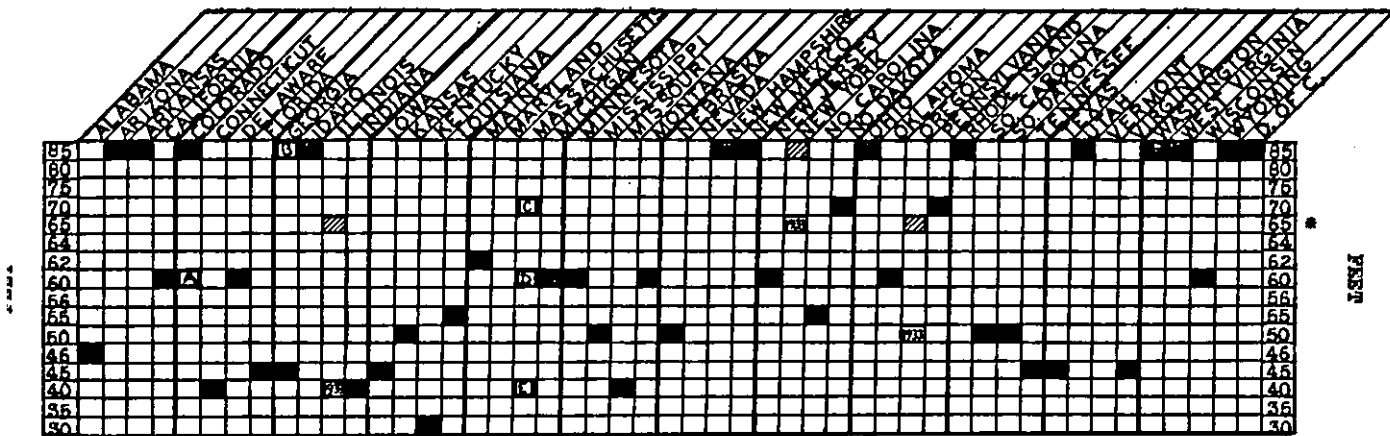
BY Dr. Lawmaker

Rx Take 44 legislative pills next year

A 35 FT. BASIC LENGTH FOR SINGLE VEHICLE REQUIRES 45FT.
OVERALL LENGTH FOR TRACTOR SEMI-TRAILER



INTERPRETATION OF COMBINATION VEHICLE LENGTH REGULATIONS AS OF OCTOBER 1, 1932

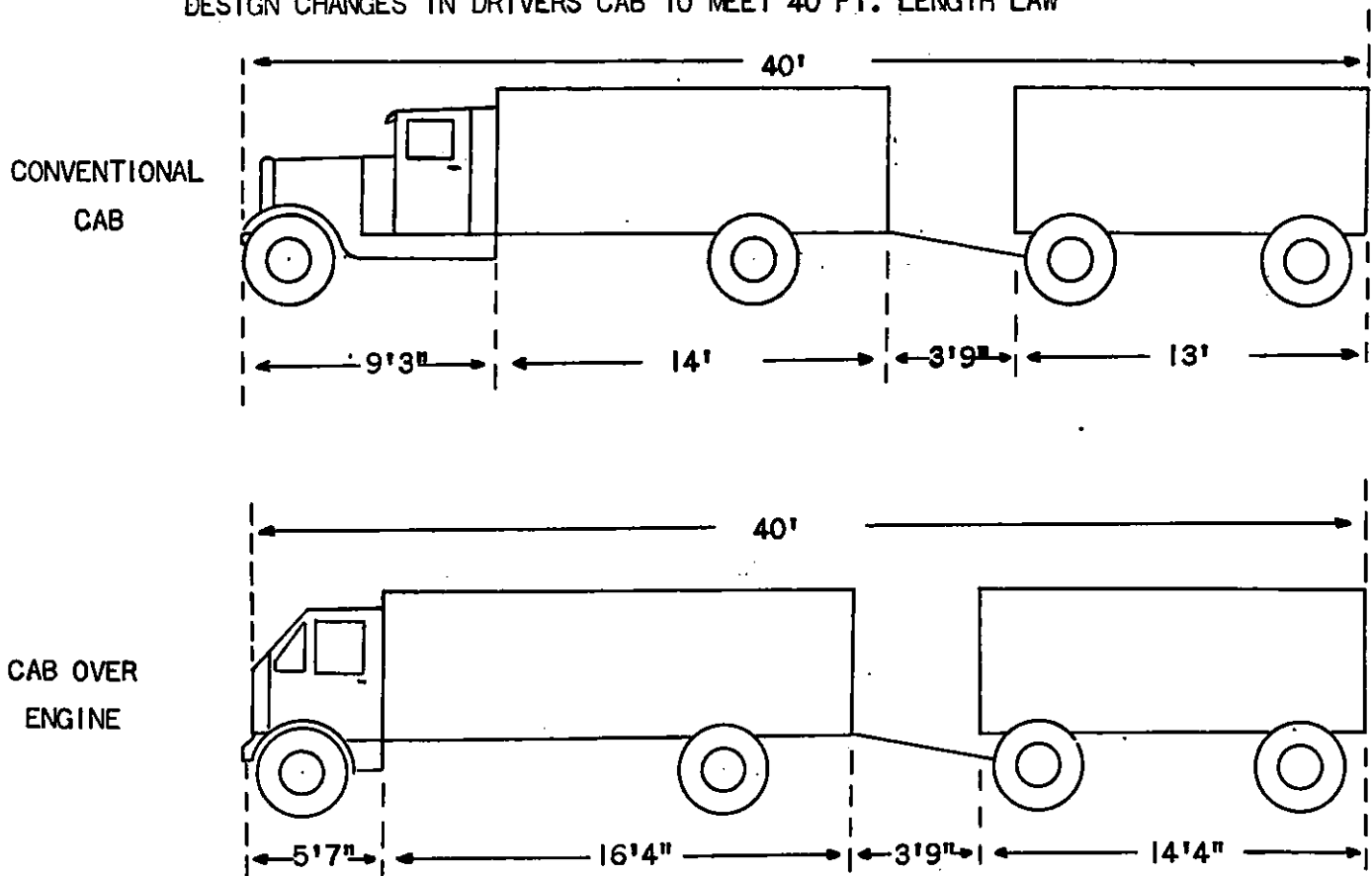


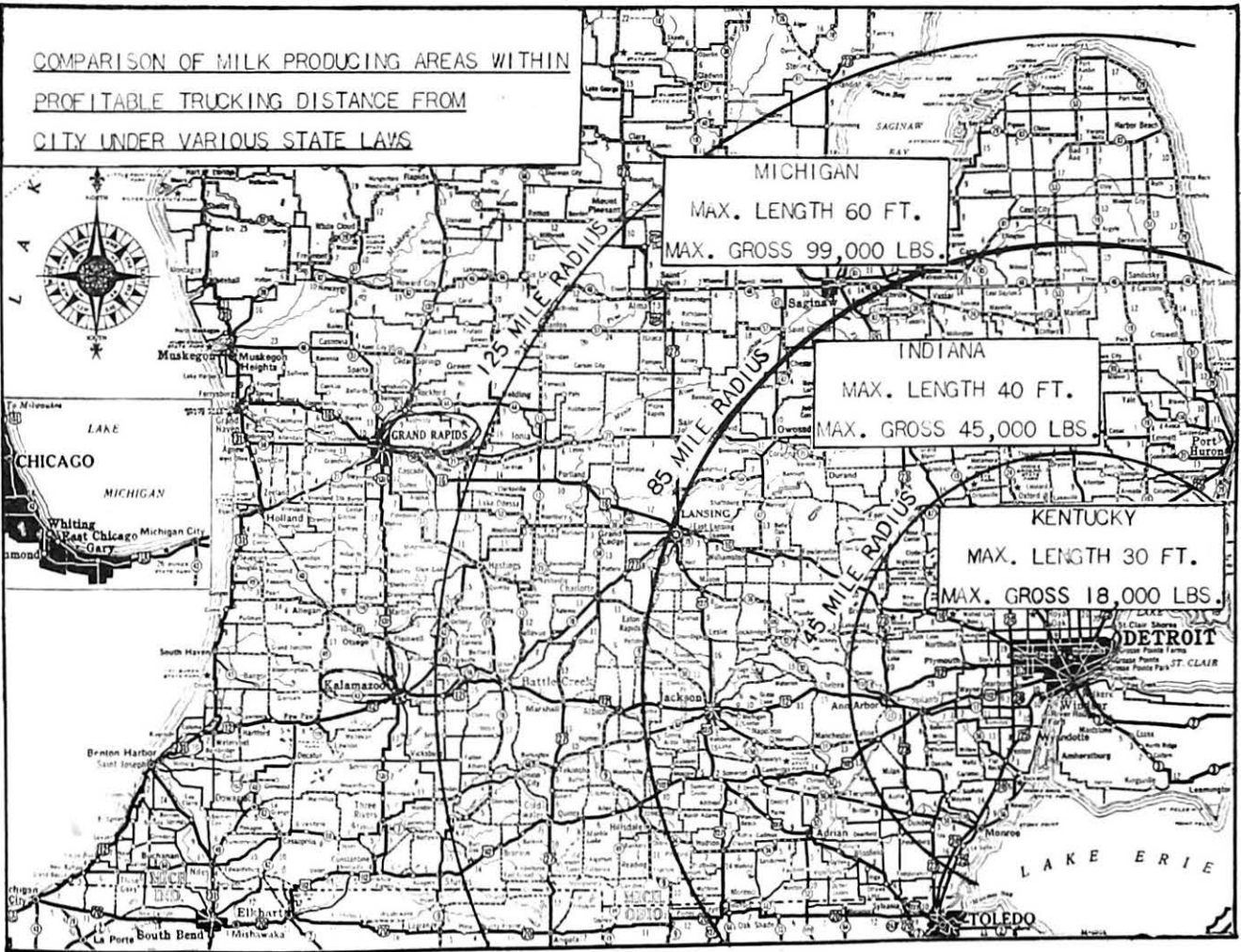
- A - COMBINATION LENGTH ON MOUNTAIN ROADS
- B - VEHICLES PRIVATELY OWNED
- C - IN LOCALITIES DESIGNATED BY DEPT. OF PUBLIC WORKS
- D - TRUCK AND FOUR-WHEEL TRAILER
- E - TRACTOR AND SEMI-TRAILER

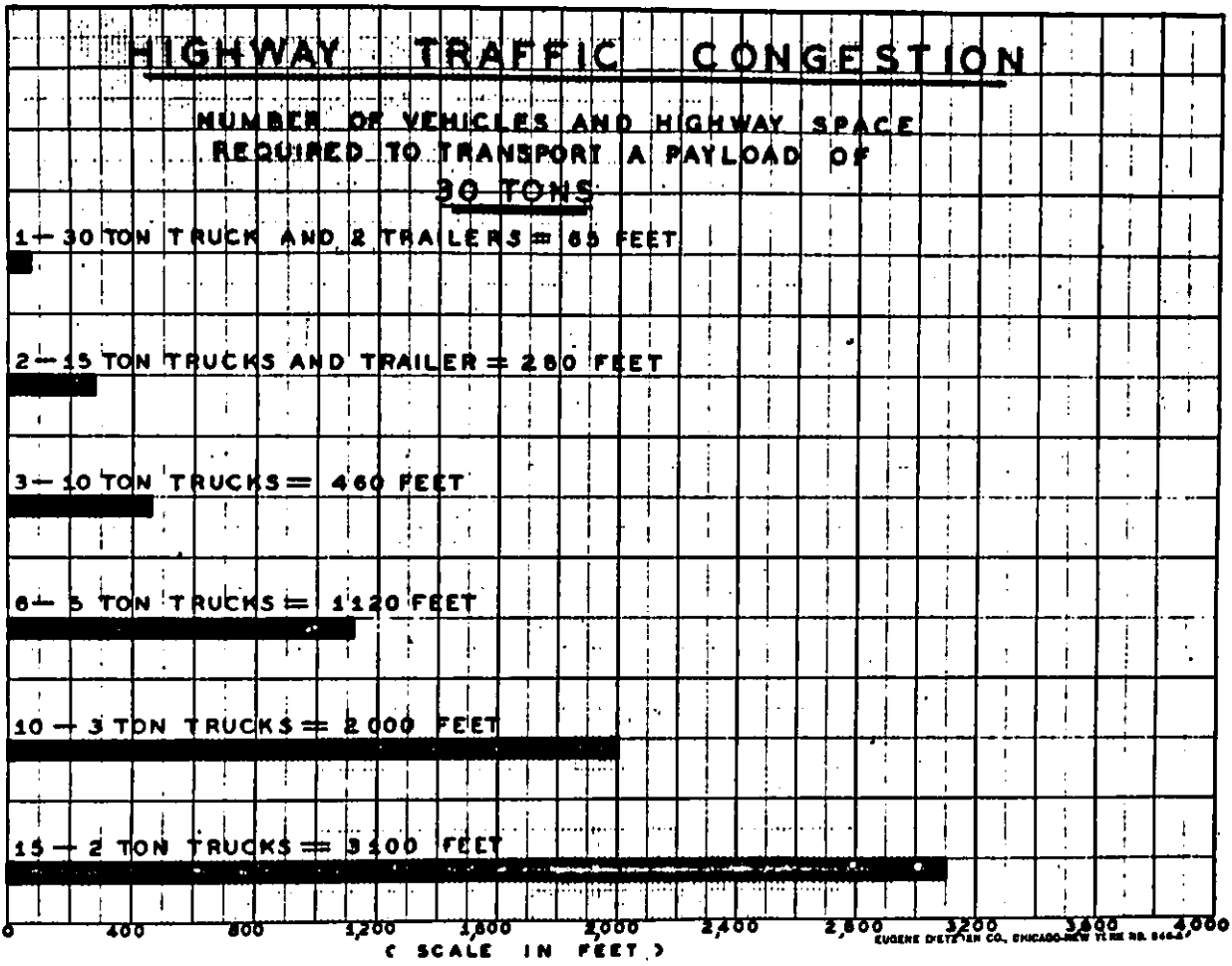
BASIC LAWS

3 States have no regulation	2 States 55 ft.
14 States 85 ft.	5 States 50 ft.
3 States 70 ft.	1 States 46 ft.
2 States 65 ft.	6 States 45 ft.
1 State 62 ft.	3 States 40 ft.
8 States 60 ft.	1 State 30 ft.

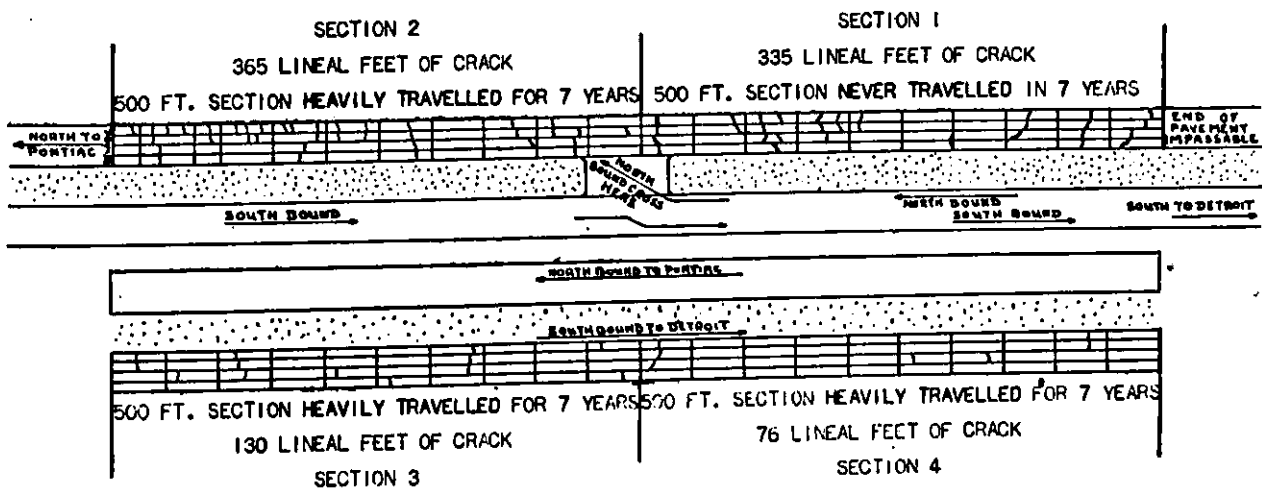
DESIGN CHANGES IN DRIVERS CAB TO MEET 40 FT. LENGTH LAW







COMPARATIVE EFFECTS OF VEHICLE TRAVEL ON CONCRETE PAVEMENT
PART OF U.S. HIGHWAY NO. 10 BETWEEN DETROIT AND PONTIAC, MICHIGAN



AVERAGE LINEAL FEET OF CRACK PER 100 FEET IN UNTRAVELLED SECTION - 67FT.
AVERAGE LINEAL FEET OF CRACK PER 100 FEET IN HEAVILY TRAVELLED SECTIONS - 38FT.

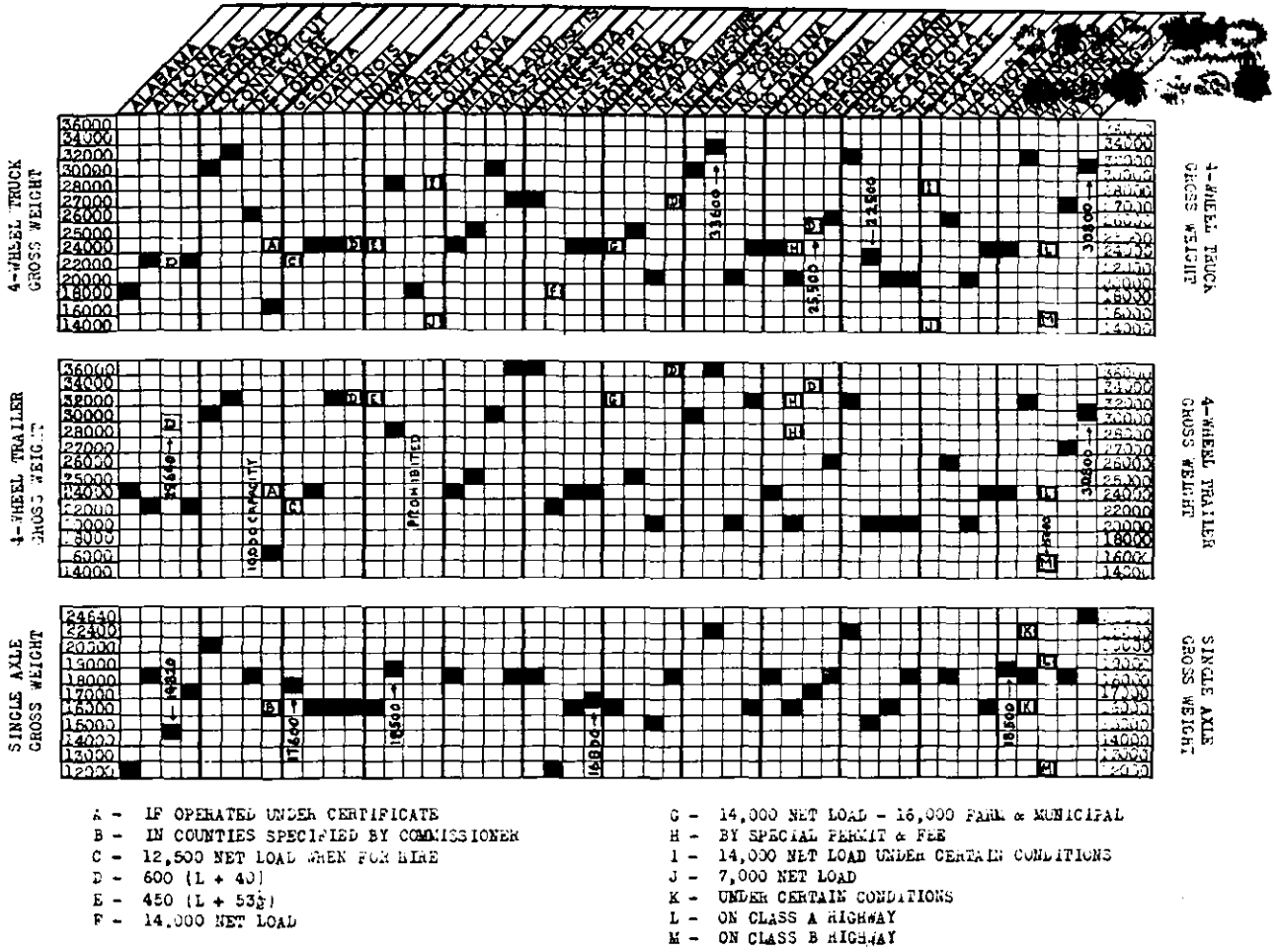
COMPILED BY GENERAL MOTORS TRUCK COMPANY
TRANSPORTATION SURVEY DIVISION
AUGUST 1, 1932

THE ABOVE IS A TRUE REPRODUCTION OF CRACKS
IN PAVEMENT ON U.S. HIGHWAY NO. 10

William A. Johnson

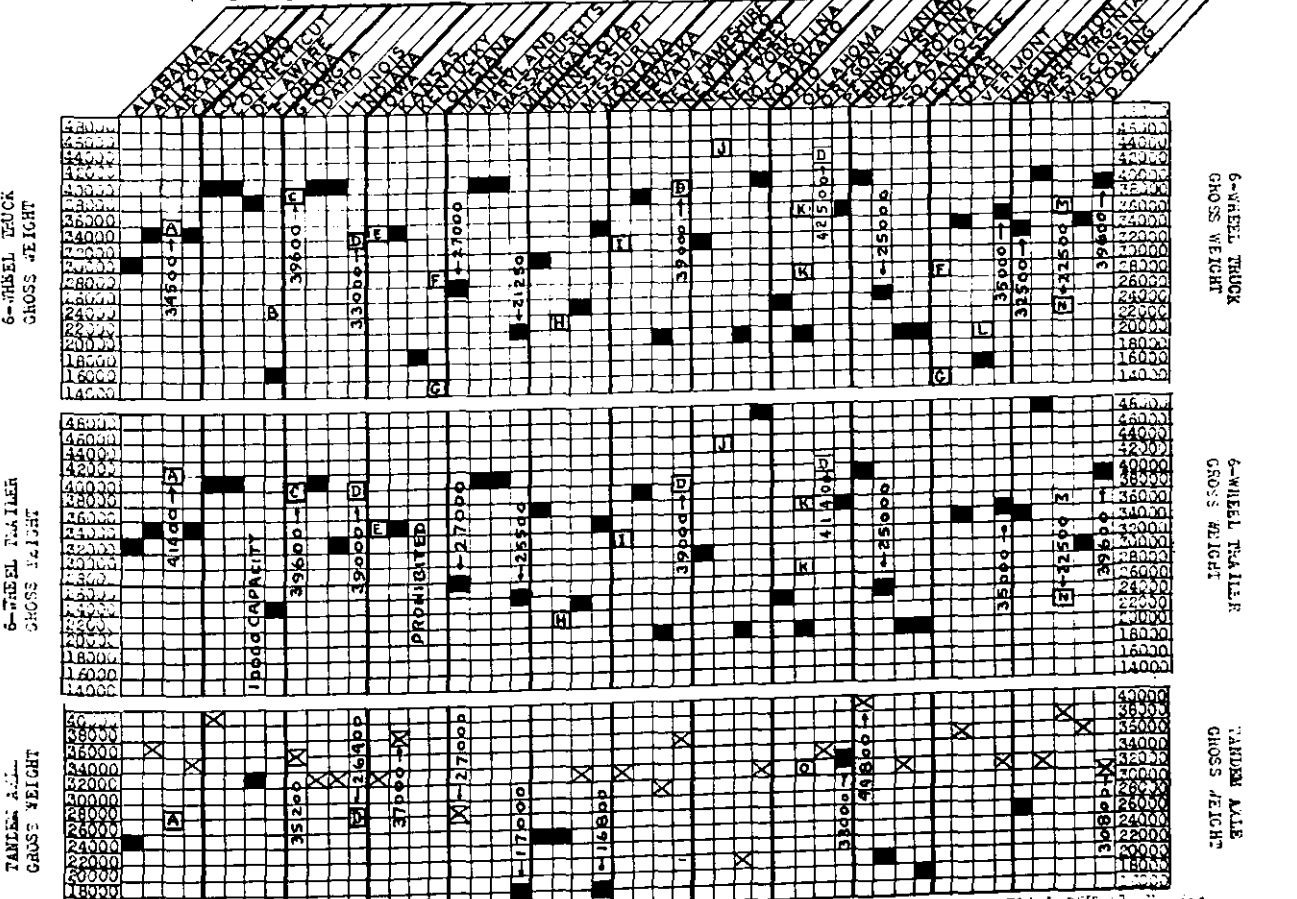
CHIEF OF POLICE
BLOOMFIELD HILLS, MICH.

INTERPRETATION OF MAXIMUM GROSS WEIGHT RESTRICTIONS AS OF OCTOBER 1, 1932



- A - IF OPERATED UNDER CERTIFICATE
- B - IN COUNTIES SPECIFIED BY COMMISSIONER
- C - 12,500 NET LOAD WHEN FOR HIRE
- D - 600 (L + 40)
- E - 450 (L + 53½)
- F - 14,000 NET LOAD
- G - 14,000 NET LOAD - 16,000 FARM & MUNICIPAL
- H - BY SPECIAL PERMIT & FEE
- I - 14,000 NET LOAD UNDER CERTAIN CONDITIONS
- J - 7,000 NET LOAD
- K - UNDER CERTAIN CONDITIONS
- L - ON CLASS A HIGHWAY
- M - ON CLASS B HIGHWAY

INTERPRETATION OF MAXIMUM GROSS WEIGHT RESTRICTIONS AS OF OCTOBER 1, 1932



- A - 25000 + 650L
- B - IF OPERATED UNDER CERTIFICATE
- C - 12500 NET LOAD WHEN FOR HIRE
- D - 600 (L + 40)
- E - 450 (L + 53½)
- F - 14000 NET LOAD UNDER CERTAIN CONDITIONS
- G - 7000 NET LOAD
- H - 14000 NET LOAD
- I - 14000 NET LOAD - 16000 FARM & MUNICIPAL
- J - 30000 + 750L. MAX. GROSS 44000
- K - BY SPECIAL PERMIT AND FEE
- L - ON STATE AID ROADS
- M - ON CLASS A HIGHWAYS
- N - ON CLASS B HIGHWAYS
- O - 26000 IF AXLE CENTERS 48" OR LESS