# Effect of Governors on Passenger Car Performance

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● RESULTS of earlier tests on the effect of governors on the performance of passenger cars are not readily available in the literature. The objective of the investigations reported here was to establish and record the facts with respect to current production cars.

In establishing the tests, two types of governors were procured and installed on two cars of the same make but different models, equipped with Hydra-Matic transmission. The program consisted of conducting engineering performance tests and interpreting the results in terms of the relative capacity to perform in traffic.

It is not our interest to compare the governors or to relate the results to any specific make, so we will not describe the governors in detail, except to say that both were adjustable through somewhat different but overlapping speed ranges, that one was a throttle type governor which controlled engine speed, and the other one was an experimental governor driven off the speedometer shaft which controlled car speed. The engine type governor was installed in Car No. 1, and the car speed governor was installed in Car No. 2.

It is our opinion that the results observed with these two types are generally representative of results which would be obtained with other governors of the same types; we would expect some variation in details, but we would not expect significant changes if installed on current types of automobiles.

In the following discussion, wherever we refer to the speed at which the governor control was set, we mean in the case of Car No. 1, the engine speed corresponding to the stated car speed in top gear; in the case of Car No. 2, the governor setting refers directly to the car speed.

The test program consisted of a series of full throttle accelerations from a standing start under various conditions of governor adjustment. In these tests, measurements of time, distance traveled, engine rpm, and car speed were recorded continuously by oscillograph techniques. From these data, various aspects of car performance and relative performance have been calculated.

The tests were run on a level straightaway; the results could be transferred to corresponding performance on hills, the general difference being that changes in relative performances become greater as the gradient increases.

In any discussion of governors, the first thought is the relationship of engine speed and car speed, and Figures 1 and 2 show these relationships for Cars 1 and 2.

It has been noted that both governors are adjustable; and in Figure 1, the engine speed-car speed relationships of Car No. 1 on full throttle acceleration from a standing start are shown without the governor and with governor settings corresponding to the engine speed at 35 and 60 mph in the top gear of the transmission. As may be expected with this governor, the engine speed is governed in all the gears of the transmission; the forced upshifts would not occur without releasing the accelerator.

It may be considered that any other engine throttle type of governor would behave in generally the same fashion, although there would doubtless be variation in detail. It may also be assumed that the general engine speed characteristics would be comparable for all other types of transmission, automatic and manual. It appears that the benefits of the transmission are reduced increasingly as the control speed is reduced and largely lost at the lower speeds.

Figure 2 shows the same type of relationship for Car No. 2; this governor is sensitive to car speed since it is driven off the speedometer drive. It will be noted that over a range of governor settings from 32 to 74 mph, the engine speed is not affected below the controlled speed setting; at this point

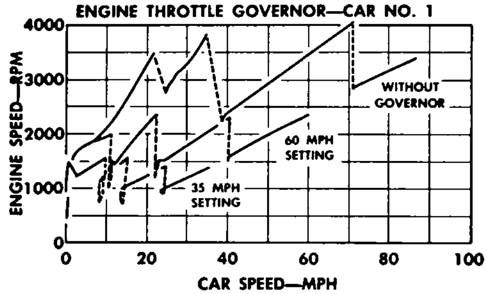

Figure 1. Engine speed vs. car speed.

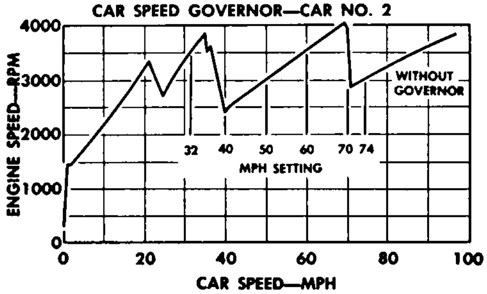

Figure 2. Engine speed vs. car speed.

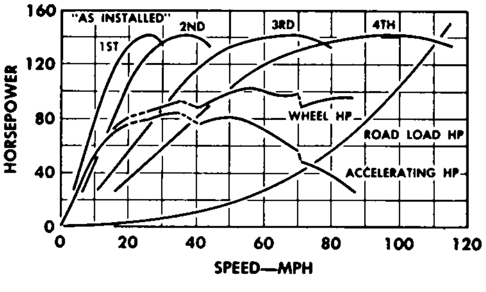

Figure 3. Horsepower.

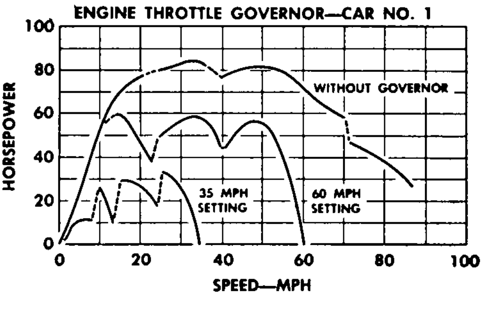

Figure 4. Accelerating horsepower.

both engine speed and car speed become constant. Such a governor does not affect the engine speed in any gear below the car speed at which the governor is set, and transmission effectiveness is unchanged below the control speed.

In other papers, we have made use of the configuration of Figure 3 which shows the various aspects of horsepower. The upper curves labeled "As Installed, 1st, 2nd, 3rd, and 4th" show results of the engine dynamometer test, adjusted for road speed in the four gears of the automatic transmission. The rated horsepower is a value considerably above the 142 horsepower shown because of the particular conditions under which rated horsepower is determined.

The next curve from the top shows the power which is actually delivered to the rear wheels.

The bottom curve shows the horsepower required to overcome wind and rolling resistance, and the second curve from the bottom shows the horsepower available to accelerate the car. The data on Figure 3 are applicable to Car No. 1 in this test program in the condition of no governor.

We have seen in Figures 1 and 2 that the installation of governors and the setting at various speeds will limit the engine speed and evidently both cut off the top of the installed horsepower curves shown in Figure 3 and modify the curve of horsepower available for acceleration. It may be noted in Figure 3 that the maximum power available for acceleration is slightly over 80 horsepower in the range from about 25 to about 55 mph; this is approximately 57 percent of the "As Installed" horsepower.

With the engine throttle governor installed in Car No. 1, we get rather a marked change in the horsepower available for acceleration throughout the speed range as shown in Figure 4. With the 35-mph setting, the maximum horsepower available for acceleration is only about 30 horsepower and with the 60-mph setting, the maximum is slightly less than 60 horsepower; these values are 21 and 42 percent, respectively, of the as-installed horsepower, and 38 and 75 percent of the accelerating horsepower without the governor.

Figure 5 shows the same relationship for the car speed governor installed in Car No. 2; in general, this installation does not affect the horsepower available for acceleration below the speed at which the governor control is set. From this, we might conclude that in Car No. 1, the over-all performance is seriously affected for any setting of the governor, while for Car No. 2, the effects of the governor are not perceptible at speeds below the governor setting.

The acceleration-speed characteristics of Car No. 1 for the conditions of no governor and the governor set at engine speeds corresponding to top gear road speeds of 35 and 60 mph are shown in Figure 6. The maximum acceleration possible is reduced materially throughout the speed range for any setting of the governor.

Figure 7 shows the acceleration-speed characteristics of Car No. 2, with the car speed governor set at various values from 32 to 74 mph. In general, the acceleration curve falls to zero at the speed of the governor setting, but it is not affected at any point below the governed speed.

Speed-time curves are used frequently to describe automobile performance. Figure 8 shows the speed-time relationships for Car No. 1, with the engine throttle governor for several settings of the governor, at engine speeds corresponding to from 32 to 60 mph, and for the conditions of no governor. This chart shows that with the governor installed, there is a material reduction in the speed at any value of time, and that the speed is progressively less as the governor setting is reduced.

This indicates that the governor has a rather severe throttling affect; for example, without the governor, the car reaches 50 mph in 10 seconds, while with the governor set at the engine speed corresponding to 60 mph, it requires about 18 seconds to reach 50 mph. This might have been predicted from Figures 4 and 6 showing acceleration-horsepower and acceleration-speed.

The speed-time relationships of Car No. 2 with the car speed governor are shown in Figure 9. The characteristic of this governor is that it is not effective until the vehicle speed reaches the control setting, and at that point, the acceleration falls to 0 very rapidly; at the 32-mph setting, for example, the car speed increases to 32 mph along the same curve as with no governor and then levels out sharply.

The time-distance relationships at full

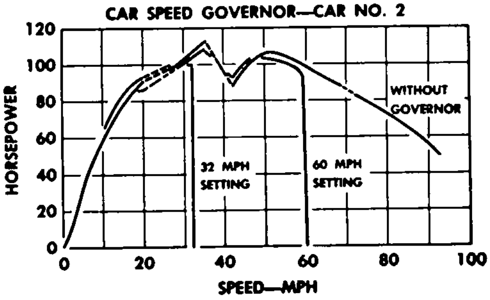

Figure 5. Accelerating horsepower.

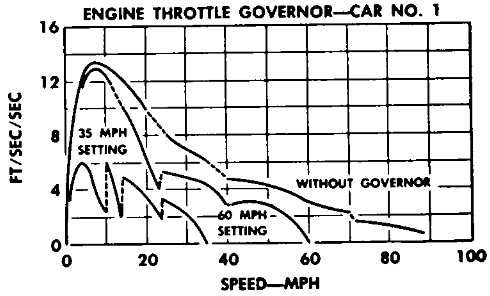

Figure 6. Acceleration—speed.

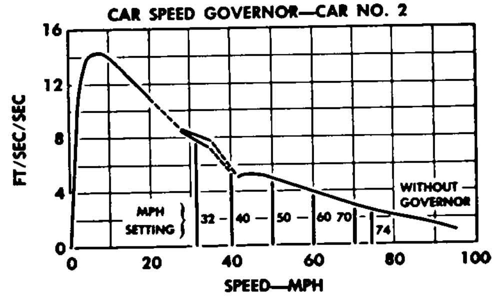

Figure 7. Acceleration—speed.

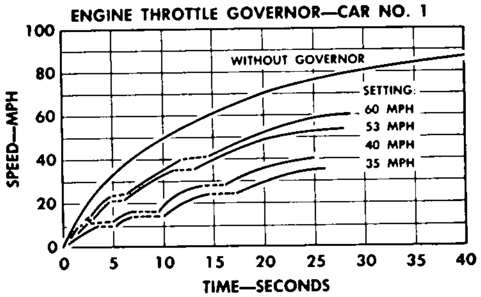

Figure 8. Speed—time.

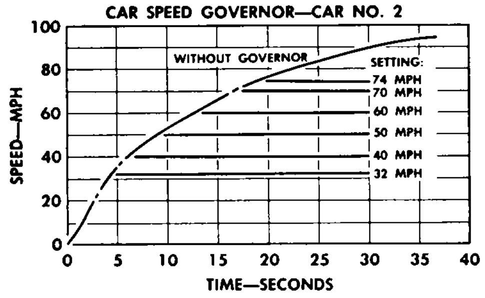

Figure 9. Speed—time.

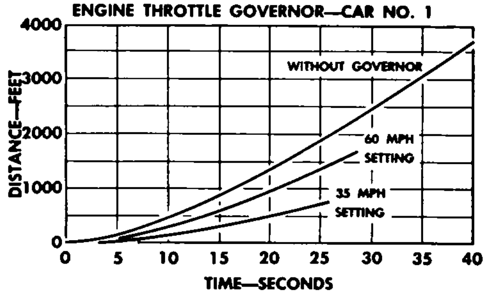

Figure 10. Time—distance.

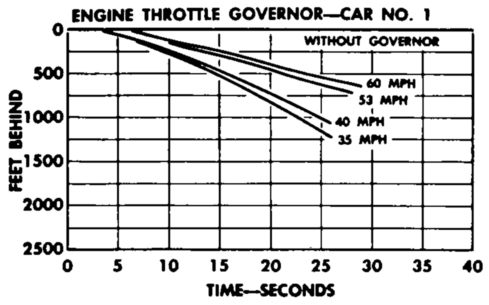

Figure 11. Performance comparison.

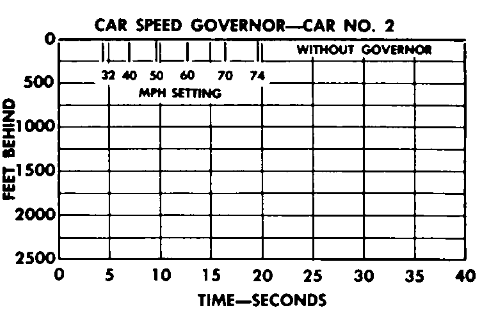

Figure 12. Performance comparison.

throttle acceleration have been found to be very useful in comparison of car performance. Figure 10 shows the general relationship of distance traveled as a function of time on Car No. 1, without the governor and with governor setting of engine speed corresponding to road speeds of 60 mph and 35 mph; the curves are terminated at the point where the governed speed is reached. It is noted that with any setting of governor, the distance traveled at any time is less than without the governor. Again this could be predicted from the acceleration-horsepower and acceleration-speed curves shown in Figures 4 and 6.

The direct comparisons of distance-traveled relationships, with and without the governors, are shown in Figures 11 and 12 for the two cars; these curves also terminate at the point where the governed speed is reached. In Figure 11, the baseline at the top of the chart is taken from Figure 10, and the "feet behind" are losses in distance corresponding to the governor settings shown compared with the basic condition of no governor.

For example, at 20 seconds, with settings of engine speeds corresponding to road speeds of 60 and 53 mph, the car is from 400 to approximately 450 feet behind the condition of no governor, and for 40 and 35 mph, the losses in distance are 750 and 850 feet.

Figure 12 shows the corresponding performance comparison for Car No. 2, with the car speed governor installed. The upper line in the chart is the basic performance without the governor installed; the successive terminal points with the wide open and controlled governor settings of 70, 60, 50, 40, and 32 mph indicate clearly that no losses in distance occur until the control speed is reached.

The objective of governor installation is to control speed. We have noted that installations have restrictive effects on engineering performance, and it is appropriate to consider whether there may be effects on performance in traffic other than that of controlling speed. One of the critical points in traffic performance is the passing maneuver, and it is possible to express the effects we have noted in terms of minimum passing distance.

Figure 13 is a chart indicating the basic passing maneuver, which has been used in earlier papers. In brief, this assumes a 2-lane highway, shown schematically in the upper part of the chart, where Car B is driving from

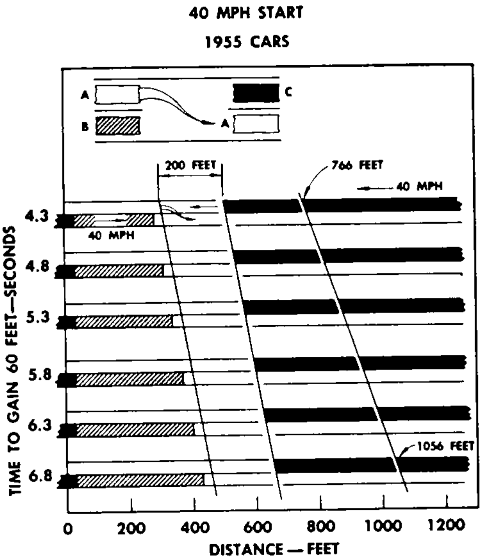

Figure 13. Minimum passing distance.

left to right at a constant speed of 40 mph. Car C is approaching from the opposite direction at 40 mph, from some distance down the road, and the driver of Car A is poised just behind Car B, eager to pass. The question is to determine the minimum distance required for clearance between Cars A and C at the beginning of the maneuver to make it possible to pass successfully.

The lower portion of the chart shows this minimum clearance distance as a function of the level of performance of Car A. In all cases the transmission gear selection giving maximum acceleration is used. Car A must gain three car lengths, or 60 feet, and then have approximately 200 feet more in which to turn back into the right lane. The best 1955 car required 4.3 seconds to gain 60 feet on a car traveling 40 mph, and it required a minimum clearance of 766 feet between Cars A and C at the beginning of the maneuver in order to complete it successfully. The poorest car required 6.8 seconds and 1056 feet.

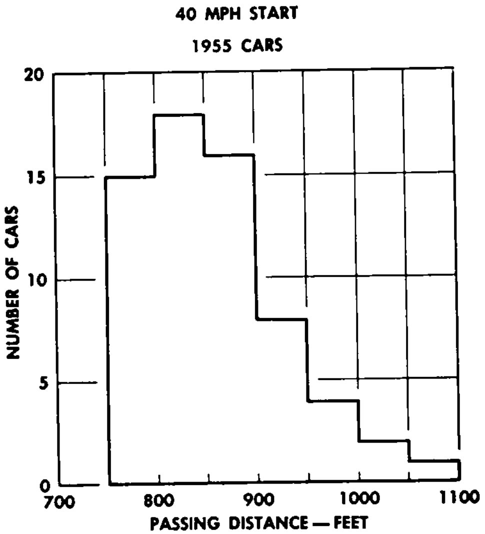

Figure 14. Minimum passing distance.

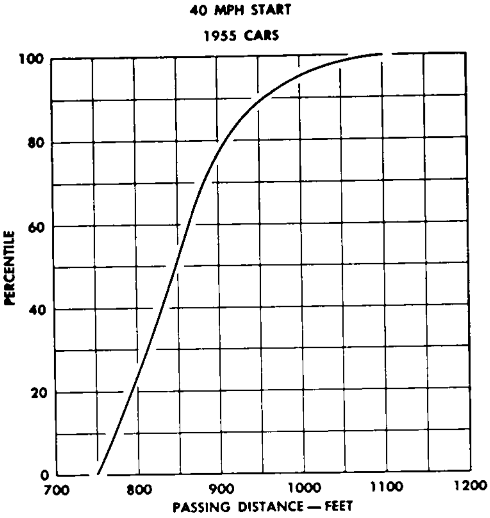

Figure 15. Minimum passing distance.

Figure 14 is a frequency diagram of the minimum passing distances required for the 1955 fleet; the minimum distances range from 766 feet to 1056 and have a median value of approximately 840 feet. It should be understood, of course, that these are current production cars in the best of mechanical condition, and that the distances required by older cars of lower performance level or cars with some degree of mechanical deterioration may be much greater than the values shown.

Figure 15 is a percentile distribution of the data in Figure 14.

Figure 16 is a percentile chart showing the minimum passing distances of the 1952, 1953, and 1955 cars; the technique for making these tests was developed in the early 1950's, and the data in this form are not available on earlier cars. The median distance has improved

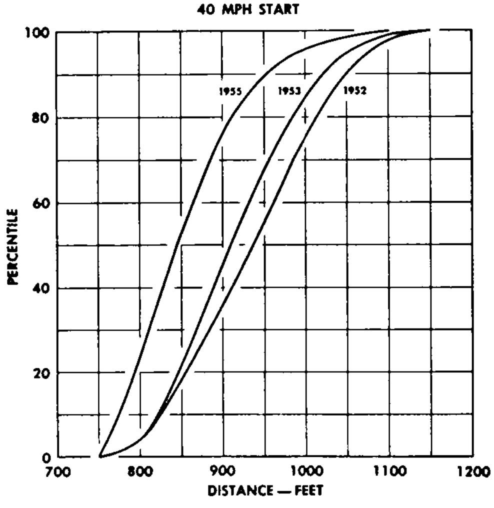

Figure 16. Trend of minimum passing distance.

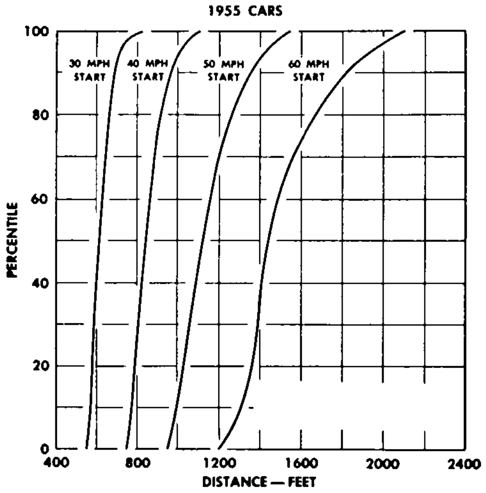

Figure 17. Passing distance.

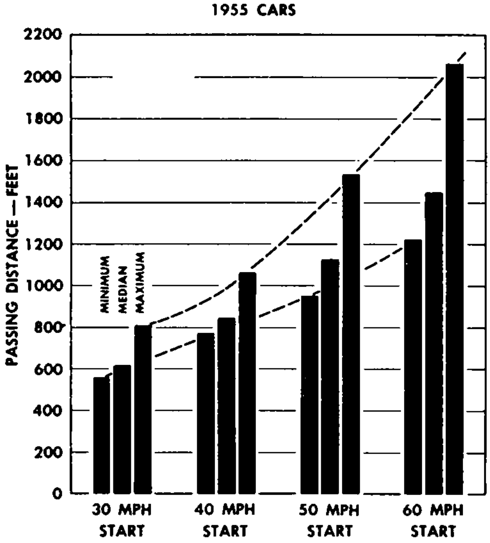

Figure 18. Passing distance.

from 935 feet in 1952 to 840 feet in 1955, indicating a trend of significant improvement in this important factor. This improvement has improved traffic safety by reducing the time and distance during which the car is in the passing lane; it has also increased the effective capacity of our crowded highways by increasing the number of opportunities for safe passing.

The distances required to pass cars traveling at speeds other than 40 mph are summarized in percentile curves on Figure 17; here we show the distances required to pass cars traveling at 30, 40, 50, and 60 mph, repeating the analogy of Figure 13 with the speeds of Cars B and C equal. The median distances are 610, 840, 1125, and 1445 feet, respectively.

The minimum, median, and maximum distances for the four speeds are shown in Figure 18. It is significant that the passing distances of the best performing cars increase nearly linearly with speed, while the distances required by the poorer cars increase much more rapidly than the speed. Again, it should be noted that these cars are in first-class mechanical condition and that the barest minimum clearance is allowed; it is easy to believe that when these poorer cars are worn a little and deteriorated a little, a distance of as much as one-half mile may be required for a comfortable pass at even 50 mph. The implications in terms of clear sight distance standards and frustration engendered by some slow moving vehicles are obvious.

The improvement in flexibility and safety on the highway from 1952 to 1955 shown on Figure 16 is the result of a design trend; Figure 19 shows the relationship between the minimum passing distance at 40 mph and the rated horsepower. This is a curvilinear relationship which makes it clear that as the horsepower increases the passing distance decreases but at a lower rate for the values of horsepower. From this relationship, Figure 20 shows the percentage decrease in passing dis-

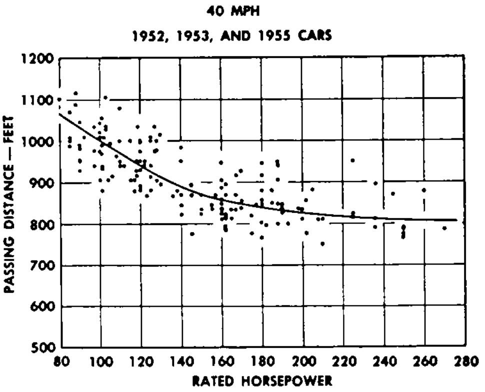

**Figure 19. Minimum passing distance vs. rated horsepower.**

tance with percentage increase in rated horsepower. If, for example, we start at the lowest rated horsepower in this group of cars, 80 hp, as the basic value, an increase of 100 percent to 160 hp reduces the passing distance by about 20 percent. An increase of another 80 hp to 200 percent reduces the passing distance by only 4 percent more. A 40 percent increase in the power of a 120 hp engine reduces passing distance by more than 9 percent, but a 40 percent increase in the power of a 200 hp engine gives only about 3 percent reduction in passing distance. Thus it is clear that while there is a direct relation between passing distance and rated horsepower, and that improved characteristics result from increased horsepower, the rate of gain is less with the more powerful engines. Therefore, to produce the same improvement in passing distance with the better automobiles as with the poorer requires a much larger increase in rated horsepower. It should be clear that an increase of 25 horsepower in a high-powered engine is less effective in improving flexibility and safety in the passing maneuver than the same percentage increase in the power of an engine rated at 100 horsepower, for example.

To ask why the industry doesn't give up at some point in this curve of diminishing return is to invite the answer that in many cases a few inches less passing distance would have avoided a dented fender and a few feet would have avoided a fatal accident.

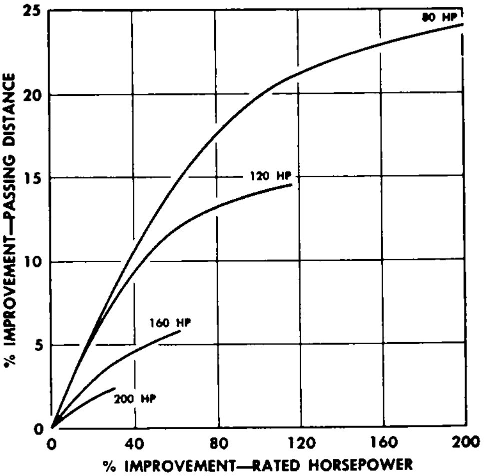

**Figure 20. Change in passing distance with rated horsepower.**

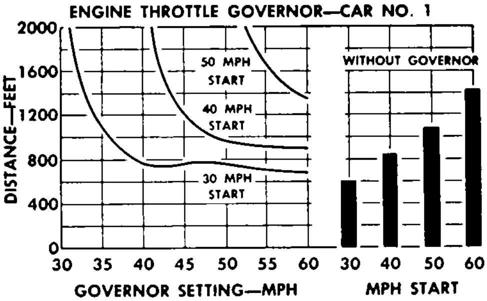

**Figure 21. Passing distance vs. governed speed.**

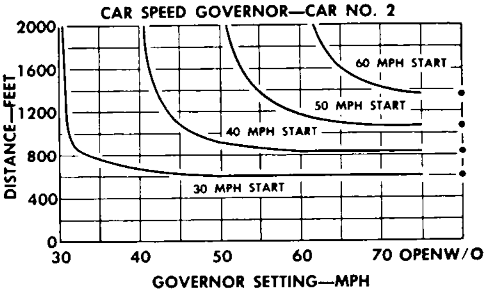

**Figure 22. Passing distance vs. governed speed.**

Figure 21 shows the effect of the engine speed governor in Car No. 1 in terms of passing distance as a function of the governor setting in terms of the engine speed corresponding to speed shown on the lower scale. For example, on the 30-mph start, that is where the speed of Car B in Figure 13 is 30 mph, the passing distance reaches a minimum of about 750 feet with a governor setting corresponding to the speed of about 42 mph. At the 40-mph passing maneuver, the passing distance reaches a minimum at about 60 mph, and with the 50-mph passing speed, the minimum is not yet reached at the governor setting corresponding to the governor setting of 60 mph. The bars at the right of the chart show the passing distance required at 30, 40, 50, and 60 mph with the governor removed. This indicates, for example, that the governor has a throttling effect equal to a 100-foot increase in passing distances at 30 and 40 mph passing speeds, even with the governor setting corresponding to 60 mph.

At the 50-mph passing speed, the throttling effect is more than 200 feet because the 60-mph limiting setting did not produce minimum passing distance. This throttling effect may be a characteristic of this particular installation rather than a general characteristic of the type of governor.

Figure 22 shows the passing distance of Car No. 2 as a function of the setting of the car speed governor. At the 30-mph pass, for example, the passing distance is affected by governor settings everywhere below 50 mph; on the 40-mph pass, the governor affects the passing distance at all settings below the 60 mph; and on the 50-mph pass, the passing distance is affected by any setting below 70 mph. On the 60-mph pass, any setting below 75 mph affects the passing distance. The points at the extreme right of the chart show passing distances without the governor; this installation has negligible throttling effect.

With both types of governors, a setting of from 15 to 20 mph above the passing speed is required to avoid increasing materially the minimum distance and the hazard of the passing maneuver. This is inherent in any governor installation; obviously for Car A to pass Car B (Figure 13), Car A must accelerate to some speed above 40 mph; the higher the rate of acceleration and the higher the speed attained during the passing maneuver, the shorter the time and distance required will be. Any governor installation which became effective before the speed of which the car is capable during the maneuver is attained must extend the time and distance required. As an example, assume that Car A in Figure 13 will accelerate from 40 to 55 mph during the passing maneuver without a governor. It is obvious that a governor installation which restricts the speed to 50 mph will extend both the time and distance appreciably.

The complications certain to result from governor installations as cars cross state lines could be gruesome. Consider how relatively inadequate a car would be with an installation tailored for a 45-mph maximum speed limit and traveling in a traffic stream in a state with a 65-mph limit.

In closing I would like to point out the fact that in driving our highways today we avoid hazardous situations as frequently by accelerating as we do by braking. Every observant driver is perfectly conscious of this, and especially the millions who cross unprotected intersections or merge into traffic streams on crowded expressways every day. For many years the ability of the automobile to decelerate has greatly exceeded its ability to accelerate. With the development of our new transmissions and engines we are making an appreciable gain in bringing the accelerating ability up to compatibility with brake deceleration. During the same period there has been a significant decrease in the fatal accident rate. From the standpoint of safety, the importance of this improved performance increases rapidly as the density of traffic on our highways becomes heavier.

The data presented indicate definitely that a governor can be detrimental to acceleration and performance. It is just as reasonable to contemplate putting a governing device on the brake system to limit deceleration and increase stopping distance as it is to install one which limits acceleration and increases passing distance.