# ABSTRACT OF THE DISCUSSION OF PAPERS READ AT THE PREVIOUS MEETING

## THE EFFECT OF DAYLIGHT SAVING TIME ON THE NUMBER OF MOTOR VEHICLE FATALITIES

JOHN A. MILLS

VOLUME XXVI, PAGE 328

### WRITTEN DISCUSSION

MR. A. L. BAILEY:

Mr. Mills need not have concerned himself with the question of how much or how many of the many methods of presentation would demonstrate the findings that he had made in his study of the effect of daylight saving time on the number of motor vehicle fatalities. The conclusion that a considerable number of injuries and deaths might be avoided each year is reached repeatedly, irrespective of the method of attack, from the data with which he concerned himself, namely those for a group of larger cities.

However, in presenting data to serve as a basis for the determination of the approximate number of fatalities which would be prevented by the adoption of daylight saving time, Mr. Mills had to choose one from a more or less unlimited number of available combinations of figures. Reductions in fatalities of from one to some five percent would have been indicated from any of the various methods of attack. The method chosen by Mr. Mills and set forth in Appendix "D" of his paper produced a 2.7% reduction. Although this is about the average result, it represented, as will be pointed out, a rather unfortunate choice of procedure. Mr. Mills compared the increased fatalities during the evening hours of 6:00 P. M. to 10:00 P. M. with the fatalities occurring during the daylight hours of 10:00 A. M. to 3:00 P. M. in the standard time cities and the daylight saving time cities, respectively, restricting his investigation to the five summer months. Had he continued his investigation to the seven winter months, Mr. Mills would have reached the surprising conclusion that the use of daylight saving time during the summer months resulted in a reduction of accidents during the winter months some two and a half times as great as the reduction in accidents during the summer months. This result can be explained only by the fact that the cities not having daylight saving time had more traffic

during the evening than did the cities having daylight saving. (In other words, the black horses were involved in more accidents than were the white horses only because there were more black horses running around.)

There is one assumption implied throughout Mr. Mills' paper which it is believed should be pointed out. This assumption is that the greater number of accidents occurring after dark in the evening than during the day is the result only of the amount of traffic and the absence of light. Nothing is said of the effect of fatigue on the increased number of accidents during the latter part of the day, despite the recognition of this as one of the most important single elements by all safety engineering studies.

Personally, I favor the following attack on the problem of how many fatalities would be eliminated in the cities by the adoption of daylight saving time: As the hours up to 7:00 P. M. are light during the summer months in both daylight saving and non-daylight saving cities, it would seem that we need concern ourselves only with the period from 7:00 to 12:00 P. M. Furthermore, in order that the fatigue element may be averaged out, this period must be contrasted with an adjacent period of time involving hours both prior and subsequent to the critical period. Let us then select the period from 5:00 P. M. to 7:00 P. M. and the period from midnight to 6:00 A. M. to serve as a basis of comparison. Again, in order that we may not become involved in the black horse problem, let us concern ourselves with the relative change from winter to summer fatalities within the respective hours.

For the base period just described, fatalities in the cities without daylight saving showed a decrease of 36% from the winter to the summer months; for cities with daylight saving, the decrease was 38%. For the critical period of 7:00 P. M. to midnight, the cities without daylight saving showed a decrease of only 18% from the winter to the summer months; whereas the cities with daylight saving showed a 30% decrease. Thus, the cities without daylight saving showed an 18% lesser decrease in fatalities during the critical period, while the daylight saving cities showed an 8% lesser decrease during the base period. This produces a net difference of 10%, i.e. 10% of the fatalities during the period from 7:00 P. M. to midnight for the winter months in the cities

without daylight saving. This is equivalent to 1.6% of all fatalities during the year.

Having admitted that there is a definite saving in fatalities in the cities which have adopted daylight saving time, we come to the problem of evaluating the over-all effect of daylight saving on the total number of accidents occurring everywhere. The New York State accident reports show that from the winter to the summer months there is an 18% greater increase in fatalities during the hours of 8:00 P. M. to midnight, as compared to all other hours of the day, for New York State excluding New York City than there is for New York City. This can be taken only as a confirmation of the a priori belief that during the summer people leave the city in the evening whenever possible. It is only natural to expect that this exodus would be materially increased wherever and whenever an extra hour is available under a daylight saving schedule.

The problem is somewhat analogous to the effect on accidents sustained by employees when the work week is cut from forty-eight to forty-two hours. There it would be reasonable to expect that the number of accidents sustained by employees during their working hours would be reduced. It is quite conceivable, however, that the employees might spend the additional six hours available in activities far more productive of accidents than their normal employment.

Having lived both on the road from New York City to Jones Beach and on the road from New York City to Monticello and Ellenville, with the opportunity closely to observe traffic jams at their origin and noting that these jams occurred, not at seven o'clock or eight o'clock, but during the two hours immediately following darkness and that they disappeared concurrently with the end of daylight saving time in the fall, I personally would want to see a compilation of data for areas immediately adjacent to the metropolitan districts similar to the compilation presented by Mr. Mills for the cities before making any statement that the fatalities for such areas do not at least completely offset the savings in fatalities occurring in the cities themselves.

MR. A. W. WHITNEY:

Daylight saving is a funny thing, for one reason because it is so wholly a product of the fact that we do not like to get up in

the morning; it is just a little monument that we erect each summer to the bad habit of lying in bed.

The ordinary human being gets up at seven and goes to bed at eleven; in other words, he gets up five hours before noon and goes to bed eleven hours after noon. Now suppose he were to reverse the process and get up eleven hours before noon and go to bed five hours after noon. That ought to work just as well! It would mean he would get up at one o'clock in the morning and go to bed at five in the afternoon and his corresponding day's schedule in this reverse order might be, a game of bridge from half past one in the morning to half past four, watching the sun rise at four thirty, working in the garden for an hour, breakfasting at five thirty, getting to the office at seven, leaving for home at three o'clock, dining at four and going to bed at five. Observe that among people that prefer that kind of schedule, such as fishermen and milkmen, daylight saving would mean setting your watch back instead of ahead, so that you could have more daylight time in the morning that you could use for playing golf, or delivering milk, or fishing, or working in the garden.

That may not seem to have anything to do with Mr. Mills' paper, but it has, for if people did as much driving in the early morning hours as they do in the late afternoon hours, putting in our kind of daylight saving would not save lives, it would do just the opposite, as Mr. Mills implies.

Mr. Mills' paper is interesting and timely and valuable and excellent and he has certainly checked the situation up in enough ways quite thoroughly to demonstrate the proposition that universal daylight saving would mean a very appreciable further saving of life. Another rough way of getting at it would be to figure up the hours of darkness that daylight saving converts into hours of light and then apply to these the known difference in the fatality figures between driving at night and driving in the daytime. There are many good reasons for daylight saving and this very considerable saving of life is another of them and it is certainly very much to be desired that daylight saving be made universal.

MR. CHARLES S. WARREN:

In reviewing Mr. Mills' paper I readily concede that there should be a saving of lives under daylight saving, but when you

take into consideration the various factors that contribute to fatal accidents, you begin to doubt whether any set of facts are dependable upon which we can definitely state that lives will be saved, IF we add a month of daylight saving in the spring and fall.

In Massachusetts for the four years 1936-1939 the fatal accidents totaled as follows:

| | 1936 | 1937 | 1938 | 1939 |
|---|---|---|---|---|
| Day Accidents | 273 | 266 | 207 | 172 |
| Night Accidents | 499 | 477 | 372 | 397 |
| | 772 | 743 | 579 | 569 |

These figures show a general reduction in fatal accidents over the four years both day and night although the night fatal accidents are still over twice those occurring in the day time.

In the following tabulation the fatal accidents are shown by Hours of Occurrence and a definite upward trend up to 7 P. M. for the four years.

NUMBER OF FATAL ACCIDENTS IN MASSACHUSETTS
FOUR YEARS — 1936-1939

| Hour of Occurrence | 1936 | 1937 | 1938 | 1939 |
|---|---|---|---|---|
| 12 to 1 A.M. | 69 | 48 | 40 | 36 |
| 1 to 2 A.M. | 28 | 25 | 25 | 23 |
| 2 to 3 A.M. | 20 | 22 | 9 | 12 |
| 3 to 4 A.M. | 12 | 5 | 10 | 7 |
| 4 to 5 A.M. | 4 | 11 | 5 | 7 |
| 5 to 6 A.M. | 6 | 10 | 5 | 12 |
| 6 to 7 A.M. | 9 | 12 | 15 | 9 |
| 7 to 8 A.M. | 12 | 7 | 12 | 9 |
| 8 to 9 A.M. | 11 | 15 | 11 | 6 |
| 9 to 10 A.M. | 11 | 8 | 9 | 8 |
| 10 to 11 A.M. | 16 | 16 | 13 | 10 |
| 11 to 12 Noon | 19 | 21 | 17 | 25 |
| 12 to 1 P.M. | 17 | 24 | 21 | 12 |
| 1 to 2 P.M. | 17 | 22 | 21 | 18 |
| 2 to 3 P.M. | 33 | 28 | 26 | 8 |
| 3 to 4 P.M. | 35 | 33 | 17 | 20 |
| 4 to 5 P.M. | 45 | 44 | 27 | 25 |
| 5 to 6 P.M. | 65 | 76 | 45 | 59 |
| 6 to 7 P.M. | 72 | 72 | 50 | 61 |
| 7 to 8 P.M. | 69 | 52 | 58 | 47 |
| 8 to 9 P.M. | 50 | 61 | 45 | 44 |
| 9 to 10 P.M. | 44 | 47 | 30 | 33 |
| 10 to 11 P.M. | 37 | 37 | 35 | 43 |
| 11 to 12 Midnight | 71 | 47 | 33 | 35 |
| TOTAL | 772 | 743 | 579 | 569 |

It is obvious that a study of this exhibit shows that throughout the year fatal accidents rise sharply between 5 P. M. and 8 P. M. and the question of daylight saving is only a minor factor.

There are many reasons suggested by the authorities who have studied the results of several surveys among which is this interesting observation.

In many cities the police patrol day and night shift, change at 6:30 P. M. leaving the highways almost without police protection. Therefore, the motoring public soon learn of this fact and speed home taking more than the usual chances. Several cities have corrected this condition by staggering the change of the highway patrol starting from 4 P. M. and ending at 8 P. M. and arranging for the greatest number of the police patrol to be on duty during that period.

The point I wish to strongly establish is that law enforcement by the State and Local Police is the only effective way of reducing fatal accidents.

Another suggestion put forth by a survey was that, after a hard day's work, many operators are at a low physical condition to meet an emergency, therefore contributing to avoidable accidents. Of course, speed is the greatest factor contributing to fatal accidents. Another factor is inattention or dreaming at the wheel or a mind occupied with family worries, causing unnecessary rear end collisions often causing a fatal accident.

Another exhibit showing fatal accidents by day of occurrence is interesting from the standpoint of a remarkable uniformity in the totals for each day of the week for four years. There is a slight decrease each year with the exception of Sunday.

NUMBER OF FATAL ACCIDENTS IN MASSACHUSETTS
FOUR YEARS — 1936-1939

| Day of Occurrence | 1936 | 1937 | 1938 | 1939 |
|---|---|---|---|---|
| Sunday | 129 | 113 | 102 | 113 |
| Monday | 104 | 100 | 69 | 65 |
| Tuesday | 81 | 87 | 66 | 77 |
| Wednesday | 85 | 82 | 60 | 65 |
| Thursday | 99 | 93 | 78 | 79 |
| Friday | 113 | 102 | 88 | 81 |
| Saturday | 161 | 166 | 116 | 89 |
| TOTAL | 772 | 743 | 579 | 569 |

Another tabulation of the Fatalities by Months and Years for 1936 to 1939 shows a definite increase in the number of fatalities after the daylight saving time expires, that is October, November, and December.

It should be pointed out, however, that all policies for Automobile Liability Coverage expire on December 31 with the expiration of the registration plates, which can be interpreted to mean that if the weather of the last three months of each year continues to be open, that is without snow or ice, motor vehicles are operated throughout this period.

You will also note that the first four months of each year show fewer fatalities, due, to some extent, to the fact that over 200,000 motorists do not operate their motor vehicles until later in the year.

Registration on January 1 about 600,000.
Registration after January about 400,000.

This can be interpreted to mean that fatalities decrease during the winter months of January, February and March.

MASSACHUSETTS MOTOR VEHICLE FATALITIES
BY MONTHS AND YEARS COMPARED
CALENDAR YEARS 1936-37-38-39

| Months | 1936 | 1937 | 1938 | 1939 |
|---|---|---|---|---|
| January | 54 | 64 | 33 | 48 |
| February | 44 | 48 | 36 | 30 |
| March | 45 | 72 | 37 | 35 |
| April | 58 | 52 | 48 | 46 |
| May | 56 | 59 | 46 | 41 |
| June | 65 | 58 | 29 | 35 |
| July | 61 | 55 | 41 | 44 |
| August | 78 | 61 | 65 | 46 |
| September | 84 | 62 | 71 | 49 |
| October | 77 | 82 | 68 | 72 |
| November | 97 | 74 | 64 | 78 |
| December | 97 | 94 | 84 | 75 |
| TOTAL | 816 | 781 | 622 | 599 |

In concluding my thoughts on Mr. Mills' paper, I have reached the conclusion that daylight saving time plays a very small part in the fatality record.

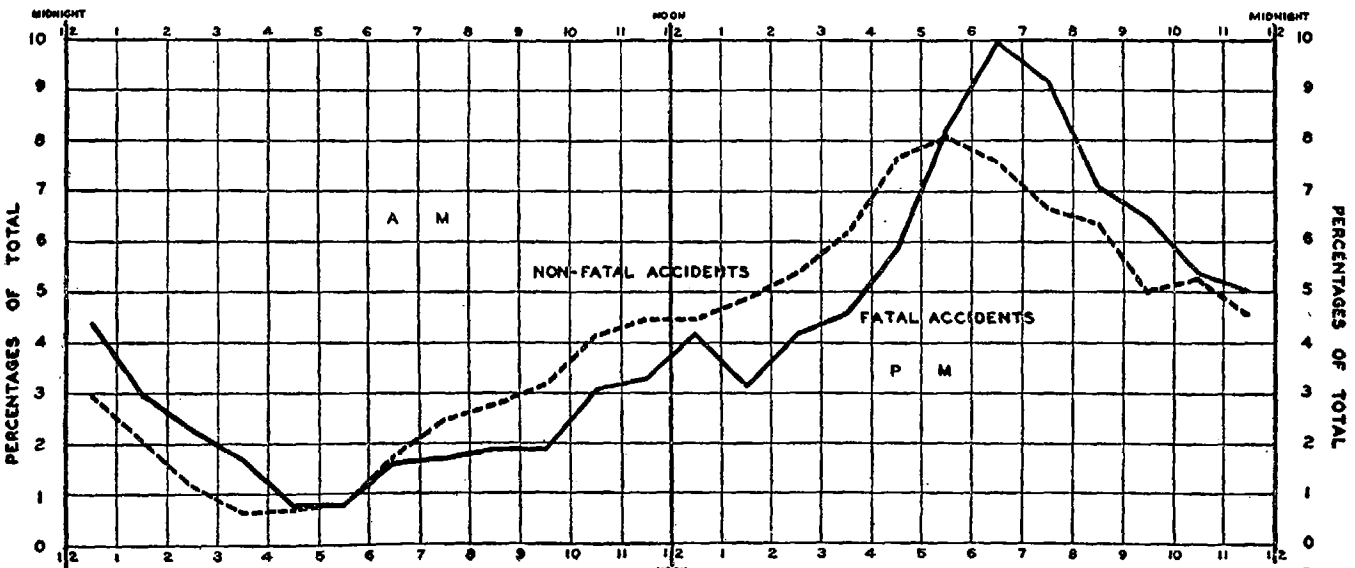
Attached hereto is a chart furnished me by the Department

MASSACHUSETTS

DISTRIBUTION THROUGH THE DAY

FATAL AND NON-FATAL ACCIDENTS

10 YEARS 1930-1939



of Public Works, Registry Division of the Commonwealth of Massachusetts which to me is remarkable.

The chart shows that for ten years the fatalities for winter and summer have a uniform distribution throughout the day, and all our accident prevention activities have not changed this apparently static record.

MR. RUSSELL P. GODDARD:

Mr. Mills has boldly attacked one of the most difficult problems that confront the insurance actuary—the handling of raw statistics. It is gratifying that his study is concerned with automobile accidents, which present one of the most interesting and mysterious fields that the statistician can explore. Automobile accidents, as we know, are caused by the presence on the highways of too many old cars with defective brakes, too many new cars with powerful motors, too many old drivers with slow reflexes, too many young drivers with no common sense, too many slow-pokes who get in the way, too many speed demons who try to pass them. Theories are plentiful and statistics are few. Out of this welter of confusion Mr. Mills brings us some actual facts about the accident records of cities using, or failing to use, daylight saving time.

Before discussing the effect of daylight saving time on automobile accidents, it may be pertinent to discuss the original reasons for the adoption of this device. Prior to 1883 standard time did not exist in this country and every important city used its own local time. Standard time was not legalized until March 19, 1918, when Congress directed the Interstate Commerce Commission to establish time zones for the country. The use of the same standard time for an entire zone naturally means that those cities in the eastern half of the zone will get an earlier sunrise and sunset than they would otherwise have. The opposite holds true for the cities in the western half of the zone, and the deviation from true sun time is as much as half an hour on the edges of the time belt. To correct for this deviation, cities in the eastern halves of these zones adopted daylight saving, and it is interesting to see that this was first adopted by New York City on March 19, 1918, the same day that the time zones were officially established. Practically all the cities which have since adopted daylight time have

been in the center or in the eastern half of a zone. Chicago, which would ordinarily use Central Standard Time, at one time put itself effectively on year-round daylight time by adopting Eastern Standard Time.

In determining accident frequencies, Mr. Mills has in general used the 1930 census as a base. In the three cities listed below, however, the populations given by Mr. Mills are somewhat different from those in either the 1930 or the 1940 census.

| | Population (Mr. Mills' paper) | Population 1930 Census | Population 1940 Census |
|---|---|---|---|
| Kansas City | 340,000 | 400,000 | 400,000 |
| Los Angeles | 2,208,000 | 1,238,000 | 1,497,000 |
| Washington, D. C. | 594,000 | 487,000 | 663,000 |

Possibly the differences in Los Angeles and Washington arise from the fact that some suburban areas have been included. This is particularly important in the case of Los Angeles which is the dominant city in the group not adopting daylight saving.

| Type of City | City | Population | Number of Accidents in 24 Mos. | Monthly Average per 10,000,000 Pop. |
|---|---|---|---|---|
| Without D.S.T. | Baltimore | 805,000 | 233 | 121 |
| | Denver | 288,000 | 121 | 175 |
| | Kansas City | 340,000 | 91 | 112 |
| | Los Angeles | 2,208,000 | 911 | 172 |
| | Louisville | 308,000 | 81 | 110 |
| | Memphis | 253,000 | 73 | 121 |
| | Milwaukee | 578,000 | 100 | 72 |
| | St. Louis | 822,000 | 163 | 82 |
| | San Francisco | 634,000 | 201 | 132 |
| | Washington, D. C. | 594,000 | 164 | 115 |
| | *Total Above* | 6,830,000 | 2,138 | 130 |
| | *Total Excl. Los Angeles* | 4,622,000 | 1,227 | 111 |
| With D.S.T. | Chicago | 3,376,000 | 1,298 | 160 |
| | Newark | 442,000 | 110 | 104 |
| | New York | 6,930,000 | 1,542 | 93 |
| | Philadelphia | 1,951,000 | 546 | 117 |
| | Providence | 253,000 | 26 | 43 |
| | Rochester | 328,000 | 71 | 90 |
| | *Total* | 13,280,000 | 3,593 | 113 |

It will be seen that Los Angeles had the highest accident frequency of all cities except Denver. With Los Angeles excluded, the cities on standard time had a slightly lower average accident

frequency than the cities on daylight time. There is also considerable variation among the cities in each group. This variation may be more apparent than real—the accident rates might be more consistent if some other base, such as the number of registered vehicles, could have been used instead of population. Unfortunately, it is practically impossible to obtain such figures.

One of the interesting facts brought out by Mr. Mills' investigation is that the cities using daylight time have a better accident record in both light and dark hours. Their superiority is particularly marked in the hours between 5 P. M. and 9 P. M. A possible explanation of this may be the relatively longer twilight in the northern latitudes where this particular group of daylight saving time cities is located.

The following table is based on the distribution by hour given in Appendix "B." The total number of accidents per 10,000,000 population was obtained by dividing 3593 by 1.328 and 2138 by .683.

| Hour | Number of Months in Darkness | | No. of Fatal Accidents per 10,000,000 Population | | No. of Fatal Accidents (Sub Totals) | | Number of Lives Saved in D.S.T. Cities | |
|---|---|---|---|---|---|---|---|---|
| | Without D.S.T. | With D.S.T. | Without D.S.T. | With D.S.T. | Without D.S.T. | With D.S.T. | No. | % |
| 12 A.M. - 6 A.M. | 24 | 24 | 529 | 525 | 529 | 525 | 4 | .8 |
| 6 A.M. - 7 A.M. | 4 | 4 | 47 | 60 | | | | |
| 7 A.M. - 5 P.M. | 0 | 0 | 880 | 814 | 927 | 874 | 53 | 5.7 |
| 5 P.M. - 6 P.M. | 6 | 6 | 263 | 214 | | | | |
| 6 P.M. - 7 P.M. | 12 | 12 | 329 | 254 | 592 | 468 | 124 | 20.9 |
| 7 P.M. - 8 P.M. | 20 | 14 | 369 | 212 | | | | |
| 8 P.M. - 9 P.M. | 24 | 20 | 257 | 196 | 626 | 408 | 218 | 35.0 |
| 9 P.M. - 12 P.M. | 24 | 24 | 456 | 431 | 456 | 431 | 25 | 5.3 |
| | | | 3,130 | 2,706 | 3,130 | 2,706 | 424 | 13.5 |

It will be seen that the daylight time cities had 20.9% fewer accidents in the hours between 5 and 7 P. M., in spite of the fact that the same light conditions obtain in these hours in cities not using daylight time. In the hours from 7 P. M. to 9 P. M., which under certain conditions may be light in one city and dark in another, the cities using daylight time were 35.0% better. This is the only period of the day, except the early morning, which is affected by daylight saving.

Mr. Mills has given us the accident rates for these hours in the

daylight saving cities, and it is possible to make a rough conjecture as to the number of additional accidents which would have occurred in these cities if daylight saving had not been in effect. This is done in the following table by multiplying the accident rates by the number of light or dark hours in the 24 months covered by the survey.

| | Average No. of Fatal Acc. per Mo. per 10,000,000 Population | | No. of Months to Which Rates Apply (Using D.S.T.) | | Estimated Number of Accidents in 24 Months per 10,000,000 Population | | |
|---|---|---|---|---|---|---|---|
| | D.S.T. Cities | | | | | | |
| | Light | Dark | Light | Dark | Light | Dark | Total |
| | (1) | (2) | (3) | (4) | (1) × (3) | (2) × (4) | |
| 7 - 8 P.M. | 4.4 | 12.0 | 10 | 14 | 44 | 168 | 212 |
| 8 - 9 P.M. | 4.0 | 9.0 | 4 | 20 | 16 | 180 | 196 |
| | | | | | | | 408 |

| | No. of Months to Which Rates Apply (Not Using D.S.T.) | | Estimated Number of Accidents in 24 Months per 10,000,000 Population | | |
|---|---|---|---|---|---|
| | Light | Dark | Light | Dark | Total |
| | (5) | (6) | (1) × (5) | (2) × (6) | |
| | 4 | 20 | 18 | 240 | 258 |
| | .. | 24 | .. | 216 | 216 |
| | | | | | 474 |

From this it would appear that these cities had saved approximately 66 lives, roughly 2.5% of the total, by the adoption of daylight saving. If we exclude the effect of daylight saving, the accident rate of these cities would still be more than 11% better than that of the other cities.

Most of the figures given in Mr. Mills' paper show the average accident rate per hour regardless of traffic volume. In Appendices "B" and "C," however, the estimated volume by hour is given, and it is possible to calculate the number of accidents per month if either day or night conditions prevailed all the time. In Appendix "B" the estimated traffic volume in the 18 hours from 6 A. M. to midnight is 92.9% of the day's total. In cities without daylight time, 64.4% of the total traffic occurs in daylight and 28.5% in the dark hours before midnight. These facts are used in the following table, based on the results in the cities not using standard time.

| | Light Hours | Dark Hours (excl. 12 to 6 A.M.) |
|---|---|---|
| (1) Fatal Accidents in 24 Months.... | 776 | 1,000 |
| (2) No. of Accidents on basis of 10,000,000 Population (1) ÷ .683 | 1,136 | 1,464 |
| (3) Average Number of Accidents per Month..... | 47.3 | 61.0 |
| (4) Percent of Traffic Volume..... | 64.4 | 28.5 |
| (5) Average Number of Accidents per Month under conditions of lightness or darkness (3) ÷ (4). | 73.5 | 214.3 |

We therefore see that these cities would have had 73.5 accidents per month if darkness did not exist, and 214.3 accidents if the sun never shone again. This gives a slightly different interpretation to the figures used in Appendix "C."

It is rather surprising at first to find that the decrease in motor vehicle fatalities resulting from daylight saving time is so small. However, Mr. Mills has shown that this device produces relatively little increase in effective daylight over a full year period. In a 24 month period, disregarding the hours from midnight to six o'clock, there are 294 hours of daylight and 138 hours of darkness as compared with 304 hours of daylight and 128 hours of darkness if an hour of daylight is added in the five summer months. The adoption of daylight saving time increases the proportion of daylight from 68.1% to 70.4%. Such an increase in daylight can produce a decrease in automobile accidents of approximately 2.5% if the accident frequency in daylight is, as Mr. Mills has demonstrated, about one-third of the frequency at night.

MR. J. MALMUTH:

Mr. Mills has presented a timely paper.

Close to 40,000 fatalities and over 1,000,000 accidents a year is the current price exacted by the motor vehicle. These figures are tragic evidence of the need for ever-increasing endeavor and diligence to discover and act on ways and means of reducing them.

The automobile industry has helped by turning out cars sturdier in construction, better equipped mechanically and easier to control. Tires have been made safer. Automobile glass has been made shatterproof.

The federal, state and municipal governments have helped by the thoughtful planning and building of excellent roads, bridges and tunnels, the efficient maintenance of these instrumentalities of traffic, the elimination of railroad crossings, the installation and improvement of mechanical methods of traffic control, and educational campaigns in the schools and generally. Driving courses are included in the curricula of many schools and colleges throughout the country. Licensing tests are more strict and more comprehensive. In some states provision is made for periodical inspections of cars for defects. In many states financial responsibility laws have been enacted which by their requirement that evidence of financial responsibility be furnished in certain situations, may be considered as tending to encourage safe driving.

Insurance companies, life, accident and casualty, have not been standing idly by. They spend substantial sums every year preaching by means of the cinema, the radio and the printed word, the gospel of careful and safe driving. The casualty companies have adopted merit rating plans which encourage careful driving by providing savings in insurance costs to accident-free car owners.

Mr. Mills makes a very constructive suggestion. Some readers of his paper may contend that he has not given proper consideration to or has not correctly evaluated all the factors which have a bearing on the question. For example, Mr. Mills points out that fatal accidents during each of the hours from 5 P. M. to 9 P. M. are roughly three times more numerous during months in which the hour is dark than during months in which it is light. It may be reasonably argued that it is not proper to attribute this fact entirely to the darkness of the hour and that the weather during the period when these hours are dark accounts in part for the more adverse experience. But, on the whole, Mr. Mills has presented a convincing case. Supporting evidence is found in the monthly and annual reports published by the New York Commissioner of Motor Vehicles. An analysis of accidents reported to the Bureau of Motor Vehicles for 1939 shows 562 fatalities for the eight hour period 8 A. M. to 4 P. M., compared to 1,076 fatalities for the eight hour period 4 P. M. to 12 P. M. The analysis also shows that 905 fatalities occurred in daylight and 1,206 fatalities at night. An analysis by conditions of vehicles involved in accidents shows 57 fatalities due to glaring headlights, 20

fatalities due to one or both headlights out and 19 fatalities due to tail-light out or obscured, all items peculiar to night driving. The Commissioner in commenting on the 1939 record said, in part, as follows:

> "As usual the hours of darkness were responsible for the most fatal accidents."

Although Mr. Mills has confined his paper to the matter of automobile fatalities, I believe a study undertaken to cover the field of industrial accidents would show that where in effect daylight saving has been responsible for a marked decrease in the accident frequency and the number of serious injuries. It is a well established fact that the last working hour of the day is the time of greatest fatigue and if at such time the worker has a daylight hour instead of an hour of artificial light, the hazard of eyestrain and fatigue is lessened, thereby reducing the risk to accident.

The original proponents of daylight saving in this country suggested putting it into effect on an all year round basis. Mr. Mills gives two reasons against it. Although it may not be feasible to establish it for the entire year, it does seem feasible to extend it so that it will include the months of March and October. One of the reasons advanced by Mr. Mills against an all year application is that a large volume of traffic moves during the hour from 7 A. M. to 8 A. M. and this traffic would be forced to move in darkness during the winter. From the chart which is part of Appendix "B" it appears that during March and October, with daylight saving, this would be an hour of daylight. Some idea of the benefit that would accrue from an additional hour's daylight during the month of October particularly can be gathered from the following remarks by the New York Commissioner of Motor Vehicles in his report for 1939:

> "October was the most dangerous month of the year, for 296 fatalities occurred during that period. This month or December generally leads in recording the most motor vehicle deaths."
>
> "The hour of greatest peril was from 6 P. M. to 7 P. M., for during that period 175 fatal accidents occurred. The hour from 7 P. M. to 8 P. M. usually had this dubious distinction."

## AUTHOR'S REVIEW OF DISCUSSIONS

### MR. JOHN A. MILLS:

The five reviews of this paper show the widespread interest of members of this Society in accident prevention and particularly in the part that statistics can play in bringing about a better nationwide motor vehicle fatality record. It is gratifying that the reviews, in the main are favorable to the conclusion reached by the author, namely, that the more general adoption of daylight saving time would save lives.

Mr. Bailey suggested that a different approach might have been used, namely that of comparing the Summer with the Winter record for daylight and non-daylight saving cities respectively. This basis of comparison was considered but it was not adopted because all of the daylight saving cities are in the North, whereas many of the non-daylight saving cities are in the South. Weather conditions are reasonably similar between the North and the South during the Summer whereas they are not similar during the Winter. In other words, we would be comparing a period of considerable snow and ice with Summer conditions in the case of daylight saving cities but a period of little snow and ice with Summer conditions in the case of non-daylight saving cities. Another factor that tends to invalidate the suggested basis of comparison is the movement of people from the North to the South in Winter and from the South to the North in Summer.

The comparison made by Mr. Bailey of the Winter record of daylight and non-daylight saving cities is distorted by variations in weather conditions and in the hourly volume of traffic between Northern and Southern cities. That weather conditions affect not only the accident hazard per mile but also the hourly distribution of traffic mileage is evidenced by statistics of traffic volumes compiled by the U. S. Bureau of Public Roads. These statistics show that during the Summer months 28.7% of the day's traffic moves between 10 A. M. and 3 P. M., and 20.9% between 6 P. M. and 10 P. M. During the Winter months 31.9% of the day's traffic moves between 10 A. M. and 3 P. M. whereas only 16.8% moves between 6 P. M. and 10 P. M. This shift in traffic is particularly noticeable in colder climates.

The possibility that the saving of lives in cities adopting daylight saving time would be offset by an increase in fatal accidents

in neighboring areas is rather difficult to measure on the basis of available statistics. However, the meager information that is available indicates that the increase in neighboring areas would not be important. We compared the fatal accident record of New Jersey and New Hampshire, which have exclusively daylight saving time with the fatal accident record of Maryland and North Carolina, which have exclusively standard time, and found that the indicated saving was in line with that shown in the comparison of city data.

AVERAGE NUMBER OF FATAL ACCIDENTS PER MONTH PER 10,000,000 POPULATION

(Five Summer Months)

| | States Without Daylight Saving Time | States With Daylight Saving Time |
|---|---|---|
| 10 A.M. - 3 P.M. | 26.9 | 28.7 |
| 6 P.M. - 10 P.M. | 48.6 | 41.6 |
| Increase | 21.7 | 12.9 |
| Percent of Increase | 80.7% | 44.9% |

New York State was referred to by Mr. Bailey in connection with this point, but since this state uses both daylight and standard time, its record is not as indicative as a comparison of states having exclusively daylight saving time with states having exclusively standard time.

Aside from the statistics we have presented, there appear to be valid reasons to believe that the indicated reduction in fatalities in the cities would not be offset by a comparable increase in the surrounding areas. To begin with, country driving is not as hazardous as city driving and consequently a shift of mileage to less hazardous roads should be a switch for the better. Furthermore, accident records show that 72% of the fatal accidents occurring in cities after dark involve pedestrians whereas only 32% of the fatal accidents occurring outside of cities after dark involve pedestrians. The high pedestrian motor vehicle mortality rate in cities after dark is due to the combination of poor visibility and the number of pedestrians exposed. Since there are fewer pedestrians exposed in the country than in the city it seems logical to reason that a shift of travel away from cities would be beneficial.

Mr. Goddard questioned certain of the population figures used in the study. The Washington, D. C., population that was used represented an estimate for the year 1937. A later date was used for this city because of its tremendous growth during the past decade. The Los Angeles figure includes the suburbs, and the Kansas City figure should have been given as 400,000. It perhaps should be pointed out in this connection that revising the population figures has no bearing on the comparisons as made or on the conclusions that were drawn for the reason that the number of accidents in the evening hours in relation to the number of accidents during the chosen daylight hours comprise the essential elements in the comparison.

The better accident record per unit of population of the daylight saving cities during all hours and not just during the hours affected by daylight saving is largely due to the lower than average ratio of motor vehicles to population in the case of New York City. In determining the saving of lives under daylight saving time, comparisons were made between different hours in the same cities and not between the two groups of cities so that any advantage held by the daylight saving cities as a result of their better accident record was eliminated.

The evening hours of 6 P. M. to 10 P. M. were chosen so as to eliminate the influence (insofar as possible) of the change in traffic volumes from hour to hour caused by varying light conditions. Because of twilight[1], daylight saving affects light conditions to some extent between 9 P. M. and 10 P. M. during June and July, and between 6 P. M. and 7 P. M. during September.

Mr. Malmuth suggested the desirability of extending daylight saving time to the months of March and October. The extension probably would reduce fatal accidents but we did not include these two months because a part of the hour from 7 A. M. to 8 A. M. would be dark in these months. In our study morning darkness is assumed to end thirty minutes before the sun is actually above the horizon. A smoky or foggy morning in March or October might cause dangerously dark driving conditions for an hour or more beyond the assumed time line.

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[1] Information from widely scattered weather bureaus indicates that the length of civil twilight (sun 6° below horizon) varies about ten minutes among various localities. This variance is too small to have any appreciable effect on the data.

The question was raised by several reviewers as to the effect which such factors as law enforcement, speed, inattention, liquor and fatigue have on the accident record. These factors are present in both the daylight saving and non-daylight saving cities and while they do cause accidents the limitations of available statistical data made it necessary for us to assume that their influence in the two groups of cities was about the same.

In the final analysis the conclusion that daylight saving time will save lives rests on the fact that the automobile accident fatality rate is greater per mile during darkness than during light and that the factor of visibility is an important determining factor in the difference. Since the fatal accident rate per mile of travel is known to be about three times as high during the night as during the day, it appears reasonable to conclude that each mile of travel shifted from dark to light will bring with it a reduction in the over-all fatality rate.