The effect of alcohol on the central nervous system can be, and has been, used as a means of investigating the properties of the latter. This assembly is, however, mainly concerned with one aspect of such researches, namely how alcohol is likely to affect the reactions of drivers on the road and whether a knowledge of the blood alcohol concentration can be used as a sure guide to the state of the central nervous system. If this were so, then a blood or breath test for alcohol might reasonably be made compulsory in the case of car drivers involved in serious or fatal accidents and the onus of causing the accident be placed upon those showing a blood alcohol concentration known to interfere with the normal functioning of the central nervous system. This would presuppose that sampling could be carried out immediately after the accident and alcohol analysis made with a reasonable degree of accuracy, matters obviously involving considerable organization and expense.

It is well known that different individuals are affected to a widely varying degree by the same dose of alcohol in relation to body weight. Individual variation in sensitivity, acquired tolerance, type of body (for alcohol concentration will be higher in the blood of fat people since it does not dissolve in fat), varying rate of absorption, all play their part in producing the observed differences. These last two factors, however, would not affect the relation between the degree of central nervous system upset and blood alcohol concentration and it is this relationship with which we are now concerned.

Is it a fact that the vast majority of people show signs of central nervous upset when the blood alcohol concentration is greater than a certain value? If this value is high enough, then the answer is 'yes', just as with any other central depressant. But over the range of concentration which is likely to affect adversely the reactions of car drivers, one has regretfully to admit that the answer is 'no'. At a given concentration of blood alcohol, not only does the degree of upset vary widely from one individual to another, but in the same individual in different circumstances.

First, there is the now well known disturbing factor of the direction in which the blood alcohol concentration is moving. If it is increasing it causes greater upset at any absolute concentration than if it is decreasing. In the subjects which I studied some years ago, comparing their performances in various sensori-motor tests
(dotting machine, pursuitmeter, typewriting) with the blood alcohol concentration, the effect was very obvious. The degree of upset of the central nervous system was expressed as % deterioration, that is the % increase in time of typing or % increase in errors in following the pursuitmeter. In one such test, a subject who showed a 40% impairment at 100 mg. alcohol, 100 g. blood (hereafter referred to as mg.%)) on a rising curve, showed only 14% impairment on a falling curve. In a subject in which 100 mg.% on a rising curve was associated with 10-25% impairment in different experiments, the same concentration on a falling curve was associated with complete recovery as recorded by the test on all four separate occasions. Mirsky and his colleagues, using larger doses and differentiating only between 'drunk' and 'sober' (abnormality of gait and of speech, etc., were essential to the diagnosis of 'drunk'), obtained similar results. When the blood alcohol concentration was increasing the subjects became 'drunk' at 150-170 mg.%, whereas recovery to 'soberness' occurred at 250-280 mg.% when the concentration was maintained steady or allowed to fall.

Secondly, not only is the effect of increasing concentration greater than that of decreasing concentration, but the rate of increase is found to be another disturbing factor. At any given blood alcohol concentration, greater upset occurs if the concentration is increasing rapidly than if it is increasing more slowly. In the subject already mentioned, a value of 100 mg.% was encountered on a rising curve on several occasions. At the slowest rate of increase, the central nervous system was little affected, but with faster rates of increase impairment became more noticeable and at the fastest reached the relatively high value of 45%. This relationship is shown in the following table.

<table>
<thead>
<tr>
<th>Absolute blood alcohol concentration</th>
<th>Percentage deterioration in test</th>
</tr>
</thead>
<tbody>
<tr>
<td>mg.%/min.</td>
<td></td>
</tr>
<tr>
<td>2.15</td>
<td>6</td>
</tr>
<tr>
<td>2.6</td>
<td>17</td>
</tr>
<tr>
<td>5.3</td>
<td>35</td>
</tr>
<tr>
<td>7.5</td>
<td>45</td>
</tr>
</tbody>
</table>

In the same group of subjects, the third disturbing factor of individual variation in response could be seen. At the same concentration of 100 mg.%, one less tolerant subject than that mentioned above showed a 40% deterioration when the blood alcohol concentration was increasing at only 2.7 mg.%/min. Another more tolerant showed only 15% deterioration at a rate of 3.2 mg.%/min; while a third, in whom 100 mg.% absolute concentration was not attained, showed a deterioration of 20% at a rate of only 1.8mg.%/min. at a concentration of only 70 mg.%. He was undoubtedly the least tolerant of those examined.

In addition to these three disturbing factors, there is another for which a good deal of indirect evidence exists. Namely, that an individual unpractised in a test will show greater impairment, other conditions remaining constant, than one well-versed. That is to say, an experienced driver will be less impaired than one newly learned to drive. I say 'indirect' evidence, for I do not think this point has been proved experimentally, but it seems highly probable from other evidence available.
In animals, there is clear cut evidence that more complex performances deteriorate more under a given dose of alcohol than do simpler ones. In rats, the ability to find their way towards food through a complex maze was lost under the influence of alcohol at a time when they could still successfully thread a simpler maze. In dogs, the salivary reflex conditioned to sound was much more depressed with a given dose of alcohol than were the older established ones of response to sight or smell of food; and in cats the most complex act to which they had been trained—turning a switch which operated a bell and light signal which dropped food into a box which the cat then opened—was most affected. When these animals had, under the influence of alcohol, forgotten about the switch, the conditioned response to bell and light signal was still intact. Since the same animals were tested under the different conditions in all these experiments, the evidence seems conclusive.

In man, however, many experiments have not been well-controlled and the older evidence is often contradictory. More modern work has led to the general conclusion that the more complex mental functions are more affected by alcohol than are the simpler ones; in regard to car-driving itself, Newman and his colleagues concluded that greatest impairment occurred with the more complicated and less frequently performed tasks. Since the simple tasks which become almost automatic in the experienced drivers are still relatively complicated to one who has just learnt to drive, his performance would be expected to deteriorate more under the influence of alcohol than that of the experienced driver.

Lastly, the effect of acquired tolerance cannot be ignored. Its existence has been directly proved in the case of dogs, and statistical analysis of the reactions of groups of abstainers, light drinkers and heavy drinkers strongly suggests that man is affected in similar fashion. All other things being equal, one driver accustomed to taking alcohol regularly will be less affected at a given blood alcohol concentration than will an abstainer.

In view of these many complications, at a blood alcohol concentration of, say, 100 mg.%, the driver might be responsible for an accident because he was under the influence of alcohol or he might not. At 200 mg.% most individuals are likely to be affected, but some only relatively slightly while others are rendered obviously incapable. Under conditions in my own experiments in which minimal effects might be expected, I have observed complete normality at 135 mg.% and only a 30% deterioration at 170 mg.%.

At a similar concentration Newman and his colleagues, scoring points for different aspects of driving in a test on the road, found that all of their subjects showed impairment in some respects, though unaffected in others, but the performance of all was such that they would have passed an official driving test.

If a danger limit of 150 mg.% should be accepted, a fair proportion of those containing such a concentration would be affected by it, though many innocents would be unfairly convicted. Perhaps even more important, however, quite a number of people with a concentration considerably less than 150 mg.% would be exonerated although the impairment of their judgment or an increase in their reaction time due to alcohol had been the
cause of the accident. It is a matter of opinion whether the law should be encouraged to convict many guiltless in making certain of the guilty, or let many guilty escape in order to protect the guiltless.

I sometimes wonder, in respect of road accidents, whether alcohol has not been used as a stalking horse. In my own country, for example, in the analyses of road accidents with a view to assessing the effect of various possible factors concerned, the names of the makes of car involved are never divulged. Yet it is obvious that the range of visibility, relation of braking power to weight, etc., vary in different types of car and if some were found to be more often involved in accidents than others, in relation to their various numbers on the road, it is one of the adverse factors that could be remedied. High speed appears to be a relatively minor factor; under some conditions, in fact, excessively slow speed would seem to be an equal danger. Undoubtedly road surface, lack of suitably placed road signs and bad lighting must take their share of blame. Another factor, accident-proneness, is probably a major factor and had as much attention been paid to that as to the effects of alcohol, the accident rate would not be as high as it is. Some large firms have conducted their own research in this direction, I am glad to say, and acted upon the results; and more information on this point is available in some other countries.

I shall, perhaps, not be popular for uttering such views in the present assembly, but although our main concern is with one particular aspect of the problem, the basic problem remains—how to diminish the number and seriousness of road accidents. If the medical profession would tackle this problem in the manner in which it has dealt with other death-dealing diseases, the mortality rate might fall as swiftly. In our present state of knowledge, however, the most rational treatment would seem to be the infliction of a heavy penalty—preferably removal of driving licence—on any driver responsible for a fatal accident, whatever the cause, whether this was due to irritable temper, accident-proneness or too much insulin, barbiturate or alcohol.

It can, however, be argued that responsibility is greatest in the case of alcohol, since this has been deliberately taken in spite of its known dangers, and that the individual therefore merits additional punishment on that score. In communities where the accident rate due to alcohol is high, the blunderbuss method (if I may be allowed to call it so) adopted by Detroit might be applied with advantage. In each December, the month of highest accident rate, drivers obviously under the influence of alcohol are sent to jail with no option of a fine. As a result, the number of fatal accidents caused by them dropped from 47 in 1941 to 2 in 1950 although road traffic density had increased by 30% and the number of injured fell from 1,774 to 115.

If the effects of alcohol in lesser degree are to be penalized, there would seem to be three possible courses of action: the legal offence could be (a) driving a vehicle if any alcohol had been consumed during the preceding few hours, or (b) driving a vehicle if the alcohol concentration in the blood was greater than 150 mg.%. Either measure would necessitate a blood or breath sampling test on all drivers involved in fatal accidents.
This would obviously be impracticable in some circumstances, but in countries like my own in which the majority of road fatalities occur in or close to towns, such testing might be done effectively if the cost, in money and man-power, involved in the requisite organization were considered justified. The third alternative would involve an assessment of the state of the central nervous system, that is a functional test for the effects of alcohol. This would have to be relatively simple, e.g. reaction time, so that the test could not be 'learned' beforehand. In principle, I think it is the method of choice, but research may show that it is not a practicable proposition.