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MEDICOLEGAL ASPECTS OF CHEMICAL TESTS OF ALCOHOLIC INTOXICATION

I. M. Rabinowitch

I. M. Rabinowitch, O. B. E., D. Sc., M. D., C. M., F. R. C. P.(C), F. A. C. P., was one of the leading participants in the program of the American Medicolegal Congress, held last January in St. Louis. We are pleased to have the privilege of presenting to our readers his excellent and comprehensive address on Chemical Tests of Alcoholic Intoxication, which he read at the Congress. Dr. Rabinowitch, who has participated as an expert witness in numerous trials in which there was a question of alcoholic intoxication, is Associate Professor of Medicine and Lecturer in Medical Jurisprudence and Toxicology at McGill University, Montreal, and Director, Institute for Special Research and Cell Metabolism, The Montreal General Hospital.—EDITOR.

In Canada there is the supposed slogan of the Royal Canadian Mounted Police that they are out to "get their man." Be it as it may be, one method by which it cannot be accomplished is the recommendation by the Committee on Tests for Intoxication of the National Safety Council of the United States that "if there was . . . fifteen-hundredths percent or more by weight of alcohol in the defendant's blood, it shall be presumed that the defendant was under the influence of intoxicating liquor."

The first attempt in Canada to make use of the alcohol content of the blood, independent of all other evidence, failed. In rendering the judgment in this case (Weir v. Dickson) the Hon. Mr. Justice McDougall, put it thus:

"The Court does not propose to follow the expert witnesses into the intricacies of the relative merits of blood for testing purposes. . . . To do so would be long and could serve no useful purpose. It will be sufficient to say that while the alcohol content of the blood may usefully be referred to as constituting some proof of intoxication in itself is not conclusive of the fact."

This case eventually reached the Supreme Court of Canada, where the judgment of the trial court was upheld.

The need of laboratory tests for the detection of drunkenness hardly requires comment. The incidence of traffic accidents is on the increase; the extent to which alcoholic intoxication is a contributing factor is on the increase (1.2.3.4.5.6.7.) and a driver of a motor vehicle or a pedestrian who is under the influence of alcohol is a menace to others as well as to himself which no improvement of motor car equipment and which no skill of sober users of the road are capable of combatting.

Introduction

I. Alcohol and Motor Car Accidents. It is not necessary to acquaint this audience with the increasing incidence of traffic accidents and the extent to which alcoholic intoxication is a contributing factor; nor to the relationship between alcoholic intoxication and crime. There is no reason to believe that the finding in an investigation (1) in 1937 that 7 per cent of all drivers and 11 per cent of all pedestrians who had been involved in accidents had been drinking does not apply to the present. In the following year, a somewhat similar study showed that both incidences had increased (2). The extent to which drivers of motor-cars who had been drinking are more liable to be involved in accidents than others is suggested from the finding in another investigation that 47 per cent of the drivers so involved had appreciable amounts of alcohol in their bloods, compared with 12 per cent only of a group of drivers selected at random who had not been involved in accidents (3). In another study, 37.3 per cent of 314 pedestrians who had been killed in traffic accidents had alcohol in their bloods (4). In Europe the experiences have been essentially the same. In one investigation (5), of a total of 2,530 persons involved in accidents, 9.9 per cent had some alcohol in the blood, fitting in with the abovementioned values of 7 and 11 per cent respectively. In another investigation, it was found that 40 per cent of persons injured in traffic accidents had more or less alcohol in the blood (6). That the presence of alcohol in the body increases the speed of motor-car driving, statistically at least, seems to be an experimental fact (7). A driver of a motor vehicle or a pedestrian, who is under the influence of alcohol, is thus a menace to others as well as to himself which no improvement of motor-car equipment and which no skill of sober users of the road are capable of combatting. To some extent this is recognized in law.

II. Alcohol and Culpability. Intoxication of the driver involved in an accident is usually regarded as prima facie evidence of his culpability. Proof that the pedestrian victim was drunk at the material time is usually evidence that he was at least guilty of contributory negligence. The practice is thus somewhat similar to that in cases of assault. Evidence, for example, that the victim was drunk at the material time raises the suspicion that he had provoked the attack, and mere drunkenness does not mitigate any crime. There is a vast difference in law between having been insane from alcohol and having been merely drunk. If, in fact, insanity supervenes as the result of alcoholic excess it is a complete answer to a criminal charge as insanity from any other cause; but, evidence of drinking falling short of a proved incapacity in the accused to form the specific intent necessary to constitute the crime, and merely establishing that his mind was so affected by drink that he more readily gave way to some violent passion, does not rebut the presumption that the accused intended the natural consequences of his act.

III. Medical Evidence. Penalties, ranging from loss of a driving license or payment of damages to imprisonment or even death, may thus depend upon proof that the individual was or was not drunk at the material time, yet, within the range of forensic medicine, there is no subject upon which the medical evidence is more unsatisfactory than that appertaining to drunkenness. The chief problem is not the driver who was so intoxicated that he was physically unable to drive his car. The markedly intoxicated pedestrian is also relatively uncommon. The difficulty is with sub-clinical intoxication—that degree which has enabled the driver involved in the accident to appear normal at the material time, but which, at the same time, had definitely impaired his driving efficiency. Any additional aid to the diagnosis of alcoholic intoxication in such cases is, therefore, very highly welcomed, and one of the great advances has been the development of chemical methods. The extent to which these tests are now accepted as evidence in Courts of Law is well known. What, however, is not fully appreciated, judging from personal experiences, both in criminal and civil cases, are the many possible pitfalls not only in the performance of these tests, but also in the interpretation of their results and, thus, possible miscarriages of justice from undue reliance upon them.

IV. Moral Aspects. We are not here concerned about some of the moral aspects, such as placing the suspect in a special cell in which there is a urinal with a false outlet—a pipe leading to a specimen container on the other side of the cell—so that a sample may be obtained without the knowledge of the suspect (2.8). Another example is an officer telling the suspect that the specimen of urine is part of the physical examination which is given to all persons held in jail.

V. Legal Aspects. Nor are we concerned here with the legal aspects of blood tests obtained without the consent of the suspect in jurisdictions in which there are no statutes which make the tests compulsory (9.10). In Canada, at least, as in Great Britain, no accused may be forced to give evidence about drunkenness by the examination of his or her body which may lead to conviction. Expressed consent to the examination must be given freely and only after a full explanation of the potentialities of the examination has been made and understood by the suspect. The consent may be withheld, and, where it has been withheld, but nevertheless has been performed, the physician, by having pricked the skin or punctured a vein to obtain the sample of blood, is in the same position as having performed a surgical operation without the consent of the patient. He has, in fact, laid himself open to a charge of assault, criminal as well as civil (6).

VI. A Legal Question. Here, however, we have to deal with the scientific aspects only of these tests, namely, (a) their limitations due to the technical steps involved and (b) limitations in the interpretation of the findings, due to the many physiological factors which influence the action of alcohol in man. The whole problem is pithily stated in this question which was asked by a British Magistrate (11): "Are physicians positive that they can make an examination which will enable them to say beyond all reasonable doubt in all cases, that the accused person is or is not, to a serious extent, affected by drink and that the real explanation of the symptoms exhibited is not to be found in some other condition?"

The importance of this question is seen particularly in those jurisdictions which have adopted the recommendation by the National Safety Council of the United States that a level of alcohol in the blood above 0.15 per cent—1.5 parts per 1000—should be considered definite evidence that the person was "under the influence" from the standpoint of motor-vehicle operation (2.3.12.13.14). As will be seen later, this question is of still greater importance in those jurisdictions in which, in addition to tests of blood, the accepted tests include those of alcohol contents of urine, saliva, and breath, all of which, it should be noted, have been accepted by the Committee on Tests for Intoxication of the National Safety Council of the United States (12).

Technical Considerations.

The following three experiences—two with blood tests and one with a urine test—will suffice as examples of possible pitfalls in the performance of these tests.

Case 1 The first experience was in a trial for manslaughter, which arose as the result of a fatal motor-car accident. In his evidence, the medico-legal expert for the prosecution stated that the amount of alcohol which had been found in the blood of the accused was "absolute" proof that he was markedly drunk at the time of the accident, independent of all other evidence. From the history which was supplied to me by defence counsel, however, and also from my questioning of the accused, I was equally certain that his mental state and behaviour in general at the time of the accident were inconsistent with marked intoxication, and it was further investigation only which revealed the cause of the discrepancies. Not only had ethyl alcohol been used to sterilize the skin for the collection of the sample of blood, but, after it had been collected, it was allowed to clot and, thus, the determination of the alcoholic content was not done on whole blood with its natural proportions of red blood cells and plasma.

I. Effects of Use of Alcohol to Sterilize Skin. In the majority of cases, use of alcohol as a sterilizing agent does not affect the results of the test very appreciably, but, as one of my associates and I showed some years ago (15) it may account for as much as 0.12 per cent of alcohol—1.2 parts per 1000.

II. Plasma v. Whole Blood. The error from failure to use whole unclotted blood with its natural proportions of red blood cells and plasma must, almost invariably, be quite appreciable. The distribution of alcohol in the body tissues and fluids is roughly proportional to their water contents (16.17.18). For this reason, plasma may, at times, contain two or more times more alcohol than an equal volume of red blood cells (19.20) as the following case showed:

Concentration of alcohol in plasma	168 mgms. per 100cc
Concentration of alcohol in whole blood	128 mgms. per 100cc
Volume of red blood cells (Haematocrit)	44 mgms. per 100cc
Alcohol contributed by plasma (0.56 x 168)	94 mgms. per 100cc
Alcohol contributed by red blood cells (0.128-94)	34 mgms. per 100cc
Concentration of alcohol in cells $\frac{34 \times 100}{44}$	77 mgms. per 100cc

$$\text{Plasma-Cell Ratio} = \frac{168}{77} = 2.18$$

In this case, it will be noted that, because of the high plasma-red blood cell ratio, the concentration of alcohol in the plasma was 31 per cent greater than in whole blood. Still higher values are found in the literature. Differences of 20 to 25 per cent are the rule, and this applies also to serum (6.21.22). In the case cited, therefore, though there were no errors in the actual analysis, some of the alcohol which was found may have been due to the use of alcohol to sterilize the skin. That the failure to use whole blood in the analysis with its natural proportions of red blood cells and plasma had resulted in the finding of more alcohol than had actually been present in the blood of the accused when the blood was in his body seemed almost certain. The prisoner was acquitted.

III. Serum Alcohol. Incidentally, it is to be noted here that, had the *entire* sample been analyzed—clot and serum—the amount of alcohol found would have probably been less than that which had been actually present, since it is almost impossible to recover quantitatively alcohol added to blood which has been allowed to clot, even if the clot is broken up (23).

Case 2. This case concerned an alcohol test of the blood of a woman who it was alleged had been killed during a drinking bout. The body, when found, had been in the open for 4½ days, and a fair degree of putrefaction had set in. Maggots were numerous at the site of the wound, though the internal organs, including the brain, were fairly well preserved. The sample of blood, obtained at the autopsy, was reported to have contained 0.177 per cent alcohol, and the question put to me was this: To what extent does the alcoholic content of the blood change following death?

As in the first case, I requested all of the details of the analysis and, on the basis of this information, expressed the opinion that there was, in fact, no evidence that the blood had contained any alcohol, because of the failure to take into consideration the putrefaction.

IV. Stability of Blood Alcohol. There are no known specific oxidizing agents for alcohol in human blood (6.24). Oxidation of alcohol may continue in the liver for a short time after the removal of this organ from the body (25) and about 90 per cent of all alcohol in the body is metabolized in the liver. Appreciable amounts of alcohol do not, however, disappear until putrefaction has reached a well-advanced stage (24), though some loss may occur (6.26). If the container of a sample of blood is sealed, the alcoholic content remains remarkably stable for at least two weeks (27.28.29.30). Certainly, little or no oxidation occurs in the presence of potassium oxalate (19). Blood to which the latter or sodium citrate has been added as an anti-coagulant may remain unchanged for about five days at room temperature. With sodium fluoride as the anti-coagulant, it may be preserved for ten days (31). Blood kept for sixteen days at room temperature, even in a warm room, and having undergone complete haemolysis has been found to show very little loss (5). Preserved with sodium fluoride it did not deteriorate appreciably in thirty days (31).

V. Effects of Putrefaction. The possible error, however, in this case was not in loss of alcohol, but in the failure to take the necessary precautions to exclude products of putrefaction which have the same qualitative effects on the oxidizing reagent used in the test as alcohol and thus yield values for alcohol where, in fact, none may be present. Volatile amines, phenols, aldehydes, ketones, hydrogen sulphide, lower aliphatic acids are examples. As an example, I cited the finding of 0.146 per cent of alcohol (1.46 parts per 1000) in a putrefied brain definitely known to have been entirely free from alcohol (32). In cases of putrefaction, it should be noted, even the finding of alcohol in the stomach, is of little medico-legal value, from the standpoint of estimation of the degree of intoxication, since, as in the case of all other toxic substances taken by mouth, other than local irritants and corrosives, it is the alcohol which has been absorbed and not that which is in the stomach which is material.

The possible effects of products of putrefaction in tests for alcohol have been known for years (33) and, there is, to-day, hardly a text-book on toxicology and similar works, which does not warn about the need of preliminary treatment of the distillate from the sample so as to remove the interfering substances before the actual steps for the determination of the amount of alcohol present (6.24.34.35.36.37.38.39). In order to overcome these interfering substances from putrefaction, specific methods have been developed for alcohol but, in most instances, they are not practical (40.41.42).

The prisoner was found guilty of manslaughter, but not on the evidence of the alcohol content of the blood. There was incontestable evidence that both he and the deceased had been drinking for several days before the attack and that the woman had been a heavy drinker, whenever she could get it. But, more important, at the autopsy, when the abdomen was opened, the organs and the peritoneal cavity had a definite odour of alcohol, and one can always smell alcohol when the blood contains a large amount of it. From the point of view of "alcohol and culpability," it is of interest to note here that the verdict was manslaughter and not murder, again emphasizing the fact that, though mere drunkenness does not mitigate any crime, if the victim of the attack was drunk, *it is* a reasonable assumption that he or she had provoked the attack.

VI. Selection of Post-Mortem Material. Incidentally, as the test in this case was done on post-mortem material, of much greater significance, as will be seen later, would have been the alcohol content of the brain, with the liver next in order of preference (43).

Case 3. In this case, the urine was reported to have contained 0.16 per cent alcohol, and two reports were cited from the literature that a finding of 0.150 per cent (1.5 parts per 1000) was inconsistent with fitness to be in charge of a motor-car (8.13).

VII. Interfering Substances in Urine. Aside from the fact that the concentration of alcohol in urine is almost invariably higher than blood, for both physical and physiological reasons, as will be noted later, and aside from other difficulties in the interpretation of urine tests, relevant here is the fact that, in urine, unlike in blood, there need be no putrefaction whatever in order to produce false alcohol values. All that is necessary is to omit to render the urine alkaline before the alcohol is distilled from it, preliminary to its estimation. In fresh bloods, the amounts of volatile reducing substances are negligible from a medico-legal standpoint (37.44.45), even apparently in diabetics (46). The average amount of volatile reducing substances in urine is also relatively small, corresponding to about 17 mgms. of alcohol per 100 c.c. only (19); but that it may be as high as 75 mgms. is a well-recognized fact (47). That this, however, is not *generally* recognized may be seen from the descriptions of the various urinary tests in the literature. Bogen (48) does not mention it. McNally (35), Sheftel (49), Cavett (50), Gradwhol (51) and Harger (52) do not mention it. In Heise's method (31) the urine is actually kept acid while the distillate is being obtained for the reaction with the bichromate-sulphuric acid mixture. Sydney Smith (38) pointed out that urine may contain sufficient of these interfering substances to account for 30 to 40 mgms. of "alcohol" per 100 c.c. Bamford (47) having found that the figure for acid urine is invariably too high, and having found the above-mentioned high value of 75 mgms., warned that "analysis of urine must always be made in the presence of alkali; the figure for acid urine being invariably too high." The warning is repeated in the latest (1947) edition of his book. Glaister includes a method for the removal of the interfering substances which may account for artificial alcohol values (39). Friedemann and Klaas (53) take the more elaborate precaution of double distillation—distillation from acid medium to remove the volatile basic substances (amines, etc.) and distillation from alkaline mercuric oxide to remove phenols, lower aliphatic acids, etc. From my own experiences, provided the urine is a freshly voided sample, this does not seem essential. The need of rendering the urine alkaline, in order to remove interfering substances, in jurisdictions where the 0.150 per cent—1.5 parts per 1000—rule is applied, is too obvious to require comment.

VIII. Capillary Blood. In the case of blood, I have said nothing of the potential sources of error in use of capillary blood, inherent in micro methods in general, nor of the fact that, since capillary blood approximates very closely arterial blood, during active absorption, its alcohol content may be twice that of venous blood (54) upon which most standards of the degree of intoxication are based.

IX. Collection of Urine. In the collection of urine samples, nothing was said of the necessary precautions so that the sample obtained will correspond as closely as possible to the condition of the blood at the material time. Without these precautions, as in the case reported by Magone and Frankish (24) to be referred to again, the amount of alcohol found in the urine may be three times as great as the amount in the blood, of which it is supposed to be an index.

X. *Nicloux and Widmark Procedures.* Nearly all of the methods (6.30.37.43.45.52.55) for determining the alcohol contents of blood and urine and of body tissues and body fluids in general are essentially modifications of the original Nicloux (56) and Widmark (57.58) procedures. In the method described by Nicloux (56) the concentration of alcohol is determined by measuring the amount of potassium bichromate in solution in sulphuric acid which is reduced by the alcohol present, the reaction involved being

$$3C_2H_5OH + 2K_2Cr_2O_7 + 8\ H_2SO_4 = 3\ CH_3COOH + 2\ K_2SO_4 + 2Cr_2(SO_4)_3 + 11\ H_2O$$

The principle of use of the bichromate-sulphuric acid mixture as the oxidizing agent is old (59). Inherent, therefore, in nearly all of the methods is the possible error due to overoxidation, that is, conversion of the alcohol beyond the acetic acid stage and thus production of artificially high alcohol values. I doubt very much whether such occurrence is common; but the test is not as simple as it has been reported to be (52.60.61). That all of the presently available methods have their short-comings is clear from the numerous attempts which have been made to modify them—distillation, desiccation, colorimetric, titrimetric, oxidation to acetaldehyde, to acetic acid, and oxalic acid, etc. (6.37.52.53.55.62). The extreme skepticism of Kleber (63)—that these methods are of no objective value and are of academic interest only is certainly opposed to the experiences of practically all others. From a study of Widmark's own data (57), however, it is clear that 1 cc.N/100 sodium thiosulphate corresponded to alcohol values which ranged from 1.000 to 1.241 mgms., and that the factor which he finally adopted, namely, 1.13, may involve a considerable error (53).

XI. *General Precautions.* A fact, however, which these observations emphasize is that no test which is being done for medico-legal purposes should be done without parallel determination, under identical conditions, of the degree of recovery of a known amount of alcohol added to material similar to that under examination (blood, urine, etc.) and known to be free from alcohol. Also, all of these tests, being oxidation procedures with a very sensitive oxidation reagent, demand the most careful attention to cleanliness of glassware, so as to exclude oxidizable dust and grease; and also blank determinations on all reagents for oxidizable content and also use of high-grade distilled water.

XII. Technicians, Public Right to Safe-Guards, Expert Testimony. I devoted some time to the technical aspects of these tests to emphasize also the responsibility of the person whose duty it is to perform them. They clearly show that a technician, except under most careful supervision of an expert chemist, alert to all of the pitfalls, has no place in a medico-legal laboratory, insofar as tests for alcohol are concerned. Only the most careful attention to all of the details of the test, from the time the material is being collected to the completion of the analysis, may prevent lodging an innocent person in jail, particularly, as we shall see, in jurisdictions which apply the 0.15 per cent rule. The public have the right to demand every possible safeguard of skill and precaution against error. This, I regret to have to say, is not fully appreciated at times, judging from reactions of expert witnesses to searching cross-examinations by counsel for the defence. By the cases which I have cited, I trust that I have also shown that the wide-spread impression and actual statement that a chemical test for alcohol "eliminates need of expert testimony in many cases" is without sound foundation both in theory and in fact (12).

But these are technical aspects only. It is now necessary to consider the physiological factors which may influence the toxicity of alcohol and which, therefore, must be taken into consideration in the interpretation of these tests. The tests to which I shall refer particularly are those of blood, urine, breath and saliva.

Physiological Variables.

I. Blood Tests. Grehant (64) first showed that there was a relationship between the amount of alcohol in the blood and its toxic manifestations. In general, the higher the concentration, the more marked is the degree of drunkenness, eventually terminating in coma and death. This has been repeatedly confirmed. The observations of Remund (65), Widmark (66), Jungmichel (67), Hoffman (68) and Schwartz (69), in Europe, and of Bogen (48.70) and Harger, Lamb and Hulpieu (18) on this Continent are examples. Statistically, this is undoubtedly true. Being statistical, however, it may or may not, and need not necessarily, apply to the individual, and *it is the individual who is on trial.* Recently, when asked if it was not a fact that some people could have 0.5 per cent alcohol in their blood (5 parts per 1000) and not be dead drunk, the witness for the prosecution replied "As a matter of fact, any man who had 5 parts or more per 1000 in his blood would not be dead drunk, he would be dead."

(a) *Limitations of Statistical Conclusions.* Opposed to this dogmatic assertion, there are the two cases of 6.9 and 10.3 parts per 1000 reported by Gettler and Freireich (71). These results seemed to be so far out of line with those of other investigators as to have induced skepticism (20); but there are also the two cases from the Attorney-General's Department of Ontario (24). In one, a man was killed in a railroad accident and from the circumstances it was clear that though he may have been on the verge of coma, he was not unconscious, and his blood was found to contain 8.4 parts per 1000. In the other case, a man had been seen staggering directly in the path of an oncoming motor-car. The driver was unable to avoid striking him, and he died almost immediately after the accident. His blood was found to have contained 5.7 parts per 1000, and there is no reason to question the reliability of the tests. Turner (72) was more conservative in his statement. He put it this way: "...... above 0.5 per cent (5 parts per 1000) coma or death may occur." In four of Bogen's six cases with blood alcohol values of 0.5 per cent it is clear from the descriptions of them, that they were not in coma (70).

In order to emphasize again the statistical character of blood alcohol values—that they may or may not apply to the individual—I cite here two personal experiences. In each case, I had every opportunity to observe the behaviour of the person at the time the sample of blood was obtained. In each case, I collected the sample myself and also made the analysis myself. Hearsay evidence is, therefore, completely excluded.

Case 1. This was a blood test in a man who had been under my care for the treatment of diabetes mellitus for many years and who had returned for his periodic examination. Notwithstanding all advice, he had consumed approximately one quart of whisky per day since his previous visit. For some time, in fact, he had consumed an average of 10 quarts per week. From 11:00 A.M. of the previous day to 2:30 A.M. on the day of the visit, he had consumed 2 quarts of beer, 15 ounces of whiskey and one-half quart of gin. He had had his last drink at 2:30 A.M. and was seen by me at 7:50 A.M., that is, 21 hours after he had commenced to drink and 5 hours and 20 minutes after he had had his last drink. Sufficient time had thus elapsed for the alcohol to come into equilibrium with all of the body tissues and fluids. The absolute amount of alcohol consumed was estimated to be as follows:

Drink	Alcohol (%)	Absolute alcohol (c.c.)
2 quarts beer	5	120
15 ozs. whiskey	40	180
½ qt. gin	40	180
	Total	480 c.c. or 385 gms.

Assuming the body had oxidized the alcohol at the high rate of 10 gms. per hour (see later), 210 gms. had disappeared from his body during the 21 hours. Allowing a 10 per cent loss by respiration and urinary excretion—a liberal allowance—21.0 grams were gotten rid of in this manner, which left a balance of, approximately, 154 grams. He weighed 80 kgms. Assuming a water content of the body of, approximately, 70 per cent, there were approximately 56 kgms. of water, which thus allowed the alcohol to distribute itself to the extent of 2.75 gms. per kgm. (2.75 parts per 1000). Actually, the blood was found to have contained 2.73 parts per 1000. Yet a careful examination of this man's mental state and activities in general, before the actual amount of alcohol in the body was known, but influenced by the history of the amount of alcohol which he had consumed, revealed very little to conclude that he was not fit to be in charge of a motorcar.

At his last visit (Oct. 20, 1947) during a period of approximately 13 hours before I saw him, he had consumed about 200 ounces of beer—approximately, 225 grams of absolute alcohol. He had had his last drink about 12 hours before the blood test. Mentally he was very clear, judging from his ability to answer questions about the diabetes and conversation generally. There were no tremors and no hesitation or fault otherwise in the things I asked him to do, including calculations. I certainly would not have hesitated to ride in a car driven by him at the time. When the blood test was completed, the blood was found to have contained 0.211 per cent alcohol.—2.1 parts per 1000.

Case 2. This was a woman, another diabetic, who had also reported for her periodic examination and had been drinking whisky from 8:30 P.M. of the previous day until 3:00 A.M. on the day of the visit. During that period, she stated, that she had "nearly emptied a 40-ounce bottle." I saw her at 8:30 A.M. A conservative estimate is that she had consumed about 30 ounces of whisky or approximately 300 gms. of absolute ethyl alcohol. Again, allowing the high rate of oxidation of 10 gms. per hour, the body had rid itself of 120 gms. of alcohol in this manner. Allowing another 10 per cent loss by respiration and excretion, another 12 gms. had disappeared, which left a balance of 168 gms. She weighed 60 kgms. Therefore, again allowing a water content of the body of about 70 per cent, the 170 gms. of alcohol had 42 kgms. of water in which to distribute itself, that is, a concentration of about 4 parts per 1000. Actually, the blood was found to have contained 3.68 parts per 1000. There was no doubt from the clinical examination that this woman was under the influence of alcohol. Her face was puffy; the eyes were suffused; there were definite tremors; and she was not very alert. Unlike in the first case, I would not have cared to have been a passenger in a car driven by her at the time. But, she gave a reasonably intelligent history about her diabetes since I had seen her last and her gait was not conspicuously abnormal. Therefore, though she was definitely under the influence of alcohol, the degree of intoxication did not conform to that generally accepted from the amount of alcohol found in her blood.

In contrast to these cases, there are those in which intoxication was associated with as little as 0.035 to 0.08 per cent of alcohol—0.35 to 0.8 parts per 1000—and even as little as 0.2 parts per 1000 (6.13.18.50.45.73.74.75.76.77.78).

(b) *Blood v. Brain.* The reasons for the discrepancies between the alcohol contents of the blood and the degrees of intoxication noted in the cases cited are not far to seek. Whether a person is or is not drunk depends upon the alcohol content of the brain and not of the blood or other tissues or fluids of the body[1] (3.26.33.43.71.79) and, for a number of reasons, the concentration of alcohol in the blood and in the brain may not be the same (78). Rate of absorption of alcohol consumed; rate of oxidation; degree of equilibrium between blood and brain alcohol; tolerance; the form in which the alcohol was consumed are examples.

(c) *Absorption of Alcohol.* Alcohol may be very rapidly absorbed from the gastro-intestinal tract, being one of the few substances which are capable of passing directly through the stomach wall. According to one observer, about one-fifth of the amount ingested may reach the circulation in this manner (78). When the stomach is isolated, it is capable of absorbing completely solutions of alcohol in such concentrations as 10 to 20 per cent (81).

(d) *Oxidation of Alcohol.* Alcohol begins to be burned in appreciable quantities soon after absorption—in 5 to 10 minutes (82). But it must be appreciated that, though the blood is the distributing medium which is the first to receive the absorbed alcohol, the time it takes for the blood to come into equilibrium with the tissues it reaches depends upon a number of factors, such as (a) the affinity of the tissues for alcohol (b) the degree of vascularization of the tissues—the amount of blood in the tissues—and (c) the metabolism of alcohol in the tissues—the extent to which the tissues are capable of oxidizing it (83).

(e) *Equilibrium and Concentration.* It is also necessary to take into consideration the fact that equilibrium does not imply *Equal Concentration,* the amount of alcohol dissolved depending to a large extent upon the water content of the tissues (16.17.18). It is this which explains to a large extent the low alcohol values in bone (6.84) and in fat (83.85.86). It explains very largely the lag of one to two hours in the establishment of equilibrium between blood and muscles (17.37.54. 45.44). It is for these reasons largely that the ratio of the concentration of alcohol in the blood to the concentration in the tissues in general is about 1:0.55 to 1:0.62 (66.85.86). For these reasons, regardless of the extent to which the blood has come into equilibrium with the brain, the alcohol content of the brain

[1] It is of interest here to note that, in general, unicellular organisms withstand higher concentrations of alcohol than multicellular. Concentrations of up to 2 per cent seem to be well tolerated by protozoa and bacteria (80).

can rarely be the same as the alcohol content of the blood. The invariably higher concentration of alcohol in the blood than in the brain, even after sufficient time has elapsed for equilibrium to be established has been noted repeatedly (71.83.44.87.88). The usual ratios of blood to brain alcohol have been found to range from 1:0.7 to 1:0.8 (17.37.66). In 10 of the 53 analyses reported by Harger, Lamb, and Hulpieu (18) the concentrations of alcohol in the bloods ranged between 40 and 50 per cent greater than those found in the brains.

Since alcohol taken by mouth must reach the blood before it can reach the tissues of the body, the time required to reach these tissues is of medico-legal importance when the amount of alcohol in the blood is taken as an index of the amount of alcohol elsewhere. That appreciable lags may occur is clear. Aside from any consideration of equilibrium, they explain the higher concentrations of alcohol for some time in the blood than in the spinal fluid (89.90.91.92); the slower increase of alcohol in the lumbar than in the cisternal fluid and, thus, the fact that a high blood alcohol does not necessarily imply an equally high brain alcohol (70.89.90.91.93). In fact, the cerebrospinal fluid may not reach its maximum until the concentration in the blood is actually well on the way down (94). Fitting in with all, is the fact that when alcohol is administered intravenously it comes into equilibrium more quickly than when it is administered orally (95).

(f) *Alcohol Tolerance.* In addition to all of these factors, there is the well-known fact of difference of tolerance. That habitual ingestion of alcohol engenders an increase of tolerance for alcohol is too well-known to require comment. It explains the much higher incidence of acute clinical intoxication at low blood alcohol concentrations in abstainers and in moderate drinkers than in chronic alcoholics (88). Variation of tolerance has been noted both in animals (96) and in man (76.97) and include the effects of alcohol on intelligence quotient, memory (98), and neuro-muscular coordination (99).

The reason for the increase of tolerance is not clear (79.100). Food, for example, slows the absorption of alcohol, possibly by not only slowing the emptying time of the stomach but also possibly to some extent by binding the alcohol chemically to some of the constituents (101). There is also the fact that the emptying time of the stomach tends to be greater with high than with low concentrations of alcohol (19.44); but, with apparently few exceptions (102) the speed with which alcohol is absorbed from the intestinal tract is actually greater in habituated individuals than in abstainers and moderate drinkers and thus enables the concentration of alcohol in the blood to reach a higher level (76.93.96.102.95.103.104).

The increase of tolerance cannot be due to a greater rate of destruction of alcohol in those habituated to it. To a certain extent it has been found that the rate of disappearance of alcohol from the blood stream may be influenced by the amount consumed (54.95.105.106). Combustion of alcohol, however, is not, as a rule, dependent upon its concentration in the blood or tissues (23.96.99.95.105.107.108). In fact, it cannot be so, since the maximum rate at which alcohol can be oxidized by the body is limited, ranging from 100 to 174 mgms. per kgm. per hour (30. 45.96.99.95.103.105.107.108.109.110). Some phenomenon, other than a greater rate of oxidation, must explain the more rapid reduction from the maximum level in habituated than in nonhabituated individuals (104.105.111.112.113.114). A possible explanation may be a more ready binding of alcohol in some manner with the body tissues in those accustomed to alcohol than in abstainers and moderate drinkers. The impossibility of recovering quantitatively alcohol added to blood which is then allowed to clot (23) suggests that there might be such a phenomenon.

(g) *Different Effects of Alcohol in Same Individual on Same Day.* A phenomenon which does not appear to be generally recognized and which was important in one of the above-mentioned cases is that the effects of a given concentration of alcohol in the blood is greater when the concentration of alcohol is increasing than when it is decreasing. This phenomenon, first noted by Mellanby in 1910 (109) has been repeatedly confirmed (20.115.116). In fact, the effects may begin to disappear while the blood is still at its maximum (117), that is, during the "Grehant Plateau" (118.119).

It is such phenomena which explain that, though 0.4 per cent of alcohol in the blood may be associated with complete unconsciousness (120), in another case, the person might be adjudged sober (87). Newman and Card (99), in their experiments on animals, did not find the amount of alcohol in the blood a reliable index of neuromuscular coordination.

(h) *Form of Alcohol.* A factor which must also be considered, aside from the amount of alcohol consumed, is the form in which the alcohol is taken. Beer, for example, in some manner, slows the absorption of alcohol. The maximum concentration of alcohol in the blood is, as a rule, lower with beer than with an equal dilution of alcohol in the form of a whisky and soda (6.

121.122). To this, however, there are also exceptions. A single glass of beer may make a person drunk (123).

(i) *Miscellaneous Variables.* Diabetics seem to be able to tolerate higher concentrations of alcohol in the blood than non-diabetics (124) and equally difficult to explain is the increased tolerance in chronic alcoholics in whom liver disease is common. It is to be noted here that about 90 per cent of all alcohol in the body is metabolized in the liver (125) and a lower rate of oxidation in liver disease has been noted (126). Fever increases the susceptibility to intoxication (6.30.126) and a number of drugs such as insulin (6.126.127) and adrenalin (6) lessen the effects of alcohol. Smoking and high altitudes increase the effects (6.30) and males appear to metabolize alcohol more readily than females (126).

The purpose of these observations was to stress the importance of considering individual variations rather than the statistical parallelism between blood and brain alcohol concentrations in medico-legal cases, in order to prevent possible miscarriages of justice. They cannot be stressed too greatly nor too often. The chief value of the blood test for alcohol, as I see it, is that it proves beyond any doubt that the person had been drinking, and, by affording an approximate measure of the amount of alcohol in the body, it refutes such statements, at times, that the person had had one-half glassful of beer only; whereas, he had actually consumed a half-pint of whisky (45).

II. Urine Tests. (a) *Basis of Tests.* The observations about blood alcohol apply with greater force to urine alcohol as an index of intoxication. It is a fact that the concentration of alcohol in urine tends to parallel the alcohol content of blood and, thus, the alcohol content of the brain—the higher the concentrations, the more marked are the clinical signs of intoxication (3.8.13.87.122). Therefore, since Southgate and Carter (8) first recommended determination of alcohol in urine as an index of intoxication, this test has been very widely employed. According to these authors, no person with more than 150 mgms. of alcohol per 100 c.c. urine (1.5 parts per 1000) is fit to be in charge of a motor-car. This, it will be noted, is even more rigid than the blood alcohol standard of 1.5 parts per 1000. There are grounds for use of the test in this manner. Alcohol appears to belong to the class of substances which the kidneys eliminate wholly by diffusion, that is, without concentrations (128.129), and the concentrations of alcohol in blood and urine have been found by some authors to be the same (56.130.58).

(b) *Urine-Blood Ratios.* When consideration, however, is given to the fact that alcohol is more soluble in urine than in blood (because of the greater water content of urine) it is obvious that, on purely physical grounds, at a given concentration of alcohol in the blood, a sample of urine *excreted* at the same time will almost invariably show a higher concentration. Ambard (128) first drew attention to this fact many years ago. It is for this reason that Jetter (37) and Haggard and Greenberg (131) noted that the specific gravity of the urine influenced the concentration of alcohol—the higher the density of the urine, the lower was the ratio of urine alcohol to blood alcohol. An additional reason for a higher concentration in urine than in blood is that the urine reflects values of arterial blood rather than venous and, as stated previously, during the period of active absorption of alcohol, its concentration in arterial blood may be twice that in venous blood (37.54). Haggard and Greenberg (131) reported urine to blood ratios of 1.22 to 1.37 (54.131). Ratios of 1.35 to 1.45 were reported by Miles (19) and ratios of 1.12 to 1.6 by Southgate (23) and by Smith and Glaister (36). In isolated instances only has the concentration of alcohol in urine been found to be lower than the concentration in the blood (35). Harger (9) states that the percentage of alcohol in urine is regularly about 20 per cent higher than in the brain. Urine concentrations of 40 to 50 per cent greater in the blood as much as 2½ to 6½ hours after ingestion of alcohol were reported by Southgate (23) and concentrations of 40 to 80 per cent greater were not uncommon (19.36), which may explain Bogen's finding (70) of three cases in which the individuals were not unconscious with urine alcohol values of 0.5 per cent (5 parts per 1000). In another report (48.132) two of thirteen individuals with similar concentrations were not unconscious. From their experiences, Smith and Stewart (84) were forced to conclude that, for medicolegal purposes, urine alcohol values were useless. The humorous portrayal of the relationship between urine alcohol and behaviour of the individual is well known to all of us. Less humorous, however, are the possible deductions from reliance on this relationship which might deprive an innocent person of his freedom.

(c) *Value of Urine Alcohol Tests.* This is not to imply that determination of the amount of alcohol in urine is of no medicolegal value. Its mere presence rebuts completely the defence that no alcohol had been consumed (122). It may serve to corroborate the finding of alcohol in the blood and, thus, complete the picture, provided the sample of urine was so obtained that it represented reasonably closely the excretion at the time the blood sample was obtained and due allowance is made for the higher concentration in urine than in blood. In other situations, when due consideration is given to the rate at which alcohol may be destroyed in the body (30.45.96.95.99.103.105.107.108.109.110) it may point to a still higher concentration of alcohol in the blood at some previous period which might, at times, be material. The case reported by Magone and Frankish is an example (24). A man was struck by a car and lived for about 9 hours after the accident. At the autopsy, the blood showed 0.2 per cent of alcohol (2 parts per 1000), and the urine contained 0.6 per cent (6 parts per 1000). These figures clearly indicate that some time before the accident the man was still more intoxicated than at the time of the accident. In another case (54) in which the subject had not passed water for ten hours after a drink, though the blood was free from alcohol, the urine showed 0.11 per cent (1.1 parts per 1000).

(d) *Absorption of Alcohol From the Bladder.* An interesting observation here is that as alcohol may be secreted into the stomach (119) so also may it be secreted into the bladder (133). More important medico-legally, however, is the observation of the extent to which alcohol is capable of passing from the urinary bladder to the blood (130). A 25.8 per cent loss has been noted in experiments by use of a 1.5 per cent solution of alcohol and a 43.6 per cent loss with a 2.2 per cent solution, but, obviously, such high concentrations have never been noted in man. It is, therefore, doubtful whether this occurs to a significant extent at the concentrations found in urine after drinking alcohol. The medico-legal value of these findings is, therefore, very doubtful (131.134).

III. Breath Alcohol. Determination of the alcohol content of the breath as an index of intoxication has been recommended (13) and is now widely employed (18). To appreciate the many pitfalls here, it is necessary to refer at least briefly to the basis of this test.

(a) *Basis of Test.* This test had its origin in the observation by Cushing (135) that the concentration of alcohol in blood is reflected in the amount of alcohol in the breath and also in the observation (136) that the alcoholic content of 2 litres of expired air is approximately equal to the alcohol content of 1 c.c. of blood. After Bogen (132) published his test, however, Smith and Stewart (84) were unable to confirm its reliability, the concentration of alcohol in the breath being dependent upon the depth of the breathing and, thus, upon the amount of alveolar air in the sample. This was confirmed by Haggard and Greenberg

(54). To correct for this variable, Harger, Lamb and Hulpieu (18) devised a method based upon the amount of carbon dioxide in the sample, on the assumption that the percentage of carbon dioxide in alveolar air is constant at a level of about 5.5 per cent (137). Thus, since the amount of alcohol in 2 litres of expired air equals approximately that in 1 c.c. of blood, the amount of alcohol which accompanies the exhalation of 198 mgms. of CO_2 equals the amount in 1 c.c. of blood.

(b) *Fallacies.* Actually, however, the percentage of CO_2 in alveolar air may vary widely—4.7 to 6.8 per cent (137.138)—and is influenced by a variety of conditions, such as food, posture, activity, etc. (84.139.140.141). Therefore, since the essence of the accuracy of the test lies in the ratio between alcohol in the lung gas and, in the blood, and since the former cannot be predicted accurately, obviously the latter cannot be predicted accurately. Average values based upon a large number of observations may, and in fact do, agree very closely and are, therefore, of value in physiological experiments; but, in medico-legal work, as in the case of blood alcohol, it is the particular amount in a particular person that matters.

(c) *Reliability of Breath Alcohol.* The degree of reliability of the test as an index of the degree of intoxication may be seen in the author's own data. The following are the comparative findings in 6 of 121 comparative tests:

BREATH ALCOHOL (mgms. per 190 mgms. CO_2)	BLOOD ALCOHOL (mgms. per 100 c.c.)
1.4	0.9
1.2	0.6
1.4	0.8
2.0	1.3
2.3	1.6
2.8	2.1

It will be noted that in 6 of the 121 cases, the predicted amounts of alcohol in the blood ranged from 33 to 100 per cent more than the amounts which were actually present. It is, therefore, pertinent here to ask: What would be the legal status of finger prints had they also been found to err in one case out of every 20? Newman (20) regards this test considerably less reliable than blood. This device, as Cameron has pointed out, (30) undoubtedly has potentialities, but it definitely needs modification and further substantiation of its scientific basis. As Smith and Stewart (80) pointed out, it is in the border-line cases in which laboratory tests are of real use, and, in such cases, use of breath, as the author's own data clearly show, is a "very dangerous" procedure. Cameron (30) drew attention to a number of variables, such as out-door temperatures, which may affect alcohol values of samples of breath collected where the accidents occurred. When consideration is also given to possible errors due to the slightest regurgitation of alcohol from the stomach (49.132), in my opinion, the sooner this test is discarded for medico-legal purposes, or at least withheld until it is improved, the better.

Advantages which are claimed for the test are (a) its simplicity and (b) that it may be made immediately at the scene of the accident. When one considers, however, that the simplicity of the test is more than counterbalanced by the numerous factors which decrease its reliability, and the fact that not more than one hour need elapse before the suspect could be brought to a hospital, if not for chemical analysis, at least for the collection of the blood sample and that, during that time, the amount of alcohol which can disappear from the blood is almost negligible —about one-third to one-half of an ounce (30.45.95.96.99.103. 105.107.108.109.110)—there is little to say in its favour.

IV. Saliva Tests. (a) *Basis of Test.* I said nothing about saliva alcohol, though it also has been approved by the Committee on Tests for Intoxication of the National Safety Council in the United States (12). There is no doubt that the concentration of alcohol in saliva tends to parallel the concentration of alcohol in the blood (53.142.143.144). Its concentration approximates that of venous blood more than it does urine (144), and it is on this basis that it has been very largely recommended. Of all body fluids, it is also the simplest to obtain.

(b) *Fallacies.* The parallelism between blood and saliva is, however, by no means uniform. Furthermore, since the alcohol content of saliva is more likely to reflect arterial blood than venous blood, its values tend to be higher than those of venous blood (5.6.50.144.145), and, during the period of active absorption may be twice as high (37). From the technical standpoint, there are also the difficulties of handling due to tenaciousness and viscosity; there are the oxidizable non-alcohol materials (53.144) and, in common with the test of breath, there are the factors of hiccough and regurgitation. In all, therefore, I am in complete disagreement with the statement that "the saliva test is of proved accuracy." (3). In my opinion, the saliva test has no place in the determination of the amount of alcohol in the blood for medico-legal uses.

In 1930, I had the occasion to deal with pitfalls in the clinical application and interpretation of the basal metabolic rate (146). The observations were based upon, approximately, 15,000 tests, and I concluded with a quotation from John Brown's essay in which the brisk dilettante student says to the great painter: "Pray, Mr. Opie, may I ask what you mix your colours with?" "With brains, Sir", was the gruff reply—and the right one. It did not give much of what we call information; it did not expound the principles and rules of the art; but, if the inquirer had the commodity referred to, it would awaken him, it would set him a-going, a-thinking and a-painting to good purpose. If he did not have the wherewithal, the less he had to do with colours and their mixtures the better. This, I then stated, applied equally to the test for basal metabolism, and I trust that I have shown that it applies equally to chemical tests for intoxication.

Expert Opinions.

In contrast to the enthusiasm of the prophets of chemical tests of drunkenness, Carlson (147), the physiologist in the United States, warned that there is no single test or criterion for the degree of alcoholic intoxication that has the social or legal implication of drunkenness. Newman and Fletcher (148) stress the fact that the idea the law has in mind is to punish drunkenness and not drinking and warns against unfair convictions possible with the 0.15 per cent rule (1.5 parts per 1000). In England, Sir Bernard Spilsbury warned that "drunkenness cannot be boiled down to a test." (122). Sydney Smith and Glaister (36) among the leading toxicologists and medico-legal experts in Scotland, warn that "chemical analysis of blood, urine and expired air does not yield information on which alone a diagnosis of alcoholic intoxication can be made or rejected." McGrath (6) in Ireland, warns against hard and fast limits of blood alcohol concentration. It is "evident", he states, "that blood alcohol estimation does not provide an automatic answer to the question: Was the individual drunk? The blood alcohol concentration is a far safer guide to the person's condition than even definite evidence (so often difficult to obtain) as to the amount of alcohol actually consumed, since it short-circuits and eliminates the relatively uncertain factors of absorption, metabolism, and excretion. The courts, therefore, might reasonably regard the amount of the blood alcohol as being more helpful and cogent than proof of the amount of alcohol consumed. But, in all cases, it is still necessary that all circumstances of the case, including an efficient physical examination, should be taken into account when assessing the relative degree of alcoholism present." He quotes the vast experiences of Hoffman (149) and of Jetter (88) and draws the conclusion that "the blood alcohol determination in practice can never indicate with absolute certainty that the accused is under the influence of alcohol." In Canada, Prof. A. T. Cameron, of Winnipeg (30) warned against the atmosphere reminiscent of the supposed slogan of the Royal Canadian Mounted Police—"Get their man", and points out that blood alcohol should not be rightly interpreted to indicate whether or not a person was under the influence of alcohol but should properly be used as additional contributory evidence, unless, of course, no alcohol at all was present, in which case the evidence would be absolute. With this, Magone and Frankish (24) of the Attorney General's Department in Ontario agree. "Clinical findings", they state, "should correspond in general with the alcohol content determined by blood analyses, and it is submitted neither shall be disregarded."

Limitations of Clinical Signs.

As all laboratory tests have their limitations, so have the clinical tests. The recommendations of the Committee of the British Medical Association (150) are an example. They include the following.

1. The word "drunk" should always be taken to mean that the person concerned was so much under the influence of alcohol as to have lost control of his faculties to such an extent as to render him unable to execute safely the occupation in which he was engaged at the material time.
2. To arrive at this diagnosis, there should be firstly proof that the person had recently consumed alcohol.
3. In the absence of any pathological conditions, a person is definitely under the influence of alcohol if there is (a) a smell of alcoholic liquor in the breath (and/or in vomited material, if any) and (b) provided there is a combination of all or most of the following group of signs and symptoms; and provided pathological conditions which may cause similar signs and symptoms have been excluded, irrespective of the amount of alcohol consumed:

I. A dry, furred tongue, or, conversely, excess salivation.

II. Irregularities in behaviour, such as insolence, abusive language, loquacity, excitement or sullenness, and disorder of dress.

III. (a) Suffusion of the conjunctivae.

(b) Reaction of the pupils. The pupils may vary from a state of extreme dilatation to extreme contraction, and may be equal or unequal.

In the opinion of many police surgeons, when alcohol in toxic quantity has been consumed, the pupil reflex to ordinary light is absent; whereas the pupil will contract in a bright light and remain contracted for an abnormally long time, indicating delayed action of the pupil.

IV. Loss or confusion of memory,[2] particularly as regards recent events, and appreciation of time.

[2] Memory tests. Accused is asked simple questions, such as date and time of day; where he lives, what he was doing prior to arrest, and where he now is.

V. Hesitancy and thickness in speech and impaired articulation.[3]
VI. Tremors and errors of co-ordination and orientation.[4]

There, thus, is no single test by itself which would justify a medical practitioner in deciding that the amount of alcohol consumed had caused a person to lose control of his faculties to such an extent as to render him unable to execute safely the occupation on which he was engaged at the material time. Tests such as presence of tachycardia; failure to repeat properly set words and phrases; character of handwriting; walking along a straight line; and failure of convergence of the eyes taken by themselves are of very limited significance.

Diagnosis of drunkenness thus demands the most careful and thorough physical and mental examination possible under the circumstances, but this seems reasonable. Furthermore, in ordinary circumstances, any person accused of "drunkenness" should be able to rely upon being seen by a doctor, if he so desires, within half an hour of the time at which he is charged.

In the most recent text-book on Forensic Medicine, the author, Keith Simpson (151) sums it up well: "Nothing is more unfair than an exacting test which includes demands the doctor or the police officer themselves might find too much. Try yourself to say 'the sinking steamer sunk' several times without a pause or spell words like gullibility or erraticism, to stand bolt upright with your eyes shut or to walk a chalk line even in your sober moments. Add, say a recent motor-car accident after a trying day when you have sought relief in a glass of sherry, picking yourself out of a wreckage of your car to be taken against your wishes and at great inconvenience to a police station, even by a courteous police officer, and you will determine to impose only the fairest and most reasonable tests for 'drunkenness'."

Combined Clinical and Laboratory Tests.

It is obvious that by relying upon the clinical signs referred to, the degree of intoxication will be appreciably greater than that which would render the person unfit to be in charge of a motor-car. Wherever it is possible, therefore, to obtain chemical information within a reasonable time, this should be a sine qua non in the diagnosis; but, in fairness to the suspect, it must, like Mr. Opie's paints, be used intelligently.

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3 Speech test. Accused is induced to talk, and his manner of talking is noted.

4 Co-ordination tests. These include approaching and picking up a small object from the floor or table; selecting a chair and sitting upon it, and getting up again; ability to stand steady with heels together and eyes shut; walking away and returning; walking along a chalk line.

The chief difficulty, as I see it, at present is lack of uniformity of clinical standards and the results of the various chemical tests with clinical signs. From a study of the literature, it is clear that the *standards* of intoxication ranged from the slightest degree to gross intoxication short of unconsciousness (9.20. 43.45.72.75.79.87.120.148.152.153.154.155). The criteria ranged from isolated tests of reaction time (76.97.119) which by themselves, as psychologists tell us, may be meaningless and combinations of reaction time tests (156) to a combination of gross abnormalities of speech, gait, and behaviour otherwise, which makes the chemical test needless. Jetter and Trowbridge (37) reported a case of chronic alcoholism in which the person showed improvement in simple reaction time when he had the highest percentage of alcohol in his blood and actually showed clinical signs of intoxication. Approaching the more practical, apparatus have been designed to simulate as closely as possible conditions prevailing in actual operation of motor-cars (3.50.72.75. 148.152).

Recommendations.

As I see it, short of total abstinence from alcohol for at least eight hours before driving, as well as during driving, there is no absolute safe-guard for the motorist, but by proper selection of clinical and laboratory tests from the many available, it should be possible by a body such as this to devise a standard type of examination, the results of which will convict those guilty of drunkenness, regardless of the little alcohol they may claim they have consumed and regardless of the little that may be found by any chemical test and, at the same time, not penalize those with greater skill in driving whose only offence consisted of having had alcohol in the blood, urine, saliva, or breath at the material time. The following, for example, is information which should be obtained in every case.

1. Name.
2. Age.
3. Sex.
4. Occupation.
5. Driving experience.
6. Nature of accident.
7. Exact time of accident.
8. Exact time of collection of sample for chemical test.
9. Method of collection of sample for chemical test.
10. Exact time test was performed.
11. Chemical method employed for the test.
12. Physical examination. In addition to the usual clinical procedures, this should include (a) tests of reaction time and muscle

coordination under conditions which would approximate as closely as possible the actual driving conditions and (b) tests involving complex cerebration, since simple reflex behaviour may not be affected.

It should be compulsory to complete the form. As in clinical records in general, one of the greatest difficulties in interpretation, is not so much in the facts which have been recorded, but in pertinent matter which the examiner had failed to record.

The examination of pedestrian victims should include as many of the above-mentioned as are applicable and possible.

Finally, in interpreting the findings, in order to punish drunkenness, and not merely drinking, the tests should not demand the highest degree of skill in driving, for, under such conditions, many drivers, perhaps most, would be punishable even without having consumed any alcohol. In proof of medical malpractice, the law does not demand the highest possible degree of skill, but only the exercise of reasonable care and judgment. This, in my opinion, should also be the basis of all clinical tests for intoxication from alcohol.

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EDITOR'S NOTE. When this paper was presented at the American Medicolegal Congress exception was taken during the discussion by some participants to certain statements contained in it. In keeping with the JOURNAL'S policy of presenting opposing views on Police Science questions a summary of these exceptions will appear in a subsequent issue.