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BREATH MEASUREMENT INSTRUMENTATION IN THE U.S.

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Alcohol is the one drug for which a reasonably well defined dose-response curve for traffic crashes has been developed. The first of these curves was calculated by Borkenstein and his coworkers, based on their well known Grand Rapids Study, in which they collected breath samples from drivers using the road but not in crashes and from crash involved drivers. Recently, Hearst has calculated similar curves for all of the other crash/control studies. While these curves shown in Figure 1 vary significantly, at least in part, on the type of crash to which they apply, they are all similar in showing the normal dose-response relationship where low doses appear to produce little behavioral effect, while with increasing dosage, a more rapidly increasing behavioral effect becomes apparent. Below .05 percent blood alcohol concentration (BAC), there is little or no slope in these curves, but the rise becomes quite steep in the region of .10 percent BAC and above. In general, the acceleration of the curve is steeper for the more severe crash.

With such curves, there thus exists a relationship for the objective measurement of impairment and ability to drive. As a result, increasing emphasis has been placed on chemical testing in recent years, culminating in the implementation of programs such as the British Road Safety Act of 1967 which defined the offense of impaired driving specifically in terms of the blood alcohol concentration of the driver. In this form, the offense has two elements; (1) being in charge of or operating a vehicle, and (2) having a blood alcohol concentration of .08 percent or greater. This definition of offense in terms of a chemical state of the body is a radical departure from previous criminal law practice in which only certain behavior is prescribed. It is true, of course, that the case against driving while intoxicated always implied a prohibition of a particular chemical state of the body. However, until enactment of laws such as the British Road Safety Act, which made the possession of a given BAC as illegal per se, the determination of the chemical state of the body was always done by inference through observation of behavior.

This movement, away from defining an offense in behavioral terms to defining the offense in terms of a chemical state of the body disturbs many individuals. While

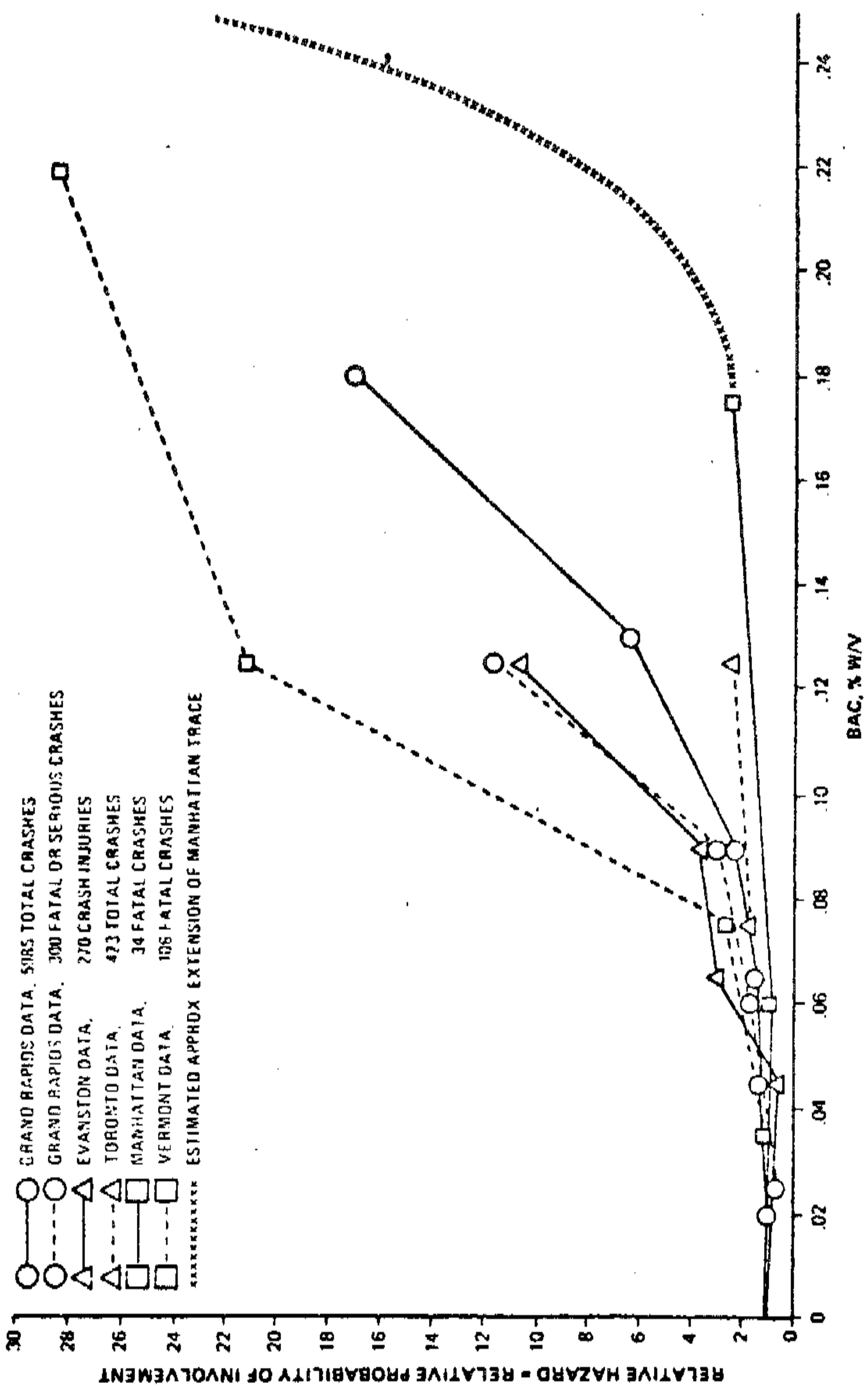

Fig. 1 - Relative probability of crash involvement as a function of BAC where 1.0 = relative probability at zero alcohol

we have always been willing to accept behavior as under the conscious control and willed by the individual, the body's chemical state cannot be directly sensed with accuracy, nor is it viewed as being as clearly under the willful control of the individual. This new approach does, however, make good sense -- both from the point of view of a systematic approach to the problem of highway safety and from the point of view of law enforcement. Because alcohol can be measured accurately and objectively after the occurrence of a crash, there is substantially more data correlating a given BAC with a crash occurrence than there is correlating any type of human behavior with a crash.

Dose-response curves shown in Figure 1 are unique. No similar behavior-crash data exist for any item or facet of driver behavior. Speeding, as an example, is commonly believed to be strongly associated with the occurrence of traffic crash. However, the frequency with which speeding occurs in drivers not involved with crashes has never been directly compared with the frequency with which speeding occurs in connection with accidents. Therefore, a curve for speed similar to the curves for alcohol shown in Figure 1 has not been developed. Part of this results from the inability to test the behavior of drivers involved in crashes at or immediately after the time at which their crash occurred. Such drivers are either too emotionally upset or too concerned with being held responsible for the crash to perform in a manner representative of their capability at the time the crash occurred. Thus, while a blood sample, providing it is taken within a short period of the occurrence of the crash, is representative of the chemical state of the body at the time of the crash; a sample of behavior taken during the same period would not be. Therefore, it is not likely we will ever have behavioral curves showing similar validity as the curve shown in Figure 1. Thus, the State has greater justification for using blood alcohol concentration as a basis for enforcement programs than any other piece of human or driver behavior.

Nor is the use of behavior to infer the chemical state of the driver a satisfactory alternative to the direct measurement of blood alcohol concentration. Since the key driver behaviors which are related to crash involvement cannot normally be measured or observed by the police officer, the arresting officer is dependent upon observing other behaviors under the assumption that impairment in these activities is predictive of impairment of significant driving skills.

The difference between those behaviors normally observed and used to judge impairment and those behaviors related to driving performance and crash involvement are illustrated in Figure 2. The policeman observes the general attitude and deportment of the driver and he may require the driver to perform certain psychomotor tests. Performance on these tests, however, may or may not be predictive of decrement in those skills which are critical to safe driving performance. The most common psychomotor tests employed by police are shown in Figure 3 as listed on the National Safety Council's Alcohol Influence Report Form. Included are tests of balance, walking, turning, finger to nose touching and the ability to pick up coins.

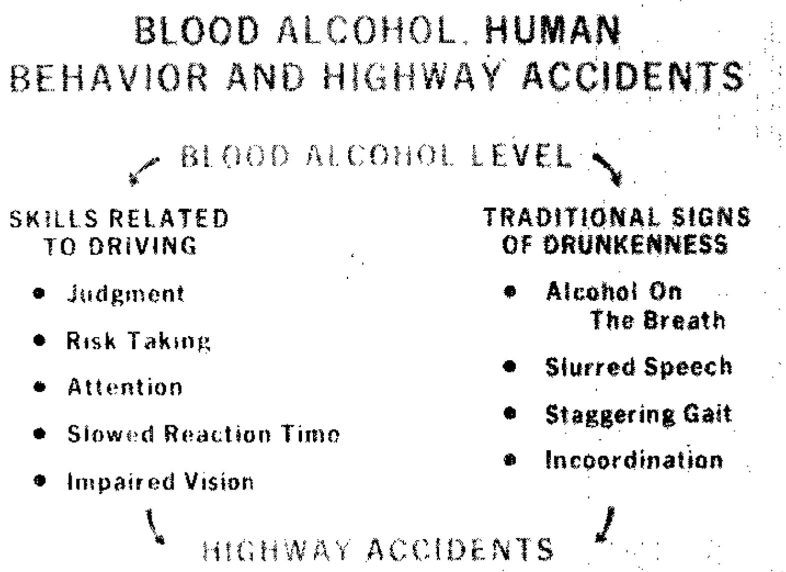

Fig. 2 - Blood alcohol, human behavior and highway accidents

Of these, the balance or Rhomberg test is generally recognized as the most sensitive behavioral measure of impairment induced by alcohol (Walgren and Barry).[1970] On closer examination, however, there is evidence that the Rhomberg, as well as the other psychomotor tests, are not as accurate and reliable indicators of behavioral impairment of intoxication as desirable. To be sure, all subjects generally show significant increases in sway at BACs from .08 to .12 percent. The problem exists, however, that even well practiced subjects show considerable sway when quite sober. Police officers and most physicians rarely take the necessary comparative no-alcohol baseline measurements when using such tests. Perrine and Coldwell (1958) have shown in a study in which physicians using the Rhomberg and other clinical tests were to judge alcohol induced impairment that only 25 out of 49 intoxicated subjects were so correctly diagnosed. In addition to such test interpretation problems is the fact that in real world situations, in which a person is subject to arrest and in jeopardy of a (DUI) conviction, subjects can muster simply

(Check)	(Check)
☐ Driver	☐ Accident
☐ Pedestrian	☐ Violation
☐ Passenger	☐ Other

Date and time of Accident or Violation ______ am/pm

ALCOHOLIC INFLUENCE REPORT FORM

Police Dept. ______
Arrest No. ______
Accident No. ______
Arresting Officer ______
Date and time in custody ______ am/pm

Name ______ Address ______

Age ____ Sex ____ Race ____ Approx. Wt. ____ Operator Lic. No. ____ State ____

OBSERVATIONS:

CLOTHES	Describe: (Type & Color) Hat or Cap ____ Jacket or Coat ____ Shirt or Dress ____ Pants or Skirt ____
	Condition: ☐ Disorderly ☐ Disarranged ☐ Soiled ☐ Mussed ☐ Orderly (Describe) ____
BREATH	Odor of Alcoholic Beverage: ☐ strong ☐ moderate ☐ faint ☐ none
ATTITUDE	☐ Excited ☐ Hilarious ☐ Talkative ☐ Carefree ☐ Sleepy ☐ Profanity ☐ Combative ☐ Indifferent ☐ Insulting ☐ Cocky ☐ Cooperative ☐ Polite
UNUSUAL ACTIONS	☐ Hiccoughing ☐ Belching ☐ Vomiting ☐ Fighting ☐ Crying ☐ Laughing
SPEECH	☐ Not Understandable ☐ Mumbled ☐ Slurred ☐ Mush Mouthed ☐ Confused ☐ Thick Tongued ☐ Stuttered ☐ Accent ☐ Fair ☐ Good

Indicate other unusual actions or statements, including when first observed: ______

Signs or complaint of illness or injury:

PERFORMANCE TESTS: (Note—See departmental instructions for conducting these tests)

Check Squares If Not Made		Check appropriate square before word describing condition observed
☐	**BALANCE**	☐ Falling ☐ Needed Support ☐ Wobbling ☐ Swaying ☐ Unsure ☐ Sure
☐	**WALKING**	☐ Falling ☐ Staggering ☐ Stumbling ☐ Swaying ☐ Unsure ☐ Sure
☐	**TURNING**	☐ Falling ☐ Staggering ☐ Hesitant ☐ Swaying ☐ Unsure ☐ Sure
☐	**FINGER-TO-NOSE**	Right: ☐ Completely Missed ☐ Hesitant ☐ Sure Left: ☐ Completely Missed ☐ Hesitant ☐ Sure
☐	**COINS**	☐ Unable ☐ Fumbling ☐ Slow ☐ Sure ☐ (Other) ____ (Balance during coin test) ____

Ability to understand instructions: ☐ Poor ☐ Fair ☐ Good | Tests performed: Date ____ Time ____ am/pm

OBSERVER'S OPINION:

Effects of alcohol: ☐ extreme ☐ obvious ☐ slight ☐ none | Ability to drive: ☐ unfit ☐ fit

Indicate briefly what first led you to suspect alcoholic influence: ______

Observed by: ______ Assignment: ______

Witnessed by: ______ Date ______ Time ______ am/pm

CHEMICAL TEST DATA:

Specimen: ☐ Blood ☐ Breath ☐ Saliva ☐ Urine ☐ None ☐ Refused ☐ Unable | Analysis result: | If Breath, what instrument?

If refused, why? ______

Fig. 3 - Alcoholic influence report form

amazing self-control, often quite sufficient to mask influences of alcohol on body sway. Thus, from the clinical and enforcement points of view, the use of behavioral tests to infer the chemical state of a driver, or as a direct measure of (impaired) driving capacity, is being shown to be increasingly inadequate in traffic law enforcement.

THE ROLE OF NHTSA, BREATH MEASUREMENT AND HIGHWAY SAFETY

In order to further this new trend in alcohol traffic offense enforcement, the highway safety community bears two major areas of responsibility. One, through continuing epidemiological and laboratory study, the causal relationship between alcohol dosage and impairment of driving ability must be further substantiated and defined. Within this question, the nagging problem of individual differences and population variability in impairment with its obvious legal and statutory implications must be pursued. The second responsibility is the improvement of the forensic-toxicological techniques for detecting and measuring the concentration of alcohol in the drinking driver.

The Department of Transportation shares a role in both these areas. The present paper addresses the activities of the Department (NHTSA) in the latter area -- towards the improvement of alcohol detection and measurement in highway safety and outlines recent technological advances in this field.

In traffic law enforcement the primary means of body alcohol measurement are through the analysis of either breath or blood, (with urine and saliva analyses conducted to only a small degree). With the apparent precluding exceptions of either serious or fatally injured drivers or those with precluding respiratory problems -- breath alcohol measurement has become the technique of choice because of the ease and speed with which a sample and analysis can be obtained and with greatly reduced subject discomfort.

In order to best describe the NHTSA programs and activities in this area, the various ways in which breath test technology has been applied in traffic law enforcement including the legal environment within which new equipment is employed should additionally be outlined.

LEGAL ENVIRONMENT

A legal cornerstone of breath measurement law is the implied consent statute now in force in each of fifty states. Commensurate with the philosophy that driving is a privilege not a basic right, each individual in applying to the state for a drivers license consents to submit to a "chemical" test to determine the alcoholic content of his blood if so requested by a police officer. Refusal to submit to such a test results in a revocation of a license, typically for a six month period. It is this law that provides a state with the basic authority to apply new advances in breath measurement technology in alcohol traffic law enforcement.

Complimenting the implied consent statute are two other more recent laws relevant to breath testing - the illegal per se law and the pre-arrest screening law. The illegal per se makes it a violation of law, in and of itself, to drive with a blood alcohol concentration over a specified limit (generally .10 percent BAC). With the connection between blood alcohol concentration and physical impairment scientifically well-documented, the arresting officer need not establish alcohol-induced impairment as required under existing DWI (driving while intoxicated) laws. He need only rely on an evidential blood or breath test indication of an illegal blood alcohol concentration to establish a violation of law. The per se law is thus a direct outgrowth and entirely consonant with the trend towards defining an alcohol traffic offense in terms of blood alcohol concentration rather than by overt behavior. As of this date the eight states shown in Figure 4 (New York, Minnesota, Nebraska, Delaware, South Dakota. Vermont, Utah, Oregon) have enacted such a law.

STATES WITH AN ILLEGAL PER SE LAW

STATE	BLOOD ALCOHOL CONCENTRATION LIMIT
NEW YORK	.10%
MINNESOTA	.10%
NEBRASKA	.10%
DELAWARE	.10%
SOUTH DAKOTA	.10%
VERMONT	.10%
UTAH	.10%
OREGON	.15%

Fig. 4 - States with an illegal per se law

The third statute enables the pre-arrest or roadside screening of drivers to determine if their blood alcohol content is sufficient to warrant charging them with an alcohol-traffic offense. With the dramatic success of the British Road Safety Act which authorized roadside breath alcohol screening (and produced an initial 33 percent decrease in nighttime highway deaths) considerable interest in using a similar procedure developed in the United States. Implementation of a screening program in the United States has been held up, until recently, pending the development of fully adequate screening tests. With the current availability of accurate alcohol screening devices, ten states, shown in Figure 5, have enacted pre-arrest screening legislation (New York, Minnesota, Nebraska, North Dakota, Vermont, Indiana, Virginia, Maine, Florida).

STATES WITH A PRE-ARREST SCREENING LAW

NEW YORK	VERMONT
MINNESOTA	INDIANA
NEBRASKA	VIRGINIA
NORTH DAKOTA	MAINE
SOUTH DAKOTA	FLORIDA

Fig. 5 - States with a pre-arrest screening law

The current procedure for making an arrest for driving while intoxicated (DWI) proceeds through four steps:

(1) First, the driver calls the attention of the police to himself by becoming involved in a highway crash or breaking a highway safety law or by driving in an erratic fashion.

(2) Once the car has been brought to a safe stop, the police officer questions the driver - trying to detect an odor of alcohol on the subject's breath, looking for signs of incoordination (such as fumbling to get the wallet for his driver's license, slurred speech, or other signs of intoxication).

(3) If these signs are present, then the officer invites the driver out of his car and requires him to perform the set of coordination tests, such as walking a straight line, standing on one foot, etc., mentioned above.

(4) If the coordination test gives indication that the individual is impaired or intoxicated, then the officer will make a formal arrest and take the suspect down to the police station for booking and for a highly accurate quantitative blood or breath test. It is the results of this test which are presented in court to provide evidence of impairment.

Screening tests are used in step two, alcohol detection, and may obviate the need for step three, psychomotor testing. The quantitative evidential breath test would then be used in conjunction with the screening test to establish violation of the illegal per se statute.

With the availability of these three new laws, <u>implied consent</u>, <u>illegal per se</u> and <u>pre-arrest screening</u> and the development of accurate breath measurement devices, enforcement of drunk driving law has been greatly facilitated.

BREATH MEASUREMENT INSTRUMENTATION

There are currently six basic types or classes of breath measurement instrumentation applied to traffic law enforcement as shown in Figure 6. Included are Screening Breath Testers (SBTs), Evidential Breath Testers (EBTs), Roadside or Remote Collection Devices (RCDs), Passive Breath Testers (PBTs), Educational Testers and Alcohol Safety Interlock Systems.

SCREENING BREATH TESTERS - Screening Breath Testers are currently available in two basic designs -- the disposable chemical reagent type and the reusable electro-mechanical designs.

APPLICATIONS OF BREATH MEASUREMENT TECHNOLOGY IN TRAFFIC LAW ENFORCEMENT

- SCREENING BREATH TESTERS (SBTs)
  - DISPOSABLE REAGENT TYPE
  - ELECTROMECHANICAL TYPE
- EVIDENTIAL BREATH TESTERS (EBTs)
  - IN STATION TYPE
  - ROADSIDE TYPE
- ROADSIDE COLLECTION DEVICES (RCDs)
- PASSIVE BREATH TESTERS (PBTs) (OR SNIFFERS)
- EDUCATIONAL TESTERS
- ALCOHOL SAFETY INTERLOCK SYSTEMS (ASIS)

Fig. 6 - Applications of breath measurement technology in traffic law enforcement

Chemical Reagent Type - The disposable chemical reagent screening devices or "baggies" are all similar in design and operation. Each is comprised of a small glass tube containing either a column or multiple bands of an alcohol sensitive reagent (a chromate salt and a mineral acid) with an inert silicagel support, and a breath volume measurement device (either a rubber balloon, plastic bag or air pump). Figure 7 shows an example of this type of device. Figure 8 lists those manufacturers and models currently available.

Electromechanical Type - Electromechanical screening breath testers are a recent development in the field of forensic alcohol measurement instrumentation. Developed since

Fig. 7 - Mobat sober-meter SM-3

SCREENING BREATH TESTERS
CHEMICAL REAGENT DESIGNS

MODEL NAME	MANUFACTURER
1 ALCOLYSER	LION LABORATORIES CARDIFF, WALES
2 BECTON-DICKINSON	BECTON-DICKINSON RUTHERFORD, NEW JERSEY
3 KITIGAWA DRUNK-O-TESTER	KOMO CHEMICAL INDUSTRIAN CO., LTD., TOKYO
4 SOBER-METER	LUCKY LABORATORIES, INC. SAN BERNARDINO, CALIFORNIA
5 ALCOTEST	DRAGERWERK LUBECK, GERMANY

All of the above utilize alcohol sensitive chemical reagents, generally a dichromate salt and a mineral acid, to indicate alcohol through a length of color stain technique.

Fig. 8 - Screening breath testers - chemical reagent designs

1970, this class of SBTs are small, reusable, electronic breath analyzers, generally the size of transistor radios, which employ a variety of alcohol sensor designs. Examples of current models are shown in Figures 9-13 and a list of devices and manufactures is included in Figure 14. Electromechanical SBTs can be classified according to the four basic alcohol sensor types employed. These include chemoelectric or fuel cells, catalytic burner, infrared and semi-conductor sensor types.

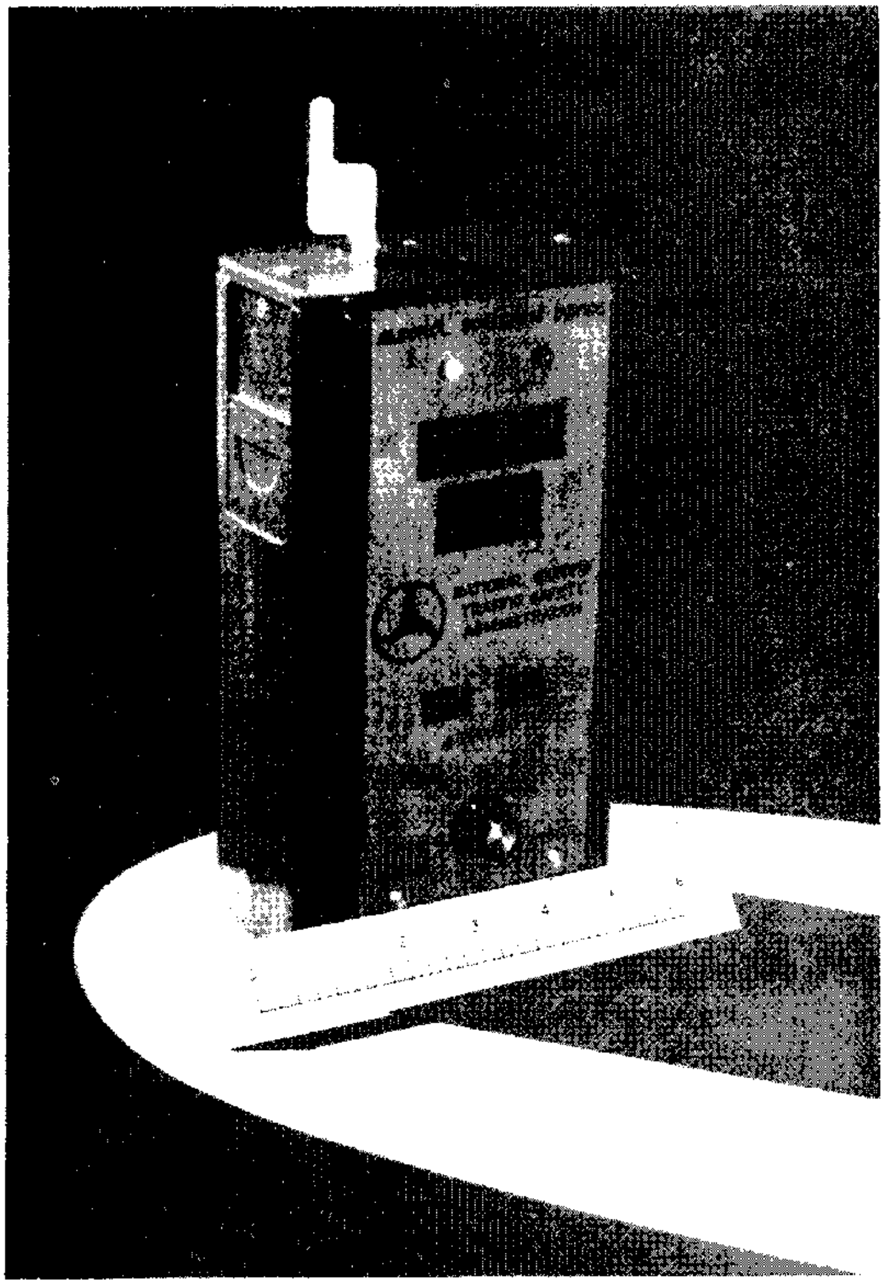

Fig. 9 - DOT/TSC roadside breath tester

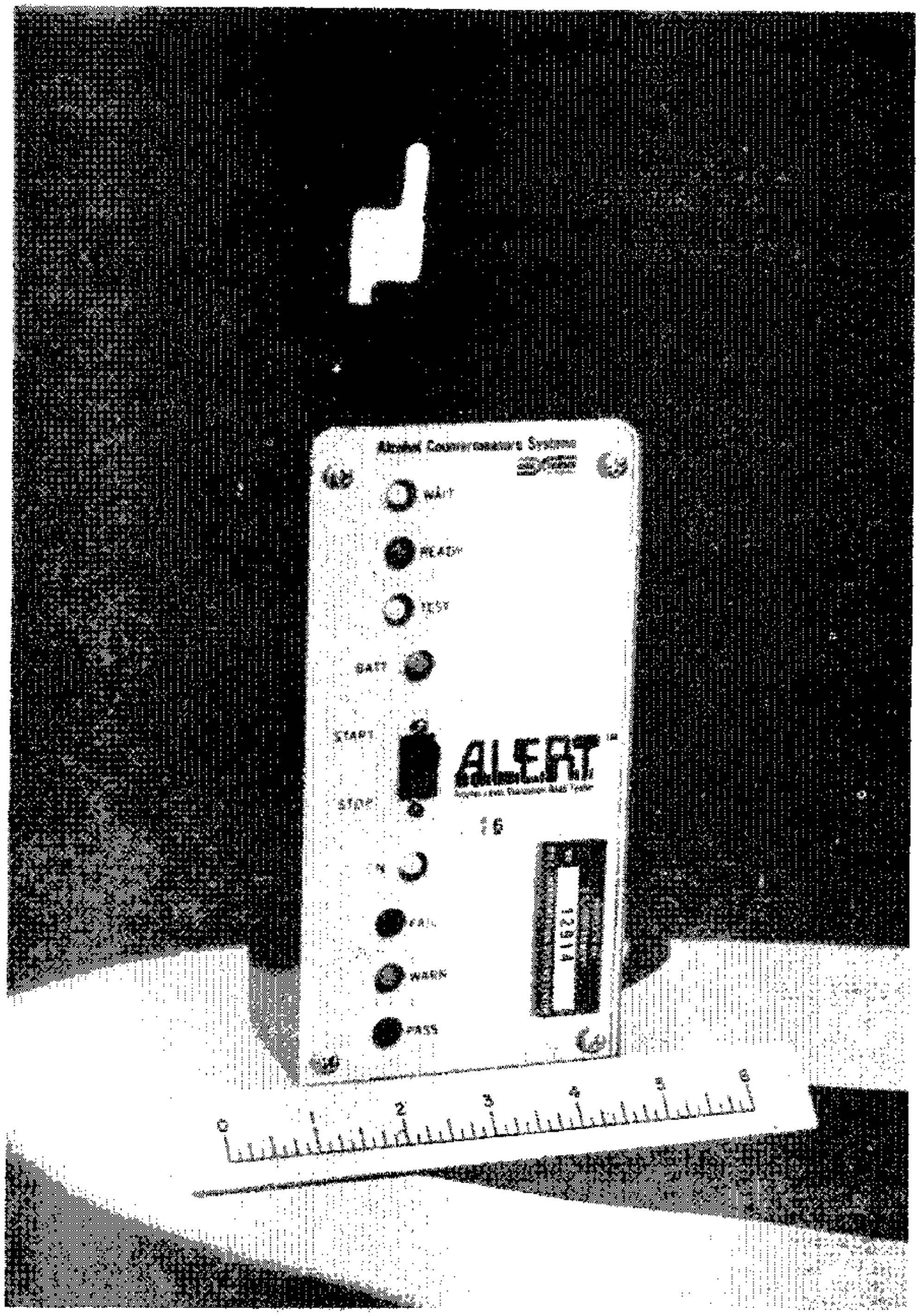

Fig. 10 - Borg Warner Corp. Alert

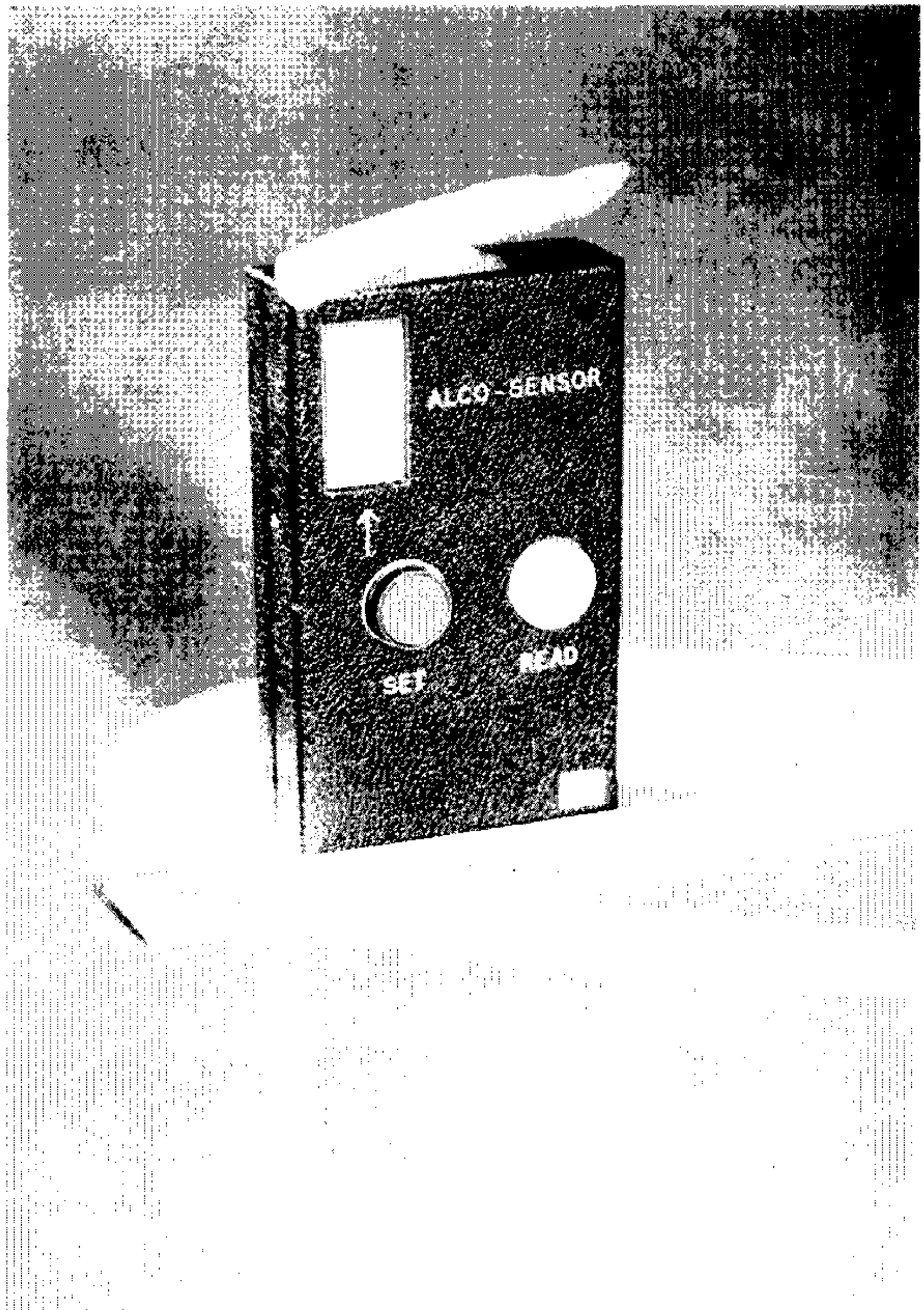

Fig. 11 - Intoximeters Inc. Alco-Sensor

Fig. 12 - Century Systems Corp. alcohol tester (BAT)

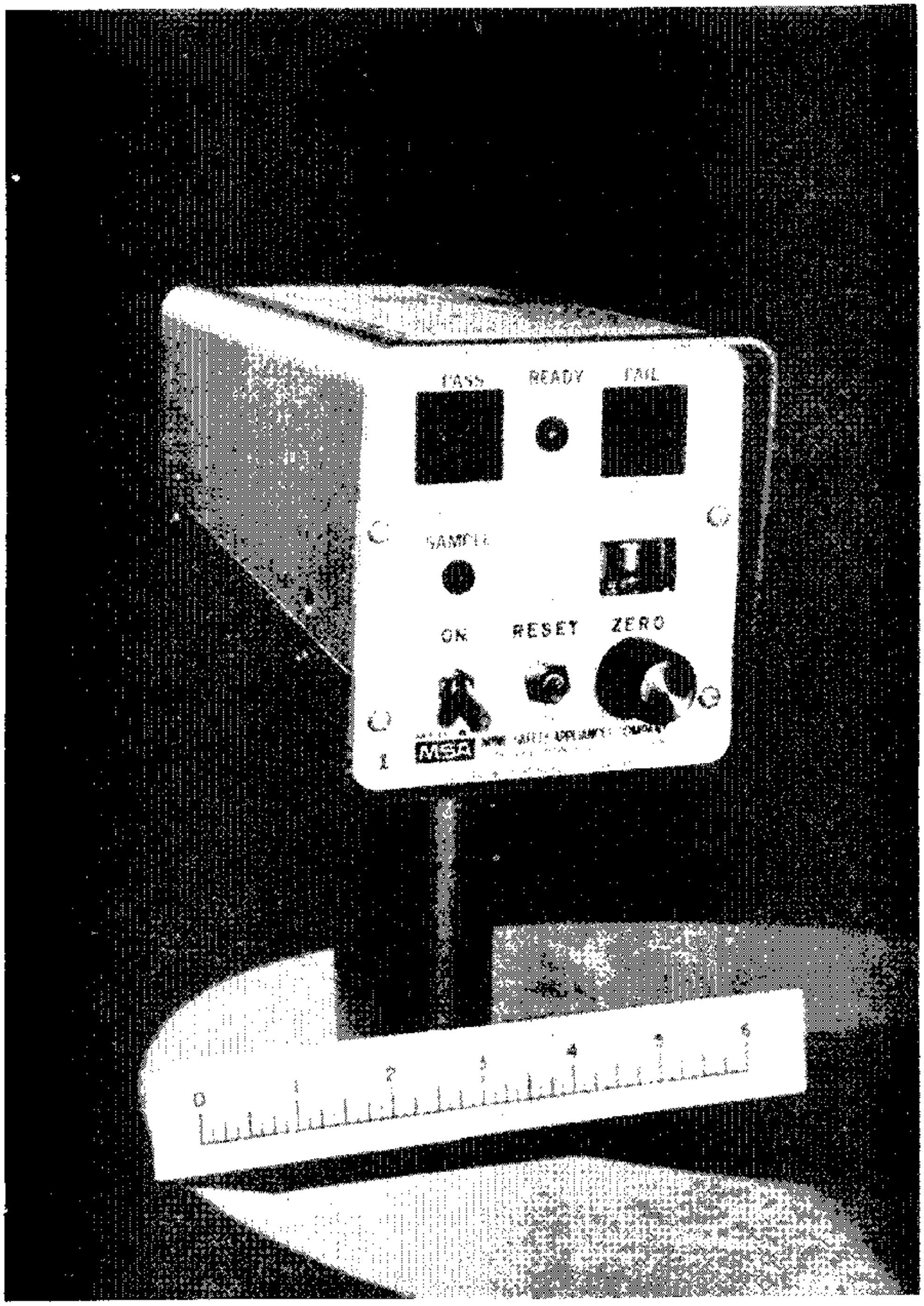

Fig. 13 - Mine Safety Appliances Co. Alcohalt

SCREENING BREATH TESTERS
ELECTROMECHANICAL DESIGNS

MODEL NAME	SENSOR	READOUT
ALCOLIMITER	FUEL CELL	METER
ALCOSENSOR	FUEL CELL	LIGHTS
ALCOHALT	CATALYTIC BURNER	LIGHTS
ALERT	SEMI CONDUCTOR	LIGHTS
BREATH ALCOHOL TESTER	CATALYTIC BURNER	METER
BREATH ANALYZER	INFRARED	METER
ROADSIDE BREATH TESTER	FUEL CELL	LIGHTS/ DIGITAL

Fig. 14 - Screening breath testers, electromechanical designs

Fuel cell SBTs utilize small chemo-electric cells, similar to those used in NASA spacecraft, to generate a measurable electric current from the catalytic oxidation of alcohol in the breath. The amount of electricity produced is directly proportional to the blood alcohol concentration and is translated through suitable electronics to either illuminated lights or meter readouts.

In catalytic burner SBTs, alcohol is "burned" at a small catalytically active element held at a constant temperature. A change in temperature from this burning induces a change in resistance in a (Wheatstone) bridge circuit proportional to the concentration of alcohol in the breath. This change in resistance is then converted to a suitable BAC readout.

Infrared sensor SBTs operate on a well known technique for measuring organic compounds which utilize the unique absorption characteristics of ethanol for portions of the infrared spectrum. Infrared light is "chopped" to an AC signal, filtered through a 3.4 micron bandpass filter, and reflected back and forth through the breath sample volume where the amount of light absorbed is proportional to the ethanol in the breath. The BAC equivalent is then displayed by either meter or light readouts.

The fourth class of SBTs, the solid state semi-conductor device, measure alcohol concentration through the change in surface resistivity with the absorption of alcohol on a transition metal oxide sensor. This change in resistance is then converted electronically to a BAC readout.

With an understanding of the technical nature of SBTs and the legal environment within which they are utilized, the manner in which these devices fit into our national program can now be discussed.

The basic programmatic responsibilities of DOT in the breath measurement-enforcement area are threefold:

(1) To develop and stimulate development of new concepts and technology that increase and facilitate enforcement of alcohol traffic law.

(2) To test and evaluate these new concepts and technologies as to effectiveness and applicability.

(3) To implement the use of demonstrably valid and effective concepts and instrumentation by the various states in alcohol traffic law enforcement.

NHTSA Screening Breath Tester Program addresses each of the responsibilities. The emphasis in screening breath testing has centered on the electromechanical type of SBT. An excellent study by Prouty and O'Neill (1971) evaluating the chemical reagent type SBTs showed this class of devices to produce unacceptable levels of incorrect test readings. There are two types of errors in breath measurement -- false positive and false negative readings. False positives result when the actual blood alcohol concentration is less than, for example, 0.10 percent BAC, but a positive or greater than .10 percent BAC indication is given. False negatives are then the converse state. Both types of errors are important, however, false positives are felt to be especially serious. Clearly both public and judicial acceptance of screening tests would be jeopardized if drivers are incorrectly identified as legally intoxicated who, in fact, are legally sober. Current models of chemical reagent testers have demonstrated high levels of both types of errors -- in some cases as high as 70 percent.

In response to the demonstrated inadequacy of the chemical reagent SBTs, DOT launched a program in 1971 to develop small, portable, automatic breath testers using the latest alcohol sensor technology. The result of this effort is the DOT Roadside Breath Tester shown in Figure 9. Concurrent with our in-house effort, DOT has encouraged commercial firms to develop and market SBTs. In response to this effort there are, at the present time, the six SBTs listed in Figure 14 which have been commercially produced.

To evaluate the operational effectiveness of these SBTs and the screening concepts, NHTSA has initiated a field test program in several of those states with the prerequisite pre-arrest screening legislation. Field tests of the DOT and commercial SBTs have been conducted or are underway in four states - Minnesota, New York, North Dakota and South Dakota. The results of the Minnesota and North Dakota field tests are especially interesting.

Minnesota SBT Field Test - The Minnesota test was conducted in Hennepin County, Minnesota (an area inclusive of Minneapolis and its suburbs) in conjunction with the federally funded Hennepin County Alcohol Safety Action Project. Thirteen of the Borg Warner SBTs were deployed for a four-month period (April-July, 1973) with seven enforcement agencies participating.

In all of the SBT field tests, a successful test would be indicated by several parameters:

(1) An increased number of DWI arrests among those patrols using SBTs (assuming SBTs are more effective in identifying legally intoxicated drivers than the officer using the old psychomotor measures).

(2) A decrease in the average BAC of those drivers arrested (assuming that SBTs are more sensitive to the legal borderline, near .10 percent, levels of intoxication than the traditional techniques).

(3) Accurate BAC readings (as confirmed by subsequent evidential breath or blood tests).

(4) Reliable operations (as indicated by low mechanical failure rates).

The first of the test results is shown in Figure 15. Of the more than 1200 SBT tests given, 48 percent showed over .10 percent BAC, 33 percent showed between .05-.10 percent, and 19 percent showed .05 percent or under. This result is especially interesting because, in most cases, officers used the SBT only when the subject was not obviously intoxicated. Thus, the SBT detected almost half of those tested as illegally intoxicated who might otherwise have been released.

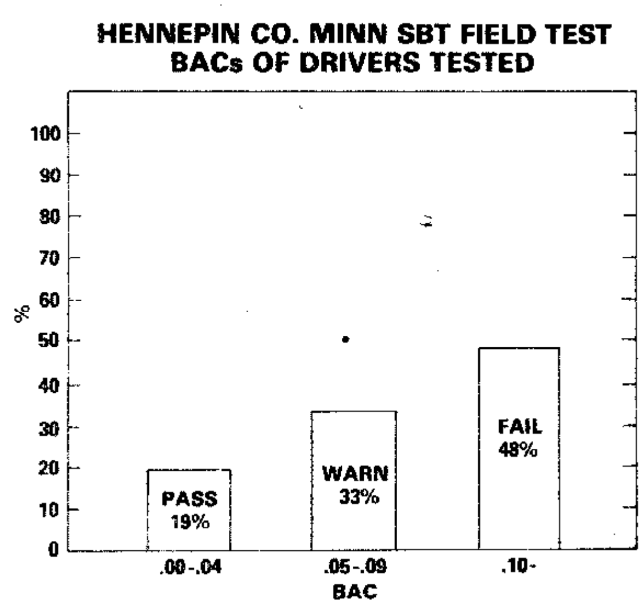

Fig. 15 - Hennepin Co. Minn SBT field test BACs of drivers tested

The impact of SBTs on arrest rates is shown in Figure 16. The DWI arrest rates of those police departments that had SBTs were compared to those without, as well as against the arrest rates for both groups over the same period the preceding year. The important information on Figure 16 is the relative slopes of the two lines rather than the differences in levels. The upper line shows a 62 percent increase in DWI arrests of the SBT equipped patrols over the previous baseline period. In contrast, the non-SBT patrols evidenced only a 23 percent increase. The difference in overall arrest level is due to the fact that the SBT patrols were exclusively ASAP officers whose job is solely alcohol traffic law enforcement and hence generate more DWI arrests. The lower line is a composite of ASAP non-SBT equipped officer and non-SBT regular patrol officer arrests.

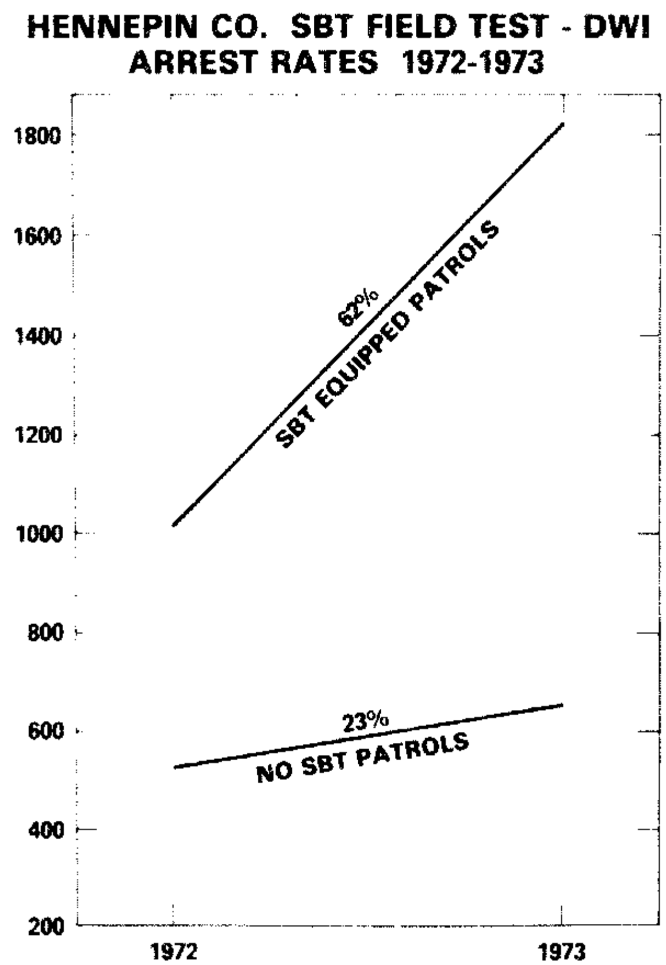

Fig. 16 - Henn‹pin Co. SBT field test - DWI arrest rates 1972 - 1973

The average BAC of those arrested with SBTs also decreased in contrast to the average of those arrested with the traditional techniques. As shown in Figure 17 the difference in average BAC was .04 percent, a significant amount in DWI enforcement. Many officers commented on the number of occasions in which a driver appeared outwardly "not too bad," yet failed the SBT test and later blew a high evidential test reading near .20 percent BAC. (It is estimated in the Borkenstein Grand Rapids Study that drivers around .20 percent BAC are estimated to be 40 times more likely to be involved in a crash).

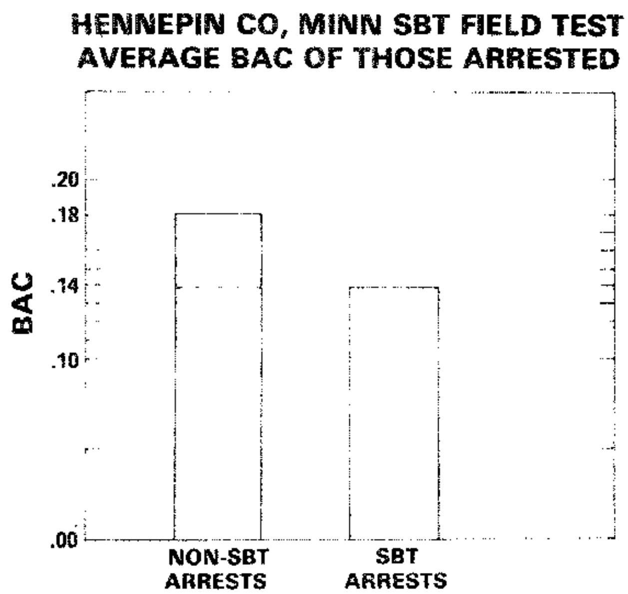

Fig. 17 - Hennepin Co. Minn SBT field test average BAC of those arrested

A direct comparison between psychomotor performance tests and SBT results was also conducted in the Hennepin County Study. Among those who failed the SBT test and were over the legal limit, 62 percent had been rated "good" or "fair" in the Rhomberg balance test. The proportion of SBT fails rated "good" or "fair" on the other performance tests were 58 percent in the walking test and 57 percent in the finger-to-nose.

North Dakota SBT Field Test - Preliminary results from the North Dakota field test are similarly encouraging. The North Dakota field test involves over 80 officers of the North Dakota Highway Patrol equipped with fifty Borg Warner Alert SBTs. With five months of test data reported, over 68 percent of those drivers tested failed the SBT test as illustrated in Figure 18. Nineteen percent received "warn" indications (in the .05 - .10 percent range) while only 10 percent passed the SBT test (below .05 percent BAC).

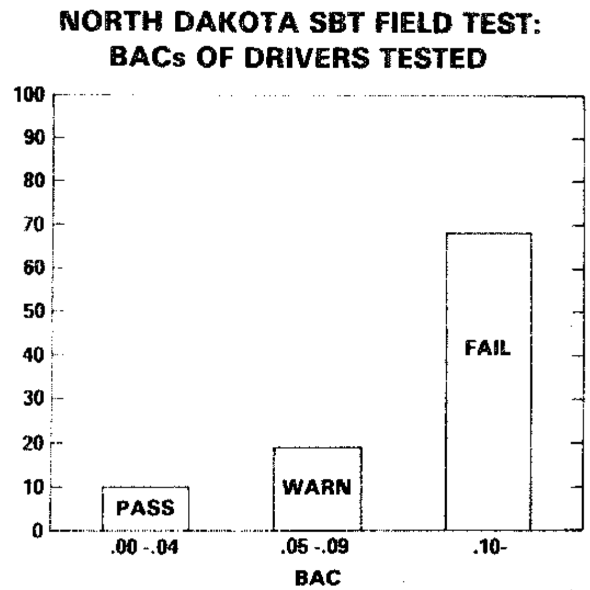

Fig. 18 - North Dakota SBT field test: BACs of drivers tested

Figure 19 shows the impact of SBTs on average BAC of those arrested. Historical DWI arrest activity by individual officer was compiled for all SBT and non-SBT equipped officers for 1972 and 1973, and the composite BAC averages of each of these two groups is shown as the "before" columns in the figure. The data indicates that SBT equipped officers reduced the average BAC of their arrests by .05 as contrasted with a .02 BAC decrease with the control group.

In the Hennepin County field tests, false positive rates of less than 5 percent were observed. In both the Hennepin County and North Dakota field tests, the operational reliability of the Borg Warner units has been good with a minimum of device failures.

In summary, there is every indication from our field test program that screening breath testing is a viable and effective concept and that those SBT devices tested are both accurate and reliable.

The third of the areas of general DOT responsibility mentioned above was the implementation of demonstrably valid and effective concepts. Toward this end, NHTSA has recently purchased for distribution to the States, 1,000 Screening Breath Testers of four commercially produced designs. These devices will be placed into police departments across the country for their own operational use and testing. It is expected that this distribution will provide valuable exposure of the SBT concept and generate additional usage data with which the States and NHTSA can evaluate equipment effectiveness and reliability.

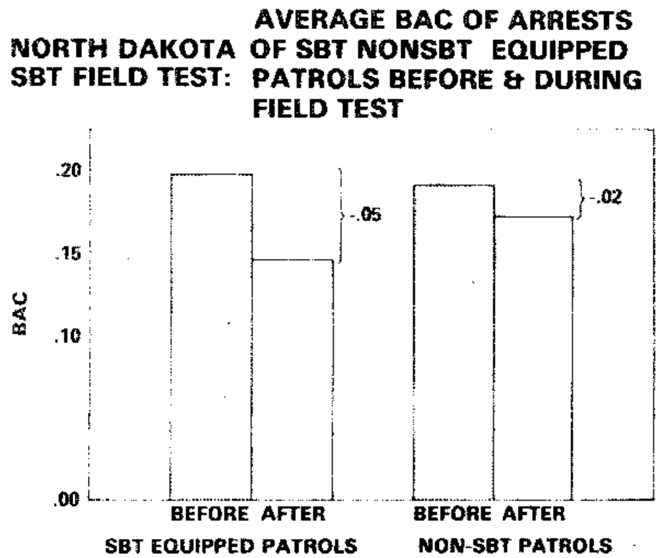

Fig. 19 - North Dakota SBT field test: average BAC of arrests of SBT non-SBT equipped patrols before and during field test

EVIDENTIAL BREATH TESTERS

A more familiar and widely used class of breath measurement instrumentation is the evidential type breath testers or EBTs. These instruments, as do screening breath testers, differ in the types of alcohol sensors employed but are distinguished from the SBTs by their greater precision and accuracy which allows their indications to be admissable in court as evidence.

EBTs are currently not only in use in police stations for forensic traffic enforcement purposes but in hospitals for rapid toxicity level determinations and in airports for screening airline pilots.

Figures 20-22 illustrate a few of the currently available commercial evidential breath testers. A complete list of the known available commercial EBTs is provided in Figure 23.

The basic techniques for alcohol detection and quantitation used in EBTs are gas chromatography, photometric colorimetry and infrared absorption photometry.

Gas Chromatography EBTs - Gas Chromatography is well known analytic technique for organic compounds. In the gas chromatographic breath testers, a measured uniform volume of the alcohol laden breath is first collected in a chamber to

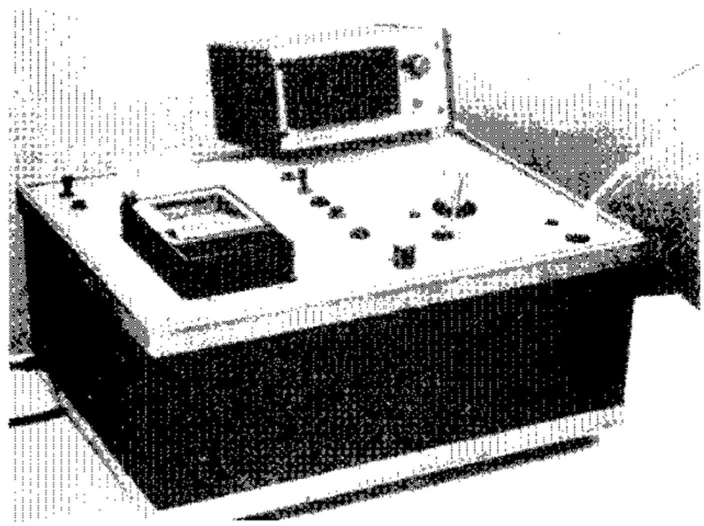

Fig. 20 - Gas chromatographic intoximeter

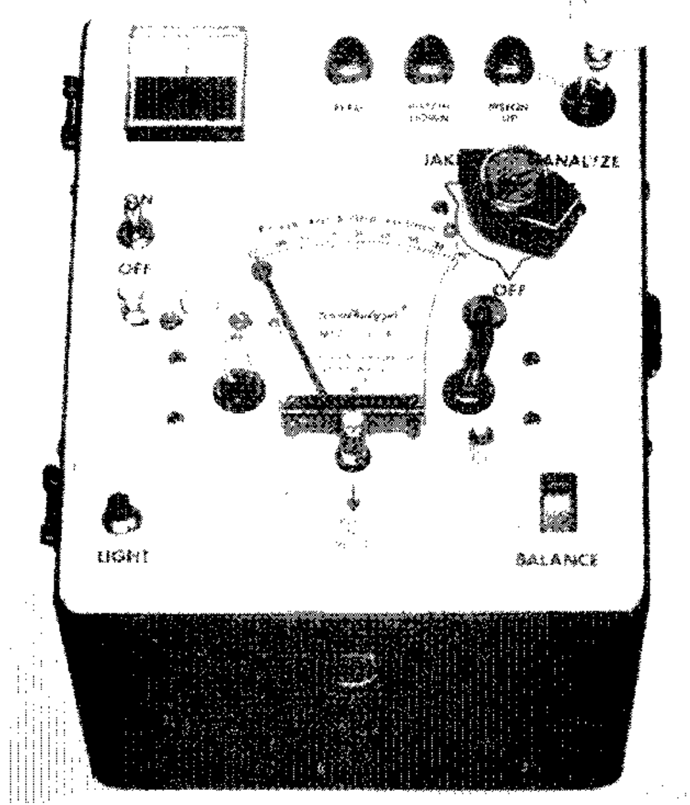

Fig. 21 - Breathalyzer

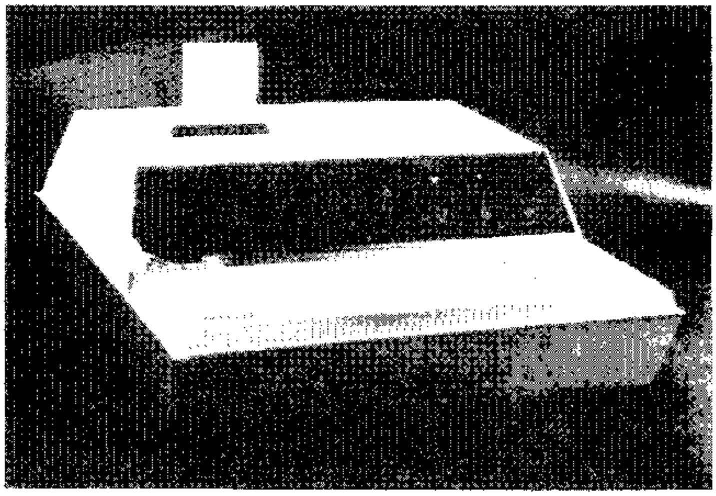

Fig. 22 - Intoxilyzer

EVIDENTIAL BREATH TESTERS

MODEL NAME	ALCOHOL ANALYSIS TECHNIQUE
1. ALCO ANALYZER	GAS CHROMATOGRAPH
2. ALCOLIMETER	FUEL CELL
3. ALCOMETER	PHOTOMETRIC
4. ALCO-TECTOR	PHOTOMETRIC
5. BREATHALYZER	PHOTOMETRIC
6. GAS CHROMATOGRAPH INTOXIMETER	GAS CHROMATOGRAPH
7. INTOXILYZER	INFRARED ABSORPTION
8. PHOTO ELECTRIC INTOXIMETER	PHOTOMETRIC
9. ROADSIDE BREATH TESTER	FUEL CELL

Fig. 23 - Evidential breath testers

ensure that a sample of equilibrated alveolar breath is obtained. The breath sample is then passed through a chromatographic column which separates the component molecules of the sample by their unique elution times (the amount of time it takes different molecules to pass through the column). Each of the sample components are then passed in turn to the detector chamber.

Two basic types of detectors are used, either the heated oven or the flame ionization types. The heated oven type employs a Wheatstone Bridge type circuit where a helium bathed, heated reference sensor is balanced against another heated wire or thermistor which is cooled by the ethanol passing over it. The amount of cooling and the current generated in the circuit are proportional to the amount of ethanol in the sample. The quantitation of ethanol is thus accomplished by knowing the elution time at which the ethanol passes from the chromatographic column and the order of peaks generated on a strip chart recorder by the detector. The other type of detector uses the flame ionization technique which consists of a hydrogen flame over which each of the sample components are passed. The burning of the ethanol component generates ions which are collected on a metallic loop and the resulting electric current is converted to strip chart BAC readings.

Photometric EBTs - Photometric Evidential Breath Testers also utilize a well known analytic technique -- photometric colorimetry -- for alcohol quantification. In these devices, a breath sample is collected (as in the GC devices) and then bubbled through a test ampule of ethanol indicator solution (usually potassium dichromate and sulfuric acid). The ethanol is oxidized producing a color change in the indicator solution. The change in color reduces the amount of light transmitted through the ampule, which, when electronically compared to the light transmittance through a non-oxidized reference solution, creates an imbalance in a Wheatstone Bridge circuit. This imbalance generates a current flow, proportional to the color change and ultimately the amount of ethanol in the sample, which is displayed on a meter or printout in BAC terms.

Infrared EBTs - Infrared Evidential Breath Testers also employ a photometric technique for ethanol quantification, but utilize the characteristic differential absorption of portions of the infrared spectrum by organic compounds as a sensor technique. The breath sample is introduced to a chamber through which an infrared beam (of a wavelength strongly absorbed by ethanol) is passed. The decrease in energy transmittance is proportional to the concentration of ethanol in the sample (as per the Lambert beer law) and is converted electronically to a BAC readout.

ROADSIDE COLLECTION DEVICES

Used in conjunction with evidential breath testers are a third class of breath measurement instruments -- Roadside or Remote Collection Devices. These devices are employed by police to collect breath samples at the roadside for later analysis on evidential breath testers, usually of the gas chromatographic design. Figure 24 shows an example of a roadside crimper type collection device. Figure 25 lists those devices known to be currently available.

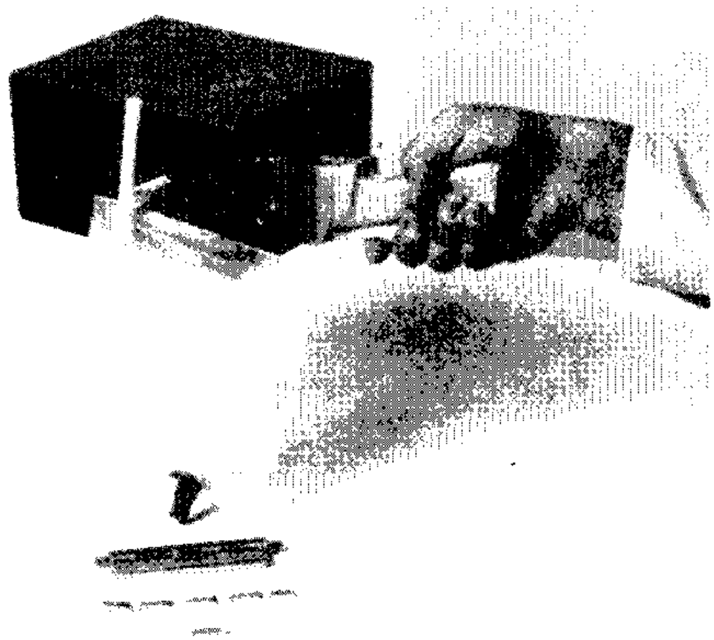

Fig. 24 - Intoximeter field (breath collection crimper)

REMOTE COLLECTION DEVICES

DEVICE	MANUFACTURER
1. ACCUTUBE	HINE LABORATORIES, INC. SAN FRANCISCO, CALIFORNIA
2. BREATHALYZER COLLECTION UNIT	STEPHENSON COMPANY RED BANK, NEW JERSEY
3. INTOXIMETER FIELD CRIMPER	INTOXIMETERS, INC. ST. LOUIS, MISSOURI
4. MINI MOBAT SM-7 SOBER METER	LUCKY LABORATORIES, INC. SAN BERNADINO, CALIFORNIA

Figure 25

Roadside collection devices capture a breath sample in one of two ways, either directly as a volume of breath in a special container or by absorption of the alcohol in the sample with silica gel which is later driven off by heat and then introduced to a gas chromatograph.

Screening, evidential and roadside collection devices are applications of breath test technology currently employed in alcohol-traffic law enforcement. Three other classes of instruments -- passive breath testers, educational testers and alcohol safety interlocks -- are presently in the conceptual or prototype research phase.

PASSIVE BREATH TESTERS

Passive breath testing is a concept currently under development at the Department of Transportation and elsewhere that would preclude the constitutional objections of self incrimination now raised with pre-arrest screening breath testing. Operationally, a passive breath tester or "sniffer" would function as a qualitative breath-alcohol sensing device to inform the police officer merely that alcohol is present on a driver's breath. No quantitative indication of BAC would be given and such a test would not require driver cooperation to administer. Such a determination would serve much the same purpose as the standard psychomotor tests of the officer's smelling alcohol on the breath in the establishment of probable cause for making a DWI arrest. After placing a subject under arrest the officer would then administer a post-arrest roadside or station-house evidential breath test to determine the actual BAC, perhaps to add a further charge under an illegal per se law. A variant of this procedure might include usage of a post-arrest screening device subsequent to the "sniffer" test to ensure transportation to the station-house for an evidential test was warranted.

There are obvious technical difficulties with such a concept as qualitative passive breath testing; a chief one being the problem of alcohol specificity. Such a device would have to be capable of distinguishing ethanol on the breath from other environmental or ambient fumes such as gasoline, perfume or after shaves.

Research is now underway at our Transportation Systems Center in Boston to assess the various environmental parameters relevant to passive breath testing. Preliminary indications are that technologically such a device with appropriate specificity can be designed and it is expected that a prototype device will be available by 1975. Investigations into the feasibility of quantitative passive breath measurement are also underway, however, the current prognosis for an operational quantitative "sniffer" are not as optimistic as for the qualitative design.

Educational Testers - Experience from NHTSA's Alcohol Safety Action Program (ASAP) has accentuated the need for a fifth class breath measurement device - educational self testers. It is well known in the field of alcohol and traffic safety that surprisingly few individuals "know their limit" or the amount of alcohol they can consume and still drive safely. It is envisioned that self testers might take two forms, very low cost individual disposable devices that could be distributed by schools, bars, liquor stores, community agencies, etc., in connection with alcohol countermeasure public information campaigns and reusable (possibly coin-operated) self breath testers that could be installed in bars, clubs or for other public establishments.

The chemical reagent type of screening breath testers have been used as individual self testers in connection with the NHTSA Alcohol Safety Action Program but in their present form are too expensive for widespread distribution.

ALCOHOL SAFETY INTERLOCK SYSTEMS

The remaining category of breath measurement instruments to be discussed are the Alcohol Safety Interlock Systems (ASIS) which are devices installed as part of the automobile ignition system that preclude operation by the intoxicated driver. In concept, the ASIS would be installed only in the vehicles of multiple DWI offenders after suitable judicial review of each case.

The need for a device such as the interlock system is continually re-emphasized by figures indicating as many as 2/3 or more of those drivers with revoked licenses continuing to drive. Quite apparently, revoking a person's drivers license and the penalties for driving without one are little deterrence to these problem drivers, many of whom are problem drinking drivers.

Alcohol Safety Interlock Systems are now in the prototype development and review stage. Two basic ASIS designs have emerged - breath testing and performance interlocks. Many readers may be familiar with one of the latter types, the "Phytester" developed by General Motors, which has been the subject of recent press reports.

The breath test interlocks are simply electronic breath testers introduced to the ignition system which require the driver to provide a breath sample before starting the car. The particular BAC operating threshold level would be determined by State or local ordinances.

The performance interlocks on the other hand involve a variety of types of tests to screen drivers. Alcohol on the breath is not measured directly; rather, decrement in reaction time, short-term memory or tracking type tasks are used as surrogate measures to detect impairment.

Prototype testing at the Transportation Systems Center has shown the breath test ASIS units to be highly reliable in terms of distinguishing drivers at BACs above the legal limit but currently require too frequent calibration. Certain performance tester designs, however, have demonstrated good test/re-test reliability but do not adequately distinguish between impaired and non-impaired drivers. At the present time, Alcohol Safety Interlock Systems require much more development and testing before an operational concept and reliable hardware are obtained.

NHTSA BREATH MEASUREMENT INSTRUMENTATION STANDARDS PROGRAM

Mentioned previously were the three basic programmatic responsibilities of NHTSA in the breath measurement-traffic law enforcement area: to develop, to evaluate, and to implement new concepts and technology. As a result of our efforts towards meeting these responsibilities, there has been the proliferation of new breath measurement devices outlined in this paper. Officials from State and local governments requested guidance from NHTSA in making purchases of such breath testing equipment; court developments have highlighted the importance of its accuracy; and the continuing use of Federal funds for purchasing breath testing equipment makes it important to ensure effective expenditure of these funds. To meet these needs the NHTSA has initiated a program to develop design and performance standards for breath alcohol measurement instrumentation.

At the present time, the three standards, listed in Figure 26, dealing with Evidential Breath Testers, Screening Breath Testers or Breath Tester Calibration Units, have either been issued or are under development.

NHTSA BREATH MEASUREMENT INSTRUMENTATION STANDARDS PROGRAM

- EVIDENTIAL BREATH TESTER STANDARD
- BREATH TESTER CALIBRATION UNIT STANDARD
- SCREENING BREATH TESTER STANDARD

Fig. 26 - NHTSA breath measurement instrumentation standards program

Development of these standards is the responsibility of the National Bureau of Standards with the input and cooperation of the National Safety Council Committee on Alcohol and Drugs, equipment manufacturers, and other experts in the field with final review by NHTSA.

Once a standard is promulgated, manufacturers are invited to submit their equipment for testing at our

Transportation Systems Center. Those devices meeting the standards' specifications are then placed on a Qualified Products List and are eligible for purchase with Federal funds.

SUMMARY

In review, it is evident that the 1970's have been years of accelerated activity in the field of breath measurement and highway safety. At the Federal level a number of programs have been initiated in this area. Rapid development of new concepts and instrumentation was begun and is continuing. Modifications and additions to the alcohol-traffic safety law has reflected technological changes.

With the availability of these new breath test laws and the increasingly accurate and effective breath test equipment, the tools to reduce the causal role of alcohol in highway death and injury are at our disposal. It is now our job to see that they are effectively employed.

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