Professor Robert F. Borkenstein — An Appreciation of His Life and Work

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ABSTRACT: Few men have made such a significant and sustained contribution to their chosen field of endeavor as Robert F. Borckenstein. He is an international forensic science celebrity, highly respected by his peers. The two most well-known products of his brilliance are the Breathalyzer, invented in 1954, and the “Grand Rapids Study”, a seminal work which established the relative risk of being involved in a traffic accident with various blood alcohol concentrations. In addition to his significant scientific achievements, he is greatly admired for his personal qualities, acute wit and total commitment to the cause of traffic safety. This article is a brief review and appreciation of his life and his many accomplishments.

Key Words: Borckenstein, Breathalyzer, drinking/driving, police education, traffic safety.

INTRODUCTION

In a 1985 paper, Professor Robert F. Borckenstein wrote about a former colleague:

“It is interesting just how much influence one person can have on a field. Just as Widmark was a “one man army” in Sweden, a young American physician, Dr. Herman Heise, became a similar one man army in North America.” [14]

No words could better summarize Bob Borckenstein’s influence on his chosen field of endeavor than his own words, as used to describe Dr. Heise.

Recently, Dr. Herbert M. Simpson, President and CEO of the Traffic Injury Research Foundation in Ottawa and a longtime colleague of Professor Borckenstein, wrote the following about his friend:

“When most people in traffic safety hear the name Bob Borckenstein, they immediately think of the Breathalyzer. Some also recall his landmark study in Grand Rapids, Michigan in the 1960s, which provided real-world evidence of the risk of collision associated with different BACs (blood alcohol concentrations). This research was influential in that area and is still widely quoted today. A few others think of Bob in the context of the International Council on Alcohol, Drugs and Traffic Safety, the organization he co-founded 50 years ago, which has fostered research cooperation and information sharing around the world.”

“Those of us who know him personally think well beyond those impressive achievements. As someone who has known Bob for 20 years, I immediately think of two prominent attributes. The first of these is his genuine dedication and intellectual commitment to the field of alcohol, drugs and traffic safety. He has never been content to rest on his accomplishments, always looking for new issues and insights. The second attribute that impressed me is the scope of his thinking. He has never been content to think about the problem in traditional ways; he is always open to new perspectives.” [22]

“Genuine dedication”, “intellectual commitment” and “innovative thinker” are perceptive summaries of Robert F. Borckenstein’s professional persona but there is much more to him than that. His friend and collaborator for over fifty years, Professor Kurt Dubowski, an international scientific celebrity in his own right, describes Bob thus:

“... a superb career-long teacher and mentor to thousands of students at all levels, a talented and highly successful (rare!) inventor, an inveterate world traveler (to all five continents, I believe), a world class researcher (whose major opus, the Grand Rapids Study, is still being cited, debated, and repeated after more than 35 years), an innovator and a highly effective, devoted and generous leader and official of many professional organizations (two of which he reorganized repeatedly — the Committee on Alcohol and Other Drugs of the National Safety Council, and the International Council on Alcohol, Drugs and Traffic Safety — very probably keeping them alive and productive through his stewardship and contributions.).” [22]

These summaries by two such distinguished researchers form an appropriate preface to this appreciation of the life and work of another. While essential biographical details will be included, most of this review will consist of an appreciation of the significant accomplishments of a remarkable individual who has actually become a legend in his own time. If Bob Borckenstein is not truly a genius, he is certainly the closest to it that most of us will ever have the privilege to meet.
I. BIOGRAPHICAL INFORMATION

Robert Borkenstein is a prime example of the sort of person who has achieved greatness from relatively humble beginnings. He was born in Fort Wayne, Indiana on August 31st, 1912. Bob’s grandparents were German speaking and, while he spoke both languages when he entered grade school in Fort Wayne, he was actually more comfortable in German (some of his papers in later life were published in German). Bob finished high school just at the onset of the Depression and, as a result, was unable to go on to college. He had, however, developed great interest and considerable skill in the rapidly developing field of photography and therefore, in the early thirties, worked as a photographic technician in Fort Wayne. This involved leaving home very early in the morning, picking up film to be developed from a variety of locations and businesses, returning to the studio/laboratory to develop the photos and then returning the finished product to the clients later the same day. The resultant long days nourished the incredible work ethic which has persisted throughout his career. The income from this work was essential to the family since, during the Depression, funds were scarce. Bob remembers buying coal by the wheelbarrow load to heat the home since that was all the family could afford at any one time [35].

Borkenstein’s father, although lacking in much formal education, had the same inventive mind that Bob subsequently demonstrated. He became a successful building contractor who built several well-known buildings in Fort Wayne and served on the City Council [23]. As Bob was growing up, he and his father worked together on many projects. During his high school days, Bob and some of his friends built a robot which, although crude by today’s standards, was remarkable for its time — and actually worked [35].

During his career as a photographic technician, Bob experimented with color film (at a time before Kodak marketed it) and developed considerable expertise which served him well in his later work [22]. Indeed, according to an article in the Indianapolis Star in 1940 [2], in collaboration with a colleague, he “developed a simplified color printing process which eliminates the black printing plate, which has a tendency to dull color brilliance.” This process eliminated several steps in the engraving of color printing plates resulting in quicker production and higher fidelity. During this time, Bob also built two color cameras of his own using an optical system similar to the Technicolor camera, demonstrating the creative and technical skills that were to mark him as a special person during his entire career.

From 1936 to 1958, he served the people of Indiana in the Indiana State Police (ISP) Laboratory, about which more will be described later.

In 1942/43, Bob also used his photography and color skills to develop the Borkenstein Color Comparator for the inspection of precision parts using color discrimination. This was produced by Rex Laboratories in Indianapolis, the same organization that later manufactured the early Breathalyzers. In a 1997 letter to Lord Bramall at the American Air Museum in Britain [16] (Bob had received a personal invitation from the Queen to attend a ceremony at the US Air Force Cemetery in Cambridge where she was unveiling a memorial [28]), Bob described a wartime application of this device:

“I was approached by a firm which was producing bomb latches intended to hold bombs in the bays until they were released when the aircraft had reached their targets. There were numerous failures because of the lack of the necessary precision. They were spot-inspecting the stampings for quality. This was slow and difficult because of the 50x magnification required and the effects of even the slightest vibration. I introduced color (both actual and afterimage) into a novel system that showed more at 10x magnification than the traditional comparator showed at 50x. Moreover, it was rapid enough that every piece could be inspected. So I feel I had a small role in the success of these missions.”

The comparator was patented in Bob’s name and the patent “was donated to the cause.” [16]

Although never hampered in his work by his lack of advanced academic qualifications, Bob’s continuing thirst for knowledge drove him to gradually accumulate science and foreign language credits at the Indiana University (IU) Extension Center in Indianapolis. He finally received his AB degree from IU in 1958, the year he retired from the ISP and joined the faculty at IU as Chairman of the Department of Police Administration. It is remarkable, and a tribute to the outstanding abilities and character of Robert Borkenstein, that he was a pioneering director of a major forensic science laboratory for twenty years and invented the most widely ever used breath testing instrument, without any formal academic background in science. Further, he became chairman of a department in an outstanding university while only recently having obtained a bachelor’s degree from that very university. These unprecedented achievements were capped with the award of an Honorary Doctor of Science degree by Wittenberg University in 1963 and, the one of which he is most proud, an Honorary LL.D. from IU in 1987. The latter is something virtually unheard of for members of the IU faculty itself [22].

During his long career, Bob has been an active con-
tributor to many professional associations including: Indiana University Society for Advanced Study, Indiana University Transportation Research Center, American Academy of Forensic Sciences, Harvard Associates in Police Science, International Association of Chiefs of Police, Academy of Criminal Justice Sciences, Alliance for Traffic Safety, American Public Health Association, National Safety Council and, the two in which his leadership was most pronounced, the International Council on Alcohol, Drugs and Traffic Safety and the Committee on Alcohol and Other Drugs of the National Safety Council which he joined in 1939.

Prof. Borkenstein has published approximately fifty papers, in both English and German, in various international journals. Most, but not all, have dealt with some aspect of alcohol and traffic safety.

In 1938, shortly after moving from Fort Wayne to Indianapolis and the ISP Laboratory, Bob married Marjorie, his best friend and strongest supporter for sixty years until her death in December 1998.

II. THE LABORATORY DIRECTOR

Bob’s photographic skills, combined with his fundamental analytical and creative ability, prompted some friends who were members of the ISP to seek his advice and assistance with their investigations in 1935. He spent many long weekends helping his friends in the investigation of traffic accidents and other incidents but, at that time, had no intention of getting into police work on a full-time basis.

As a result of this experience, however, in 1936 when the ISP decided to establish “The Indiana State Police Criminological Laboratory” in the basement of the State Capitol building, Borkenstein was a natural to be looked to for advice during the developmental stages. This was one of the first forensic laboratories in the United States. After the laboratory was actually in operation in Indianapolis, Bob was literally drafted to become a member of the staff, initially as a civilian clerk because he did not meet the minimum height requirements for a trooper [23]. His importance to the ISP became such that eventually the height requirements were waived and he became successively a corporal, sergeant, lieutenant and, eventually, captain [19].

Bob did not have any intention of making law enforcement a career and planned to return to his first love, photography, as soon as the Laboratory was running smoothly. As is so often the case with young people’s ideas, however, the plan to move on to other endeavors never reached fruition. He recognized early on the great potential of the forensic sciences and that this potential needed to be exploited, so he stayed on until retirement as captain in charge of Laboratory Services in 1958 [32].

During his career in the Laboratory, in addition to his innovations in breath testing for alcohol (which will be described below), Bob was a leader in advancing the use of photography, particularly color photography, in law enforcement. He designed and built small labs for photo and fingerprint development in many of the ISP posts. More remarkably, he actually built 300 4 x 5 cameras (at a cost of $35.00 each) to equip these facilities [6]. Bob Conley, the current Commander of the ISP Laboratory Division, describes these as the “Rex 4 x 5’s” [19], a further indication of Borkenstein’s confidence in the Rex Company.

During his career in the ISP, Bob also worked with John Larson on the development of the polygraph and, in 1957, published with Larson a paper on “The Clinical Team Approach to Lie Detection” [7]. Bob also made significant contributions to the evaluation and improvement of the first major electronic speed measurement device in traffic law enforcement [1].

Figure 1. A younger Bob Borkenstein.
III. THE INVENTOR

A. Early Work on Breath Tests for Alcohol

The observation that small amounts of alcohol were excreted in breath was reported by Anstie as early as 1874 [3]. Cushny subsequently reported, based on his work with cats, that:

"The exhalation of volatile substances (including alcohol) from the lungs is exactly analogous to their evaporation from solutions in water, and the pulmonary cells seem to be purely passive in the process." [20]

His observation that these substances obeyed Henry's Law established that the concentration of alcohol in blood could be predicted from the concentration in the alveolar air. Another important milestone in the history of breath alcohol analysis appeared in a 1927 paper by Bogen. He collected expired breath in a football bladder and made an analysis for alcohol by passing two liters of this breath through a solution of potassium dichromate in sulfuric acid. Bogen reported that:

"... as soon as the disturbing factor of alcoholic liquor still in the mouth is removed, which occurs usually within fifteen minutes after imbibition, in the absence of hiccuping or belching, the alcoholic content of 2 litres of expired air is a little greater than that of 1 cc. of urine." Further, "... the alcoholic content of these excretions (urine and breath) may also be determined for the purpose of evaluating the degree of alcoholic intoxication." [5]

Shortly thereafter followed the most substantive work of the early years of breath testing, a major publication by Liljestrand and Linde in 1930 [34] showing that the time courses in the body of breath alcohol concentration (BrAC) and blood alcohol concentration (BAC) were similar and that 1 cc of blood contained as much alcohol as is contained in 2 liters of air at 31 °C. For a detailed review of the history of the development of breath and blood testing for alcohol, the reader is referred to a publication by Wayne Jones [30].

Figure 2. Early breath testing devices. Clockwise from top right: Breathalyzer (Rex model), Alcometer, Photoelectric Intoximeter, Drunkometer, Intoximeter.
Although much of the basic research on alcohol and its measurement had occurred in Europe, little further happened there with respect to the development of breath testing after Liljestrand and Linde’s work. The construction of compact and practical breath alcohol instruments suitable for use by the police was not considered feasible at that time, therefore it was left to the United States to pursue further developments. The idea of developing a practical instrument for breath alcohol analysis came in 1931 from Professor Rolla N. Harger at the Medical School of Indiana University. Research on chemical tests for intoxication had begun to gather momentum during the late 1930s as a result of the work of Heise and others which demonstrated that excessive drinking was a major cause of road-traffic accidents. The end of prohibition in the USA in 1933 had undoubtedly contributed to this [14].

Breath alcohol testing became a major focus of interest, in part because of the practical problems associated with sampling blood for law enforcement purposes, not the least of which was its inherent intrusive nature. Other problems included the difficulty in locating physicians or other medical personnel willing to draw blood, often in the middle of the night; the need to transport the subject to that location; the requirements for the preservation of the sample and maintaining the chain of custody until the analysis could be performed; the necessity of having a qualified laboratory perform the analysis and, of major importance, the delay in the results of the analysis being available to the investigator. A device that would permit a properly trained police officer to obtain reliable results using a sample of breath overcame many of these difficulties and thus was very attractive.

The first practical instrument intended for use by the police for breath alcohol analysis was the Drunkometer developed by Prof. Harger in 1938 [26]. It was quickly followed, in 1941, by the Intoximeter [29] and the Alcometer [24]. The Drunkometer used a sample of mixed expired breath collected in a balloon; this breath was then passed through a dilute solution of potassium permanganate in sulfuric acid until the color was removed. This required a fixed quantity of ethyl alcohol, 0.169 mg. The approximate volume of breath required to reach this end point was determined by direct water displacement which provided a preliminary rapid semiquantitative screening test. For quantitative results, the volume of breath required to decolorize the permanganate was passed through a tube of Ascarite to remove the CO₂. This tube was then weighed in a laboratory and the amount of CO₂ determined. The weight of the alcohol accompanying 190 mg of CO₂ in the breath was considered to be “very nearly equal to the weight of the alcohol in 1 cc. of the subject’s blood” [26].

In 1937, looking for practical input into the development and application of his new invention, it was natural that Prof. Harger requested the assistance of the ISP Lab to field-test the prototype Drunkometer. This was Bob Borkenstein’s introduction to breath testing and the beginning of a long professional association of two great minds. Together, in 1937/38, they established a 44-hour lecture and laboratory course for the training of Drunkometer operators. Because the operation of the Drunkometer was quite subjective, carelessness could not be tolerated so they also set up a statewide system of field supervision and retraining [13]. While perhaps not directly related, it is also not surprising that the first law in the USA defining driving under the influence of alcohol in terms of blood alcohol concentration was passed in 1939 in Indiana [13].

B. Development of the Breathalyzer

As noted above, the Drunkometer, while deserving of great credit as the “first”, was somewhat complicated and, not surprisingly, the reliability of it and the other first generation breath test devices was frequently challenged. Borkenstein accepted the validity of some of these challenges and, based on this background, developed the Breathalyzer, the first of the “second generation” of breath testing instruments. This device represented a significant improvement over the earlier ones and incorporated several unique features. It was compact, robust, easy to operate and, of greatest importance, gave very reliable results. The Breathalyzer was destined to change the approach of law enforcement to drinking-and-driving problems nationwide. This technological innovation enabled traffic enforcement authorities to determine and quantify blood alcohol concentrations with sufficient accuracy to meet the demands of courtroom evidence and with an immediacy that dramatically increased the ability of the police to respond quickly to potentially dangerous traffic situations.

In an interview with a writer for the IU Alumni magazine in 1988, Borkenstein recalled:

“The Breathalyzer came out of all this because I became so very discouraged with the whole problem. An invention is not just an idea; it’s an idea to fill a need or an anticipated need. Here was a tool that was needed. It was my interest in photography that led to the Breathalyzer. In color photography work, I had developed a number of instruments for measuring light and had developed a densiometer to make the methods more exact. I drew on these same basic principles to create an instrument that would be extremely stable and objective in measuring body alcohol.” He went on: “The Breathalyzer is so amazingly simple - two photo cells, two filters, a device for collecting a breath sample, about six wires. That’s about all that’s in it. I left out every nut, bolt, screw and wire that was not important. The strength of the Breathalyzer is its innate stability. It requires less skill
on the part of the operator, and its life expectancy is unlimited. There's nothing to wear out. The Breathalyzer is so simple and direct that it will be hard to kill.” [40]

Although it has now been replaced in most jurisdictions by more recently developed instruments, the fact that the Breathalyzer is still in use in some jurisdictions, forty-five years after its invention, confirms Bob’s prediction of its persistence!

Borkenstein had been thinking about the device for a long time, but it took only about two weeks, his annual ISP vacation, to build a working model in the small, partially dirt-floored basement of his Indianapolis home in February 1954. The prototype Breathalyzer was contained in a wooden case with a sample chamber made from a 100 mL glass syringe and a cut-off portion of the plunger as the piston. Bill Picton, formerly with the RCMP Laboratory in Edmonton, Alberta recalls visiting this “workshop” and being amazed at the almost primitive nature of the facility in which such an important invention had been conceived:

“Bob Borkenstein showed that it was the forensic scientist and not the facilities that count.” [39]

The first public demonstration of the Breathalyzer was in October 1954 at the National Safety Congress in Chicago. This was described by George Larsen Jr. in Traffic Digest and Review:

Lucas • Borkenstein Biography
"A new and significantly improved and simplified method of using breath to determine the degree of alcoholic influence was demonstrated last month before the Committee on Tests for Intoxication of the National Safety Council at the National Safety Congress in Chicago. Both the method and a lightweight compact device for using the method were developed by Lt. Robert F. Borkenstein, chief technician of the Indiana State Police and director of the ISP crime laboratory. Tests run by Lieutenant Borkenstein under varying conditions, many of which were observed by this writer, have given highly uniform results. In addition, other experts in the field such as Dr. R.N. Harger of the Indiana University School of Medicine and Dr. Ward Smith of the University of Toronto have run large numbers of tests with excellent results, according to reports they made to the Committee." [33]

Six prototype units were built based on the original model. These were field tested by various workers in the USA and Canada including Kurt Dubowski (at that time the first State Criminalist of the State of Iowa), Lloyd Shupe (of the Columbus, Ohio PD Laboratory) and Ward Smith (at the University of Toronto). After incorporating and testing their suggestions, 100 instruments were built. These quickly found their way into practical police and courtroom use in many parts of the United States and in Canada. The first commercially-built instrument went to Grand Rapids, Michigan, and the second and third to the Province of Ontario in Canada [13].

C. The Design

Despite this considerable activity in the mid-fifties, it is interesting that a formal publication about the Breathalyzer did not appear in the peer-reviewed scientific literature until 1961 [8]. In addition to being so busy with this and other projects, one of the reasons for this delay was Borkenstein’s hesitancy to publish since, as already described, he had minimal academic qualifications in science, particularly chemical analysis and very limited experience in the preparation of a scientific paper. Bob finally was persuaded by his friends of the need to document his invention in the literature so he turned to Ward Smith to assist him with the preparation of the manuscript. By 1961, the Breathalyzer had been in use by the police in Ontario (under Smith’s leadership) since 1956 so there was practical operational experience available to support the technical data in the paper.

The paper describes the unique and innovative features that were incorporated into Borkenstein’s design and which accounted for the Breathalyzer’s wide acceptance, not only as a tool for law enforcement but also in scientific research.

1. The Sampling Device

Most of the earlier devices relied on mixed expired air and required an estimation of the proportion of alveolar air based on the CO₂ content. The sample in the Breathalyzer is collected using a modification of Haldane’s method [25]. The breath is led into a stainless steel cylinder where it causes a piston to rise until it is above the level of two vent holes. As long as the subject blows until, at the end of an expiration, the piston drops to close the two vents thus capturing a fixed volume of the last portion of an expiration ("end-expiratory air"). The volume collected is equivalent to 52.5 mL at 34°C. (In Ref. [8], Borkenstein and Smith used a temperature of 31°C as "the temperature at which the breath leaves the mouth". This was the temperature reported by Liljestrand and Linde [34] in 1930 but later work by others confirmed 34°C as the more acceptable figure for this temperature.) This volume (52.5 mL) is 1/40th of 2100 mL and thus equivalent to 1/40th mL or 25 µL of blood. It was determined to be a sufficient volume to contain enough alcohol for an accurate determination and yet small enough to ensure uniform sampling of something approaching alveolar air. In Borkenstein’s original design, 100 mL was collected using a 100 mL glass syringe but he eventually became convinced that a smaller sample was practical and the final prototype had a vent slot cut in the 100 mL syringe at the appropriate level. (Because the 100 mL syringes broke quite regularly during this experimentation phase, their cost almost aborted the project prematurely) [22].

2. The Reagent

Using a very simple valve arrangement, the breath sample is passed through a glass ampule containing acid dichromate, a common reagent for alcohol analysis. The ampule serves not only as a container for the reagent but also as the fixed length light path for the subsequent photometric measurement. One of the modifications made after the prototype was examined by Bob’s colleagues was the concentration of the reagent. The original concentration, which was based on Heise’s and others’ work with blood and urine samples, was too strong for the very small amounts of alcohol in a breath sample. (It must be remembered that Borkenstein’s expertise was based on his background in photography, not chemistry. He was comfortable with color, filters and photocells but not chemical stoichiometry.) Dubowski calculated a more appropriate concentration of 0.025% potassium dichromate in 50% sulfuric acid [22].

In the early Breathalyzers, the reagent was heated to 50°C using an automobile cigarette lighter unit but eventually a silver nitrate catalyst was added to the reagent and the heater was no longer necessary [22, 40]. Under
these conditions, the alcohol is quantitatively oxidized to acetic acid within 90 seconds. While many compounds may react with dichromate if introduced directly into the solution, when the sample is breath from a living person, considerable "biological specificity" is imparted to it. The analytical conditions (reagent concentration, temperature and time) also provide some specificity. Acetone, one of the chemicals that may be found on the breath of some living persons, does not react under these conditions. The reading for ethyl alcohol remains virtually constant after the usual 90 seconds. If methyl alcohol is present, a second reading at the end of 10 minutes will have changed significantly from the first. In the early days, when many small hospitals in rural areas had minimal laboratory facilities, it was not unknown for them to request a Breathalyzer-equipped police officer to assist with the diagnosis of patients suffering from possible methyl alcohol-induced intoxication.

3. The Photometer
The most unique design feature of the Breathalyzer is its photometric arrangement using a visible light incandescent source (an automobile light bulb) on a moveable carriage between two similar ampules (one "test" and one "reference"), two blue filters and two photocells wired in opposition through a simple galvanometer. The reaction between the acid dichromate and alcohol causes a quantitative decrease in the yellow color of the reagent and therefore, in accordance with the Beer-Lambert Law, a logarithmic increase in the blue light transmittance. If only one reagent cuvette, filter and photocell had been used (a conventional arrangement), the increments on the BAC scale would have had to be logarithmic as well.

Of greater importance, it would also have been necessary to use a potassium dichromate solution of exact, known strength. This would have presented a production quality control challenge because of the very weak

Figure 4. Captain Borkenstein explaining the Breathalyzer photometer arrangement to a class.
solutions of potassium dichromate necessary to make the instrument sufficiently sensitive for the small amounts of alcohol actually being measured in a breath sample. With the photometric system in the Breathalyzer, the change in transmittance of the "Test" solution is measured by the distance through which the light source must be moved to re-establish a null condition in the photoelectric circuit (the so-called Bunsen Principle [22].) This movement is automatically expressed in blood alcohol units (‰/v) on the instrument scale by a pointer driven across the BAC scale by the movement of the lamp carriage. Because the galvanometer is always electrically and mechanically "null" when readings are taken, indicating that the two photocells are receiving identical amounts of light through the ampules and filters, the actual difference between the ampules is determined by the position of the light required to attain this condition. Thus the intensity of the light source, its age, or changes in line voltage do not affect the results.

The photometric arrangement of the Breathalyzer also makes the scale reading virtually independent of the concentration of dichromate. It thus allows for a "blank" test for possible contamination, a "standard" test of the calibration and tests of two or more samples of breath from the subject, all with the same ampule of reagent. Many users of the Breathalyzer incorporated these quality control checks into their operational protocols.

The linear BAC scale on the Breathalyzer was originally calibrated on a purely mathematical basis. The factors in this calibration were the volume of the sample, the relationship between the concentrations of alcohol in breath and blood (1/2, 100), the quantitative relationship of the reaction between alcohol and acid dichromate, and the optical and spatial relationship between the movement of the light and the position of the pointer. These calculations were subsequently tested during practical evaluations and found to be valid.

D. Commercial Production

While it had never been Borkenstein’s intention to patent his invention, he was persuaded by his friends and his attorney to do so. To pay the costs of this process he had to sell his dearly loved British sports car. The patent application was filed in 1954 and US, British, Canadian, Australian, Mexican, French and German patents were eventually obtained. The royalties were assigned to the Indiana University Foundation [32].

Commercial production of the Breathalyzer was first arranged with a small company in Indianapolis, Rex Metalcraft. Borkenstein was familiar with this company because they produced his Optical Comparator and also the metal cases for the Drunkometer [22]. Being located in Indianapolis, he was able to closely monitor the quality of their production. The actual manufacturing and distribution rights had been purchased by the Stephenson Corporation of Red Bank, NJ. Stephenson, a company which produced a variety of respiratory equipment, had also been the distributor of the Drunkometer. Although the early models of the Breathalyzer were manufactured by Rex, the Stephenson Corporation later turned to another company, Radio Frequency Laboratories in New Jersey, to redesign the electronic components of the Breathalyzer (with little or no input from Borkenstein). The resultant RFL model was produced for only a few years as it was quite unpopular with users because it was much more difficult to service than the original Rex model.

Stephenson responded to the complaints about the RFL units and, with Borkenstein’s substantial input, redesigned the Breathalyzer into the Model 800 which rapidly evolved into the Model 900. A 1969 modification of the galvanometer in the Model 900 to an electronic unit converted the 900 into the Model 900A. This also was done without Borkenstein’s advice and resulted in a brief furor in 1982 when an issue arose in the courts about the possibility of an effect on test results with the 900A as a
result of "radio frequency interference" (RFI). The amplification in the null meter of the 900A actually did result in fluctuations of the needle if a source of electromagnetic radiation (usually a police portable radio transmitter) was activated in very close proximity to a 900A. This effect was quite well known to users of the instruments and was easily compensated for in their operations or with minor modifications to the electronics of the instrument. Nevertheless, it did, for a brief period, slightly tarnish the reputation of the Breathalyzer.

When the Stephenson Corporation was purchased by the Bangor Punta Corporation in the late sixties, the Breathalyzer rights were assigned to one of its subsidiaries, Smith and Wesson (S & W). In addition to its engineering/manufacturing capability, S & W also had significant marketing contacts with the law enforcement community through their firearms and chemical crowd control agents sales. S & W designed, on their own, and marketed, briefly, the semi-automated Model 1000 Breathalyzer. They also worked closely with Borkenstein in the development of the Model 2000, a microprocessor-controlled unit which used infrared (IR) absorption as the alcohol measurement technique. Bob had started thinking about an IR unit in the early seventies and, although the Model 2000 was produced as a prototype in the early eighties, it was never marketed. Despite this, his interest in IR devices for breath testing persisted and he assisted his friend Werner Adrian with the development of a prototype IR breath alcohol analyzer which became the progenitor of the BAC Verifier and subsequently the BAC Datamaster [22].

S & W continued to manufacture the Breathalyzer until 1984 when the rights for the Models 900 and 900A were sold to National Dräger Corporation. (Rights to the Model 2000 were not included in this transaction) [4]. Dräger also worked closely with Bob in the late eighties/early nineties to develop the Model 900B, a semi-automated version of the 900A. It used the same sampling device, reagent and photometer arrangement as the Model 900A but incorporated a timer to turn on the light after 90 seconds, a microprocessor-controlled motor to drive the lamp carriage and an internal printer. It too was never marketed, primarily because the market had moved on to automated instruments that did not require the use of a chemical reagent.

Dräger continued to produce the Model 900A until late 1997. The final five instruments were sold in early 1999. In all, over 30,000 of the various models of the Breathalyzer were built and sold between 1955 and 1999, a remarkable record for any piece of equipment, particularly an analytical instrument. The Breathalyzer was, at one time, used in almost every state in the USA and Australia as well as every province in Canada (where it is still often referred to as "the Borkenstein" in the courts to differentiate it from other devices). Despite the introduction of third generation instruments in the early seventies, in 1985, 30 years after its introduction, the Breathalyzer was still being used in 24 states in the USA. Today (1999), 150 are still in use in New York, 950 in New Jersey and about 1500 in Canada [4]. It is difficult, if not impossible, to think of any item of equipment, other than the microscope, that has had such a prolonged and important role in forensic science. The Breathalyzer can surely be considered to law enforcement what the Douglas DC-3 has been to air transport.

E. The Breathalyzer in Research

The significant role of the Breathalyzer as a reliable tool for measurement of BAC was not restricted to law enforcement. It soon found its way into scientific research on the effects of alcohol on behavior. Research in this area had slowed considerably during World War II but the explosion in motor vehicle registration and use which followed in the late forties/early fifties brought with it a dramatic increase in highway fatalities and rekindled interest in drinking/driving research and legislation [14]. The fortuitous arrival on the scene of the Breathalyzer facilitated much of this research.

One of the early reports of such usage was a paper by Drew et al., "Effect of Small Doses of Alcohol on a Skill Resembling Driving" [21]. Although primarily dealing with the effect of alcohol on driving simulator tests, in this project Drew compared the results of the then existing breath methods with blood and urine tests and stated:

"The results from the Breathalyzer were good enough to warrant its consideration from a practical point of view."

This was a remarkable statement by investigators in a country that had theretofore viewed breath testing with skepticism, and it therefore attracted considerable attention in England and elsewhere.

The Breathalyzer was used in epidemiological studies by McCarrol and Haddon in New York City [36] and, of course, by Borkenstein himself in his massive Grand Rapids Study [10]. It was used in studies of the effect of alcohol on driving ability as measured by road tests by the Royal Canadian Mounted Police [18] and by Smith and Lucas in 1966 in the classic Canadian Television Network (CTV) television documentary "Point Zero Eight". Although unpublished in the conventional sense, this documentary had a major impact on legislation in Canada and copies of it became very widely used internationally in driver education courses.

Lucas • Borkenstein Biography
The Breathalyzer gave rise to a large body of literature concerned with its design, applications, limitations and characteristics. Studies have been done in Switzerland, Germany, Australia, France, Italy, and Canada, particularly in the late fifties and sixties. Countless correlation studies between Breathalyzer results and blood tests have been conducted. Some of these directly impacted on legislation in various countries. For example, in Australia a study was done in the Australian Capital Territory in 1969, details of which are included in a "Report on Breath Analysing Equipment for Drivers of Motor Vehicles". This report states:

"Having taken evidence from medical officers, scientists, police officers, and others experienced in the use of this equipment, the Committee is satisfied that the Breathalyzer is an accurate instrument providing a reliable method of measuring blood alcohol concentration in the human body."

This led to the adoption of the Breathalyzer as the only official instrument in the Australian Capitol Territory. Other Australian states followed this lead and the Breathalyzer became the standard instrument for law enforcement and court evidence in Australia for many years [13].

Similarly, in 1967/68 Canada's Parliament gave careful consideration to the Breathalyzer as a device which would make it practical to enact enforceable legislation establishing a 0.08% "legal limit" based primarily on mandatory breath testing. In a letter to Prof. Borkenstein at that time, Mr. P.J. Farmer of the Canada Safety Council stated:

"The outcome of much soul-searching was that the Parliamentary Committee agreed that the provision of breath samples was neither an invasion of privacy nor self-incrimination. This and the fact that the Breathalyzer was considered reliable and the simplest way to measure blood alcohol content pretty much dictated that the .08 (%) legislation be tied to breath testing for legal determination of blood alcohol content." [13]

In fact, the Canadian legislation enacted in 1969 was widely referred to as "The Breathalyzer Law" and a large legal reference book is entitled *Breathalyzer Law in Canada* [37].

A sidelight to the legislation in Canada is that it includes a clause requiring the police to offer to collect a sample of breath for the use of the defendant before they can demand a breath test for evidential purposes. This
clause was based on work that Borkenstein was doing in the mid-sixties on a method for collecting the alcohol from a sample of breath for later analysis and which, it was believed, was nearing perfection. Bob had been working with tubes packed with calcium chloride (later calcium sulfate) as an adsorbent and in fact, with Dubowski, published a paper on this work in 1977 [11]. Problems with production of tubes that would meet his standards for quality persisted and the project never achieved commercial viability. The “sample for the accused” clause in the Canadian Criminal Code was therefore never proclaimed into force but the rest of the legislation, including the provisions for a demand by the police and a “per se” limit of 0.08%, was. The clause is still there thirty years later, passed but unproclaimed, like a ticking time bomb, waiting for an acceptable practical method for its application.

Typical of activity in the various states in the USA, W.E. Smith of California, published a paper in 1969, "Breathalyzer Experience under the Operational Conditions Recommended by the California Association of Criminalists". In it he said:

"It is concluded that the Breathalyzer meets the standards of good law enforcement when operated in accordance with the operational disciplines recommended by the California Association of Criminalists."

Similar statements have emanated from many other states in the USA and the Breathalyzer was one of the first instruments to be placed on the 1974 Approved Products List issued by the National Highway Traffic Safety Administration of the Department of Transportation. [13]

F. The Breathalyzer and the Law

There have been hundreds of appellate court decisions bearing directly on the Breathalyzer. None were successful in attacking the scientific analytical principles on which it is based. Reversals have, of course, occurred but based on improper use or on circumstances such as untrained operators, lack of evidence of the quality of the solution in the ampules, lack of evidence of allowing sufficient time for mouth alcohol to disappear, civil liberties issues, and biological variables. Suffice it to say, the Breathalyzer has weathered almost half a century of scrutiny by law, medicine and science and has survived, paving the way for later generations of equipment.

One of the major challenges occurred in 1989 in State v. Downie in New Jersey. This case concerned the reliability of the Breathalyzer and particularly its reliance on the 1/2100 breath/blood ratio to convert the BrAC to the BAC. Bob marshalled an impressive array of expert witnesses, of whom he was the most persuasive, to present data in support of the Breathalyzer. The court ruled in favor of the use of the Breathalyzer in law enforcement and there have been few significant challenges since. Boris Moczula, one of the prosecutors in the case, described his first contact with Prof. Borkenstein as follows [38]:

“I had previously known him only by reputation. Influenced by his status as a giant in the forensic scientific community, I expected to meet a man of imposing physical size. How surprising to find such a diminutive individual, with the ever-present sparkle in his eye.”

Prosecutor Moczula was also impressed (although it will come as no surprise to Bob’s friends) that the professor insisted on receiving no compensation for his testimony in order that no one could suggest that his testimony was influenced by anything other than the facts. He describes an example of Bob’s expertise as a witness:

“At a point in the litigation when defense attacks on the Breathalyzer’s components were particularly intense, Doctor Borkenstein offered this simple analogy as explanation and encouragement: ‘If we focus upon the individual parts of a bumblebee, no one would expect such a cumbersome insect to be airborne. Yet the bumblebee flies.’ Several months later, when I first notified him of the court’s favorable decision, I ended my correspondence with these same words: ‘The bumblebee flies.’” [38]

It has been said of Professor Borkenstein that, “He was not only one of the founding fathers of breath-alcohol testing but also the attending pediatrician” [31] and, by now perhaps its geriatrician.

IV. THE RESEARCHER

At a Symposium on Alcohol and Road Traffic conducted at Indiana University in 1958 and chaired by Prof. Borkenstein, a panel of seven distinguished international experts approved the following statement:

“As a result of the material presented at this Symposium, it is the opinion of this Committee that a BAC of 0.05% will definitely impair the driving ability of some individuals and, as the BAC increases, a progressively higher proportion of such individuals are so affected, until at a BAC of 0.10%, all individuals are definitely impaired.” [14]

This statement was soon endorsed by the National Safety Council, the American Medical Association, the International Association of Chiefs of Police and the Junior Bar Association, among others.

While immensely pleased with the fact that he was able to persuade such a panel of experts to agree on anything (the statement had required an all night session

Lucas • Borkenstein Biography
The Grand Rapids Study was a large-scale roadside survey designed to assess the risk of a driver being involved in an accident as a function of the BAC. The concentration of alcohol in blood was estimated indirectly by taking samples of breath at the roadside in special plastic bags for later analysis with the Breathalyzer. The BAC of the drivers involved in accidents was compared with a large control group of drivers passing the site of the accident on the same weekday and the same time of day as the accident group. In this way, the risk of being involved in an accident was plotted as a function of BAC. As later described by Borkenstein himself:

“...This study was designed to explode the monolith of the ‘drunken driver’ into as many components as practicable so that target groups could be identified. It was also designed to compare the alcohol factor to other factors involved in traffic accidents, or parametric to them. It was not originally designed to generate countermeasures or to estimate the relative risk of driving while intoxicated; however, the data by their nature suggest an exponentially increasing relative risk curve which was calculated from the data as an afterthought. This relative risk curve has been the basis of much controversy because of the under-representation of drinking drivers in accidents at 0.03% BAC. In spite of this, it has found its way into countless papers, books and educational material.” [12]

(The Grand Rapids Study is addressed in greater detail elsewhere in this volume.)

As principal investigator of the study, Bob demonstrated the wide scope of his detailed thought processes, his analytical mind and his innovative problem-solving ability. Not content to pick the most convenient site (Bloomington or perhaps Indianapolis), he researched and selected one which would meet his broad criteria and which would ensure the validity of the findings. Some of the factors involved in the selection of Grand Rapids were its size (large enough to have a sufficient sample of accidents for statistical validity), freedom from extreme seasonal population fluctuations, a good balance of heavy and light industry, commerce and educational institutions, a good accident records system and a progressive police department. In addition, and not inconsequentially, the population demographics closely reflected those of the entire nation.

Another matter which contributed to the significance of this research was the fact that it studied the role of alcohol not only in drivers who were involved in accidents, but also the involvement of drinking drivers at the same locations and in similar circumstances, who did not have accidents. The one, by itself, was not significant without the other.
Borkenstein also recognized the importance to the study of obtaining the cooperation of the drivers being interviewed. There were a number of sensitive areas in the questionnaire used for the interviews which required subjects to provide information of a personal nature. Bob identified another organization within his own university that had considerable experience with asking intimate questions of large numbers of people, the Kinsey Institute for Sex Research. Since, for some, “drunken” driving can have a stigma attached to it similar to that placed on socially unacceptable sexual practices, the Kinsey results suggested a risk that Borkenstein’s investigation might find drinking and driving to be acceptable behavior unless it was discussed seriously by the interviewees. Staff members of the Institute for Sex Research were therefore asked to train the members of the research team who would conduct the interviews in Grand Rapids. This training proved to be of immense value to them and thus to the study. [12]

The BAC “legal limit” of 0.08%, which has become so widely accepted internationally, was derived principally from the Grand Rapids Study which included other factors such as age, socioeconomic status and education that interact with alcohol as accident causation factors at concentrations below 0.08%. The study concluded, however, that this competition diminishes and appears to disappear as BACs exceed 0.08% [14]. The impact on public policy both in North America and in Europe is exemplified by events in England. In 1967, Barbara Castle, the Minister of Transport, while launching the Drink/ Drive publicity campaign associated with the new Road Safety Act of 1967, stated:

“In recent years research has further increased our knowledge of the effects of alcohol on drivers. The most important contribution was Professor Borkenstein’s study at Grand Rapids, Michigan, involving over 12,000 drivers. The results confirmed a good deal of earlier research, which by itself had remained inconclusive, and also gave more precise information than ever before about the increased accident risk at various blood-alcohol levels. Faced with the need to strengthen the law, and armed with this new scientific evidence, we decided that it would be right to lay down a blood-alcohol level above which it should be illegal to drive. The level has been set at 80 mg/100 ml (0.08% BAC) and to exceed it is to commit an offence.” [14]

Also in 1967, at the 17th meeting of the Council of Ministers of the European Conference of Ministers of Transport, it was resolved that the member countries adopt a BAC not higher than 0.08% in legislation [14]. Reference has already been made to Canada and Australia where legislation was very much influenced by the study. This policy has also found its way to several states in the United States, which have adopted a 0.08% BAC as the dividing point above which driving is prohibited by law.

The Grand Rapids Study has become a cornerstone of traffic alcohol control legislation in the United States and abroad, and in the highway safety standards of the US Department of Transportation.

V. THE PROFESSOR

Although the Breathalyzer and the Grand Rapids Study exemplify Bob’s outstanding abilities as an inventor and as a researcher, some would say his most impressive achievements were associated with his career as a teacher. Sharon Faville, who worked closely with Bob for sixteen years, describes him thus:

“... a compassionate, caring human being whose commitment to service assisted many young students and colleagues to develop their talents and careers. Teaching for Dr. B was both a passion and a mission. He challenged students to think independently and shared the analytical tools he used himself. He inspired creativity and critical thought. At a commencement address, he spoke to graduates about the ‘indissoluble residue’ they would take from their university experience: the process of learning to learn, of critical thought and investigation.” [23]

Robert Borkenstein’s initial association with IU occurred when he joined the ISP Laboratory. The ISP Academy was located in Bloomington and became affiliated with the University in 1936/37. It was the first police academy to be directly associated with a university, although the cadets were housed in tents during their stay. Lectures were held in the Chemistry Building auditorium. Because of his position in the Laboratory, Borkenstein had a close association with the police academy as a lecturer and, through this, with members of the faculty of the law school who also lectured at the Academy. In addition, the Laboratory occasionally required assistance from the IU Medical School in Indianapolis and so he developed associations with this faculty as well [1].

Eventually, the Academy courses evolved into university credit courses and a Department of Police Administration was established in the Faculty of Arts and Sciences. Several attempts were made to recruit Bob into this Department on a full-time basis but he resisted these efforts until 1958, when he retired from the ISP. The Associate Dean of Arts and Sciences was then finally able to persuade Bob to become an Associate Professor and Chairman of the Department of Police Administration. At that time, there were only two other similar programs in the USA, one at the University of California at Berkeley.
and the other at Michigan State University. Within a few years, Bob was promoted to full professor rank [32].

As the new Chairman of the Department, Borkenstein's initial goals were to strengthen the faculty, to attract better students and, perhaps most challenging, to persuade the University that this Department deserved to be based within the University. Eventually he succeeded but it took time. Prof. Borkenstein distinguished his Department's program from the Police Academy program by convincing the University that, while the Academy effectively taught the "how", his Department taught the "why". He insisted that the program become multidisciplinary, drawing on resources in psychology, political science, sociology, law, philosophy and other disciplines. The curriculum was thus knit into the entire fabric of Arts and Sciences. In 1970, the Department changed its name to "Department of Forensic Studies", and in 1985 it became the "Department of Criminal Justice" [32].

Eventually Prof. Borkenstein was also able to develop a Master's and finally a Ph.D program. The Department had developed from one of only three in the United States, in a very humble and simple beginning without much acceptance in the academic environment, to one that contributes significantly to the University and the community it serves.

Not content with having established a viable university department, Bob was very interested in ensuring that the resources of the Department were made available to the community. He therefore formed the Center for Studies of Law in Action ("law" and "action" are words not often used in the same phrase) as a means of collecting relevant information from the field and disseminating it to practitioners. The philosophy of the Center is to expose practitioners to academic developments while at the same time exposing faculty members to the real world from time to time to learn what problems they need to work on. For example, in one of its most successful programs, the Center brings qualified people from all over the country to Bloomington to learn the latest concepts in the supervision of programs for alcohol testing of drivers and the techniques that are used to carry out these tests. Resource people from around the world interact with these practitioners to try to develop solutions to a major societal problem. This course, established in 1958 as "Supervision of Chemical Tests for Alcohol" with eleven students, is now known as "the Robert F. Borkenstein Course on Alcohol, 

Figure 8. Receiving a Special Minister of Justice's Award from the Rt. Hon. Kim Campbell, Minister of Justice of Canada, Halifax 1992.
Drugs and Highway Safety: Testing, Research and Litigation". The May 1999 course had 43 students [35].

Boris Moczuła, following his association with Prof. Borkenstein in the Downie case, became one of the instructors in the course. He says about it:

"I would marvel at how class members scourred for the opportunity to speak to him (Borkenstein) or be photographed with him. He greatly enjoyed the interaction and unpretentiously honored all requests." [38]

In summary, Prof. Borkenstein converted the Department of Police Administration from a traditional police training program to a multi-disciplinary teaching, research and service center that rapidly achieved national prominence for its pioneering insistence on the integration of a liberal arts core into professional training in criminal justice. His vision established the department as one of the few in the field that is truly of university caliber, with emphasis on research and scholarship as well as teaching and service. Bob served as Chairman until 1971 and continued as a Professor in the Department until his retirement from the University in March, 1987. He continues to hold the position of Professor Emeritus and Director Emeritus of the Center for Studies of Law in Action.

VI. THE LAUREATE

For almost sixty years, Robert F. Borkenstein has been an international leader in the forensic sciences, criminal justice education, and traffic safety. His extensive research on highway safety has established this field as an area for scientific research as well as social concern, and he has served as a consultant in many countries around the world. Professor Borkenstein is most famous for his contributions to the understanding and control of alcohol impairment in traffic accidents, and his research and numerous publications on this subject are well known to the international forensic science and traffic law community. As might be expected, he has been the recipient of many awards and other honors. Among these are:

- The Liberty Bell Award from the Indiana Bar Association "for outstanding contribution to public understanding of the law", 1966;
- A Special Citation from the Ministry of the Interior of the Republic of China (Taiwan), 1970;
- The Distinguished Service to Traffic Safety Award of the National Safety Council, 1982;
- The Award of Merit of the Association for the Advancement of Automotive Medicine, 1982;
- A Distinguished Service Award in Recognition of Service to the State of Alaska, 1983;
- Induction into the Safety and Health Hall of Fame International, 1988;
- A Special Minister of Justice's Award, Government of Canada, 1992;
- The Gerin Medal of the International Association for Accident and Traffic Medicine, 1992;
- A Special Presidential Award of the International Council on Alcohol, Drugs and Traffic Safety, 1995;
- The National Association of Governors' Highway Safety Representatives Award, 1996.

While each of these is very special, Bob would probably acknowledge two others as being particularly close to his heart. These are the prestigious Widmark Award of the International Committee (now Council) on Alcohol, Drugs and Traffic Safety (ICADTS) awarded in Toronto in 1974, and the Robert F. Borkenstein Award established by the National Safety Council in recognition of his lifetime work in the area of alcohol and drugs in relation to traffic and transportation.

The Widmark Award was established in honor of Professor Erik M.P. Widmark of the University of Lund, Sweden, whose comprehensive research work during the first half of this century touched on all aspects of the pharmacology of alcohol and its quantitative estimation in body materials. He was the first person to apply the then contemporary knowledge to the problem of transportation safety. This award is the highest honor that the ICADTS can confer on individuals who have made outstanding contributions to the basic knowledge of alcohol and other mood-altering drugs and have applied it to traffic safety problems. Each laureate must have contributed significantly and must have achieved international recognition over a sustained period of many years. These are demanding criteria. The first recipient was Bob's colleague, Prof. Rolla Harger, in 1965. This award is so special to Bob because he was a founding member of the ICADTS, President of it from 1969 to 1986, and its driving force for over forty years. He chaired the Widmark Awards Committee from 1986 to 1992. Of Bob's importance to ICADTS, Dr. John Havard says:

"He is one of the few people I know who has won international fame and yet has found time, as he so often has, to encourage and to help young workers in his many fields of interest. There are a number of well-known figures working in the field of alcohol and road accidents today who owe their success to his insistence, as a long serving member and as President of ICADTS, that priority should be given to helping young workers and, in particular, to making it possible for them to participate in its international conferences." [38]

The Borkenstein award honors Bob's active participation in many of the activities of the National Safety Council for almost sixty years, including chairmanship of the Committee on Alcohol and Other Drugs. The first of these awards was presented to Prof. Borkenstein himself on October 26, 1989. It is a source of great pride to him that
his name is being used to honor the recipients, all of whom to date have been close colleagues and good friends and all of whom consider it to be one of their greatest honors because it is named after a person for whom they have enormous respect.

In addition to these formal awards, Bob has been honored by invitations to present papers to national and international conferences on law enforcement, traffic safety and forensic sciences in Austria, Australia, Canada, the Republic of China (Taiwan), England, Finland, France, Germany, The Netherlands, Puerto Rico, Sweden, Switzerland and New Zealand. He has served on the editorial boards of Alcohol, Drugs and Traffic Safety, Forensic Science Review, and Journal of Traffic Medicine as well as serving as a consulting editor for Blutalkohol.

VII. THE PERSON

All of the above outlines the truly outstanding contributions that Robert F. Borkenstein has made to his chosen profession and particularly to traffic safety. What it does not adequately describe, however, is the enormous impact of his person on friends, students, colleagues and associates. His mind is always working; many of his colleagues describe one of his outstanding characteristics as being that he is always working at a new project. His enthusiasm for these projects can be almost overwhelming. While discussing some of the activities of the Department of Criminal Justice as recently as 1996, he enthused:

"I'm excited about it, I'm really excited about the years to come" [32].

A journalist who interviewed Bob in 1988 described him thus:

"He is a reporter's dream. He automatically answers Who? What? When? Where? And How? It's as if he's methodically going through in his mind how the material should be presented and in what order—much like he must do when conducting an experiment or devising an invention." [40]

Although deeply committed to his work, Bob is not a "one note tune". He is equally at home in a snowball fight at his Divide, Colorado "cabin" as he is in the meeting rooms of international professional organizations. He and Marjorie were deeply caring, thoughtful, gracious and consummate hosts at magnificent dinner parties at 821 South High Street in Bloomington and at the Colorado cabin. These locations became the "crossroads of the world of alcohol-and traffic safety and professional policing on a truly international scale" [22]. Lloyd Shupe describes one of these occasions (many years ago) when:

"Bob asked a group of us to stop at his home for what he called a 'Meeting of the Young Bucks with the Old Farts'. The young bucks were Ward Smith, Kurt Dubowski, Jim Osterburg and me. The old farts were Rolla Harger, Charles Wilson, Clarence Muehlberger and Raphael Ruesen (from Havana)." [41]

Although by now himself qualifying as an "old fart", Bob's friends will always consider him a "young buck".

Bob was very much a hands-on host at these affairs. Kurt Dubowski remembers:

"He personally prepared his special punch in ample quantities and arranged the cheese platter just so, after hours of personally shopping for the right ingredients in Chicago, Indianapolis and Bloomington" [22].

The Professor also has a recreational as well as a professional interest in good wine. Bill Picton describes a discussion about wine with Bob during which Bill mentioned that there was a winery in Edmonton, a city known more for its snow and cold winter weather (its football team is named "the Eskimos") rather than for its viniculture:

"Upon my departure, Bob presented me with a bunch of plastic grapes for use by the Edmonton winery" [39].

Bob's secretary since 1991 and current Borkenstein Course Coordinator at the Center, Darlena Lindsay, describes how they had lunch together in Bob's office at the University every day he was in the office; they took turns at preparing it. The conversations, usually one-sided, covered an amazing range of topics with Bob's encyclopedic knowledge and catholic interests never failing to amaze her. She remembers:

"If anything came up that he didn't know at that time, he would by the next day. He loves the theatre and dancing and, as an adult, took up fencing, the only sport he had any use for."

In these lunchtime conversations, Bob described his travels and the many wonderful places he had been, Vienna and Paris being his favorites [35].

His telephone bills must have been enormous; if he did not invent the term "networking" he certainly was one of its foremost practitioners. Many of his colleagues all over the world would describe his calls, arriving straight out of the blue, sometimes to discuss whatever was Bob's issue of the moment, or sometimes just to talk. This author's calls almost invariably arrived early (for him) on Saturday mornings, including one Saturday that happened to be Christmas day. John Havard describes this characteristic:
“One of the most remarkable facts about Bob is the wide range of eminent people in different countries who count him among their friends. Around 1962, I was trying to interest a very large and important government department in Britain about a certain problem, and was having no luck whatsoever in getting anyone in authority to listen to me. I was astonished when the distinguished chief of the department (later ennobled as Lord ...) phoned me personally explaining that he had heard that Bob was visiting London and had given my number as a contact. He asked me to make it clear that he insisted that Bob stayed with him in London!” [28]

Bob’s wife, Marjorie, was a highly talented artist who fostered his interest in art. One of Marjorie’s pieces, of which he is most proud, is a collage made from old component parts of Breathalyzers. It still hangs on his office wall at the University. They had no children but shared a love for their beautiful cabin on the side of a mountain near Divide, Colorado, which they visited whenever possible until they found it necessary to give it up in 1996. Some of Bob’s most creative thoughts were developed in the peace and solitude of the Rockies.

CONCLUSION

As a forensic scientist, one might assume that Bob Borkenstein would have considered that the solution to the problem of alcohol and traffic safety rested with technology and better ways of measuring BAC. As a police officer, he might have seen the answer in greater enforcement of stricter laws. As an educator, perhaps public information was the route to go. While each of these has a role to play, such single solution approaches are not the way he thinks. A much broader approach is required. In a plea for more creative thinking to an international audience in 1985, Bob said:

“Perhaps we have been too optimistic in believing that the media, public information meetings, driver education schools and other means of disseminating information would solve the problem of understanding and would gain support of the public. This has been a dismal failure. I read over most of the papers I have written on this general subject during the past 30 years. In nearly every one of them I stated that the weakest link in attacking this problem has been public support. What we perceive as low-level action against the drunken driver is probably a direct result of lack of public support. We can inform and we can enforce and as a result change behavior through fear for a while. But when we fail to change attitudes, regression is bound to occur.” [14]

In 1985, John Havard described one of Bob’s legacies in the following way:

“If I was asked to identify the person who has made the biggest contribution toward the reduction of death and disability from motor accidents associated with alcohol, I would have no hesitation in identifying Bob.” [27]

The first words in this appreciation of Robert F. Borkenstein’s life and work were those of Dr. Herb Simpson, so it is fitting that he should also have the final words:

“His spirit, enthusiasm and dedication inspired me very early in my career and I think fondly of his influence, not only in the field of traffic safety, but on me personally.” [42]

There are hundreds of others, including this author, who can only add “Amen”.

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The nature of this type of article is such that it depends on the willingness of many people to share their recollections and memories of associations with the subject. The contributions of Robert Conley, Kurt Dubowski, Sharon Paville, John Havard, Wayne Jones, Boris Moczula, William Picton, Robert Reeder, Lloyd Shape and Herb Simpson are gratefully acknowledged. Much of the material for this article was derived through personal access to Prof. Borkenstein’s papers in his office at Indiana University. The cooperation of Darlena Lindsay in guiding me through this material and her diligence in seeking out items that would answer my many questions could not have been more complete. Without it, this article would not have been possible. Dr. Ray Liu and Forensic Science Review made this visit possible.

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**ABOUT THE AUTHOR**

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Doug Lucas retired as the Director of the Centre of Forensic Sciences in Toronto, Ontario, Canada in 1994 but continues to remain active as a forensic science laboratory management consultant and with several professional association committees. He holds a B.Sc. and M.Sc. from the University of Toronto, receiving the latter in 1957. Following graduation, he joined the staff of the Attorney General’s Laboratory (now the Centre of Forensic Sciences) as a chemist/toxicologist in 1957 and moved through progressively more responsible positions culminating in his appointment as Director in 1967. His first assignment with the Laboratory in 1957 was to develop the training and operational programs for the use of the Breathalyzer by police in Ontario. This brought him into early contact with Prof. Borkenstein through Ward Smith who was the Director of the Laboratory at that time. This association has continued to the present day. In addition to breath testing and alcohol analysis, Doug’s particular interests were fire and explosion investigations. He published the first paper on the application of gas chromatography to the identification of flammables and, in cooperation with the Toronto Police Bomb Squad, developed new equipment and procedures for safer handling of improvised explosive devices.

Doug Lucas has been active with many professional associations and has served as President of the Canadian Society of Forensic Sciences, the American Academy of Forensic Sciences, the International Association of Forensic Sciences and the American Society of Crime Laboratory Directors (ASCLD). He has been honored with several awards including the Dérôme Medal of the Canadian Society of Forensic Science, the Gradwohl Award of the American Academy of Forensic Sciences, the Adelaide Medal of the International Association of Forensic Sciences, the Briggs White Award of ASCLD, and the Borkenstein Award of the National Safety Council.