Surface Potential Detector to the Chemical Agent Monitor (CAM): The development of nerve agent detectors in England from 1970 to 1981.

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Summary

BACKGROUND AND CONTEXT

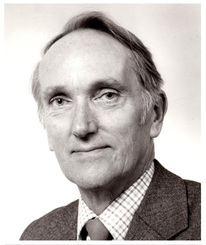
Located on the Salisbury plains in Southern England, the chemical research facility Porton Down was born from sodden, verminous trenches in Belgium in WWI. As a direct result of German gas attacks at Ypres in 1915, the British military purchased land to build a competing chemical weapon production and research facility. In those days (WWI through WWII), Porton trailed behind German artillery and gas munitions and after WWI with relevancy. The discovery of German nerve agent production at Raubkammer and Dyhernfurth in 1945 gave Porton Down new purpose—to pursue development of nerve agent defense and detection. This led to innovations in technology culminating in the Chemical Agent Monitor, CAM through a series of individuals and organizations influenced by other technologies.

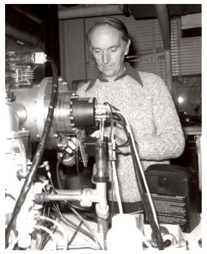
DAVID BLYTH AND THE SURFACE POTENTIAL DETECTOR

David Blyth was born in Southampton England in 1928. Upon graduating from Southampton University with a Physics degree, he took a job at Porton Down and immediately joined a group in the Physics Division whose interest was improving the charcoal filters in CWA respirators.

In the 1960s, the British Army was heavily invested in the development and production of an electrochemical detector called the Nerve Agent Immobilization Enzyme Agent Detector (NAIEAD), much like the US Army M8. Electrochemistry proved impractical for the battlefield as well as insufficient for accurate and dependable detection. Early in his search for a dry detector, Blyth began working with a method developed in England called the surface potential detector (SPD) [1].

"That was developed quite a long way down its path, but the British soldiers were not very happy with it …so I was brought in to look for a solid state dry detector. We started from scratch, really." ~David Blyth





The SPD consisted of two parallel metal plates of dissimilar material. Blyth used gold and platinum which constantly vibrated at 10,000 times per second. Both metals emit thermionically at differing rates producing a potential difference between the plates which can be measured. When large organic molecules entered the detector and briefly contact the plates, the potential difference is affected and registered as a change in a volt-meter. The surface potential detector functioned well in laboratories with inert gases as a GC detector [2] . The vanishing small potentials developed between gold and platinum provided challenges to amplifier electronics in the early 1970s and modifications of this concept were needed. Better electronics or more electronic charge in the detector or both. Blyth sought advances in both.

DICE- DETECTION BY ION COMBINATION EFFECT

After this initial failure with the surface potential detector, Porton officials forbade Blyth to continue studies on a dry nerve agent detector; however, during his lunch breaks, he modified the SPD, first addressing the low number of charges by adding a radioactive source to increase ion current. This completely overwhelmed the device's electronics. Modifications produced a more stable device: Blythe kept the radioactive source, discarded the metal plates, and placed a detector plate at the end of a flow chamber. Blyth had transformed the surface potential detector into a marginally good filter of ions at ambient pressure in air. As ions from the radioactive source were pushed through the chamber, small positive and negative ions would collide or recombine and neutralize. Large organophosphate ions would lumber along in the gas flow reaching a detector.

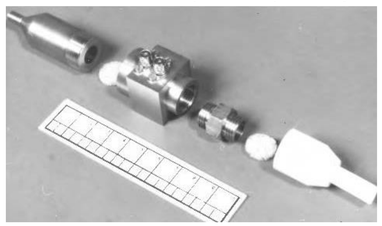
This was named "Detection by Ion Combination Effect" and was fundamentally identical to Steve Harden's independently developed M43A1 Ionization Cell at Edgewood Arsenal in Maryland, USA. Structures were different and DICE was to be revised with a second generation design with improve selectivity and eventually with a patent [3] (below)

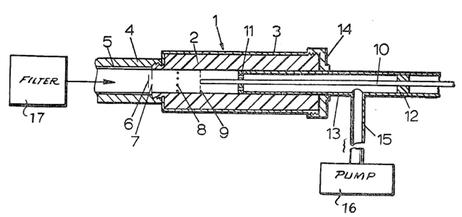
THE TROUBLES, PYE, AND THE PD 1

While Blyth worked at Porton for nerve agent detection with the SPD, Pye Dynamics, later Graseby Dynamics, was under contract with the British Government to develop a portable vapor detector for explosives for use in "The Troubles". From 1972 to 1979, there was a dramatic increase in political conflict and bombings in the war-tormented counties of Northern Ireland, hence, "The Troubles". At Pye Dynamics a series of detectors, the first as PD1, was developed around an electron capture detector (ECD). The PD 1 was briefcase size and the ECD was provided argon [4]. Explosives permeated through a membrane inlet. In an ECD, gas ions formed from a radioactive source establish a current flow between two conductors. An electronegative substance can capture electrons and be swept with gas flow from the detector before reaching a conductor, reducing the current. This is a type of primitive mobility filter though the radioactive source and ionization chemistry would later appear in IMS instruments. Later versions included PD 5 and a GVD 6.

DICE FINAL DESIGN AND TRANSITION

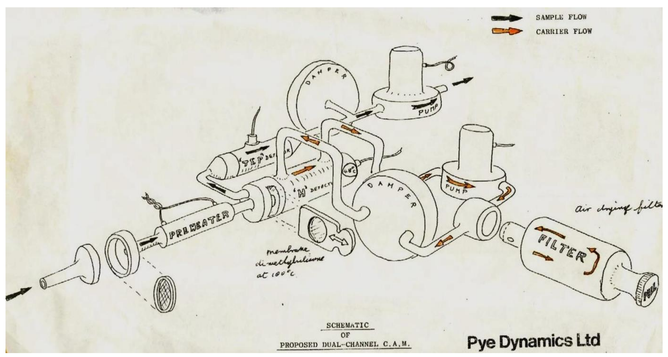
Blyth contacted Robert Bradshaw at Pye seeking a low noise, sensitive amplifier for DICE and thus began a decades-long partnership between Pye Dynamics and Porton Down. Improved electronics (presumable from PD 1 developments) allowed Blyth good sensitivity and allowed some improved specificity. The chamber structure was retained





Source: Neil Underwood and DSTL Porton Down

and an inter-digitated polarized parallel wire grid was place in the cross-section of the drift tube. Small ions crashed onto the wires and neutralized, while large ions moved slowly passed the wires and reached the detector plate. This device was selective in response to nerve agents because of it filtered ions based on mobility in electric fields.



Source: Neil Underwood and DSTL Porton Down and with permission Smiths Detection

"It is quite clear that for some purposes more specificity is needed, which in turn needs a better understanding of the identity of ions formed and the factors affecting their productions." ~Blyth, review in 1983

TRANSITION TO IMS AND THE CHEMICAL AGENT MONITOR

In 1978, DICE was evaluated in field trials and found lacking in selectivity of response and improved selectivity was found in ion mobility spectrometry. In 1977 when visiting Pye, Blyth meet a young engineer, John Petinarides who had began work with the MOD and created the prototype aluminium castings for Britain's Special Weapon and the Yellow Sun.

In 1980, Graseby Dynamics received a one-year contract to design and build 12 prototypes of CAM based on IMS. Petinarides was tasked with turning a breadboard, laden with tubing, fittings, and wires, into a sleek and durable hand-held field instrument. He was given the breadboard and a report on chemical hardening, evaluating the different materials and fittings affording least chemical contamination.

Petinarides' first design featured a pistol grip and some ergonomic challenges only added to the dangerously compromised utility. As the soldier sought to read a display, visual contact with the item measured was lost, as was positioning of CAM, possibly giving a false measurement. The handle was changed to the lateral top, containing the battery, as it is in the final design. .

Conclusions

In England, studies parallel to those of Harden in the US led to a gas ion detector from an initial start with a surface potential detector and developed through one individual's initiative, sometimes at odds with his institution. Basic technology from explosive detector developments for The Troubles aided Porton Down though a simple ionization detector DICE was too general in response. Key personalities included Robert Bradshaw, John Brokenshire, and John Petinarides in England with Pye Dynamics, eventually Graseby Dynamics, Ltd. and led to the production of CAM, the first rugged hand-held IMS instrument.

References

1. G. Phillips Journal of Scientific Instruments 1951, 28, 342-347.
2. J. H. Griffiths and C.S.G. Phillips, J. Chromatography, Gases and Vapours. Part IV. 1954, 3446-3453
3. D.A. Blyth, Detection of polar vapours, US 4368388 A Publication date Jan 11, 1983; Filing date Nov 15, 1979
4. Looking for electron hungry explosives in Ulster, *New Scientist*, May 9, 1974, p.310; also, Detection to cut out the big bang, *New Scientist*, April 13, 1978, p. 89.
5. A.E. Eiceman, "An Oral History Archival Project for Ion Mobility Spectrometry: Martin J. Cohen and Franklin GNO Corporation," ISIMS Conference, July 2012.
6. A.E. Eiceman, M.A. Thesis entitled, *From the Grievousness of War: The Global Events and Individual Relationships that Influenced the Scientific Development of Sophisticated Automatic Chemical Warfare Agent Detectors.;* Department of History, New Mexico State University, Las Cruces, NM October 2013.