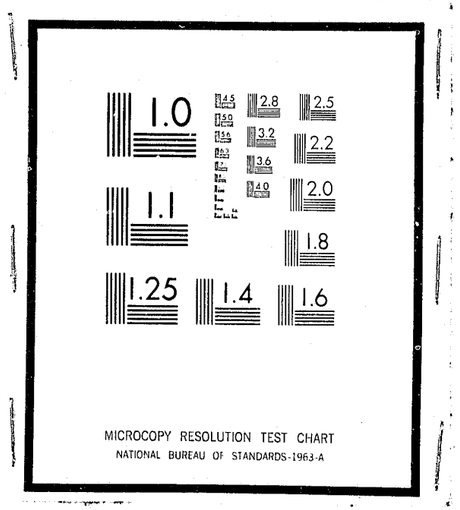

R-76-155

LAW ENFORCEMENT ASSISTANCE ADMINISTRATION
POLICE TECHNICAL ASSISTANCE REPORT

SUBJECT: New Hampshire Survey of Crime Laboratory Service Delivery System

REPORT NUMBER: 76-85

FOR: New Hampshire Governor's Commission on Crime and Delinquency

CONTRACTOR: Westinghouse Justice Institute

CONSULTANT: Theodore R. Elzerman

CONTRACT NUMBER: J-LEAA-003-76

DATE: July 1976

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FOREWORD

This request for Technical Assistance was made by the New Hampshire Governor's Commission on Crime and Delinquency. The requested assistance was concerned with conducting a survey of the Crime Laboratory of the State of New Hampshire to determine what crime laboratory services are available presently, what services are needed to better serve the criminal justice system, and what is proposed to improve or increase the availability of services to the criminal justice agencies. The results of the survey would be used to provide guidelines and recommendations for future funding of the New Hampshire Crime Laboratory.

Requesting Agency: New Hampshire Governor's Commission on Crime and Delinquency, Mr. William H. Golding

Approving Agency: LEAA Region I (Boston)
Mr. John M. Keeley, Police Specialist;
Mr. Alfred G. Zappala, Systems Specialist;
Mr. Francis T. Burke, New Hampshire State Representative

1. INTRODUCTION

The New Hampshire Crime Laboratory is a unit within the Detective Bureau of the New Hampshire State Police Department of Safety. The physical location of the laboratory is in the Public Safety Headquarters building in Concord. Concord, the State Capital, is located in the south central portion of the State. The Crime Laboratory provides the only criminalistics service to all criminal justice agencies in the State. The population of the State is approximately 824,000; the majority of the residents live in the southeastern portion. The Consultant was requested to survey the present crime laboratory services available in the State of New Hampshire and give recommendations for future needs. To address the problem, the present crime laboratory service was evaluated by the Consultant through on-site inspection and interviews with various law enforcement officials and staff members of the Laboratory.

The Laboratory site inspection provided the Consultant with information on the Laboratory's current capabilities. Interviews with laboratory staff and with users of the Laboratory's services provided the Consultant with information on needs of the Criminal Justice Agencies.

The following individuals were interviewed:

- Mr. Ron Curran, Deputy Director, Governor's Commission on Crime and Delinquency.
- Colonel Paul A. Doyon, Director, Division of State Police.
- Captain/Specialist Roger D. Beaudoin, Crime Laboratory.
- Roger H. Klose, Criminalist II, Crime Laboratory.
- Warren H. Edmonds, Criminalist II, Crime Laboratory.
- Phillip Harmon, Criminalist I, Crime Laboratory.
- Morris Boudreau, Chemist I, Crime Laboratory.
- Thomas Geno, Photographer, Crime Laboratory.
- Sheriff Ronald D. Daniels, Jr., Merrimack County.
- Sheriff Herbert W. Ash, Grafton County.
- Chief of Police, Craig D. Sandler, City of Nashua.
- Sheriff George Sampson, Rockingham County.
- Chief Deputy Charles F. Velter, Rockingham County Sheriff's Department.

2. UNDERSTANDING THE PROBLEM

2.1 Problem Addressed

The problem briefly stated was "What forensic laboratory services are available" and "What is needed, if anything, to improve forensic laboratory services in the State?" Are satellite or regional laboratories needed or can one well-equiped and well-staffed central forensic laboratory fulfill the physical and chemical analysis physical evidence needs for the entire State?

2.2 Objectives of the Assignment

The objectives of the assignment were as follows:

- Determine present capabilities of the present Crime Laboratory.
- Determine needs of the Crime Laboratory to improve present service and provide service that is not presently available in the Laboratory.
- Make recommendations to improve present service and increase the capabilities of the Crime Laboratory.

3. ANALYSIS OF THE PROBLEM

3.1 Methods Used to Address the Problem

The problems were addressed by conducting interviews, visiting the Crime Laboratory facilities, and reviewing limited statistical data on Laboratory operations. Interviews were conducted both with Laboratory staff and law enforcement agency heads. Limited lead time prevented scheduling interviews with investigators and county attorneys who could have also offered some input.

3.2 Data Sought

3.2.1 Current Laboratory Capabilities

- Staff.
- Physical facilities.
- Instrumentation.
- Statistical data.
  - Cases.
  - Case types.
  - Agencies served.
- Budget information.

3.2.2 Agency (User) Evaluation of Current Service

- Frequency of use.
- Results received.

3.2.3 Needs to Improve Crime Laboratory Service

- As proposed by Laboratory staff.
- As proposed by user agencies.

3.3 Data Obtained

3.3.1 Current Laboratory Capabilities

3.3.1.1 Staff

The Laboratory director is a uniformed officer who holds the rank of

Captain/Specialist. He is not police schooled, but does hold a Master's degree in Chemistry. Approximately 45 percent of his time is spent in management and supervision; the rest of his time is devoted to case work, which involves firearms and toolmark identifications as well as other physical evidence comparisons.

All other staff members are civilians with the following titles and general assignments:

- Criminalist II -- Two: One devotes all of his time to physical evidence examinations such as arson, hit and run, burglary and other trace evidence; one devotes 70 percent of his time to drug and marijuana analysis and 30 percent of his time to arson and related evidence analysis.

- Criminalist I -- One who devotes all of his time to durg and marijuana analysis.

- Chemist I -- One who devotes all of his time to drug and marijuana analysis.

The above four staff members have a minimun of a Bachelor's degree in chemistry or related natural sciences. There is also a fingerprint technician, photogrpaher, and steno II on the crime Laboratory staff.

3.3.1.2 Physical Facilities

The Laboratory operates in an extremely overcrowded space approximately 1,500 square feet, which was not designed as laboratory space. This Laboratory, as did other laboratories in the country, started because of a need for scientific analysis of physical evidence in criminal proceedings. The real growth began in 1964; and space, in the form of additional rooms, were allocated as staff and services increased.

The Laboratory is scheduled to move into new facilities on or about January 1977. This new facility will provide about 4,800 square feet of laboratory, darkroom, and office space that should greatly improve the operation of the Laboratory. Currently, an item of equipment and, in some cases, evidence must be moved so that another item of equipment may be used. It appears that this sort of problem will be eliminated, adequate work space for staff members will be provided, and work space around each Instrument will be available in the new facilities.

3.3.1.3 Instrumentation

Although some equipment is still needed to do organic analysis and serological examinations, this Laboratory, for its size and staff, is moderately well equipped with the latest in instrumentation. This is

evidenced in the following list of major instrumentation currently available in the New Hampshire Crime Laboratory:

- Atomic absorption spectrophotometer with tantalum ribbon atomizer.
- Emission spectrograph with laser exitation and spectrographic film analyzer.
- Portable X-Ray unit.
- Microscopic equipment.
  - CP-6 computer.
  - Stereo microscopes.
  - Firearms comparison microscope.
  - Document comparison microscope.
  - Polarizing microscope.
  - Infrared image converter.
- Gas chromatograph (Another gas chromatograph is on order).
- Infrared spectrophotometer.
- Ultraviolet spectrophotometer.
- Fluorescence spectrophotometer.
- Clinascreen gas chromatograph.
- Balances.
- Two Polaroid MP-4 cameras.
- Complete darkroom equipment.
- Ford Econo Van mobile unit with evidence collection kits.
- Abbe refractometer.

3.3.1.4 Statistical Data

The New Hampshire Crime Laboratory is not much different from other

crime laboratories that started because of a need for scientific analysis of physical evidence, and grew rapidly. As a result, a "bench person" became the manager; he had little time to function in an administrative capacity because his time was still needed on the bench. Therefore, statistical data, other than cases received and general case types, is lacking. Although case numbers give some indication of work performed and turnaround time gives some indication of additional needs in staff and equipment, data are not available for good budgeting procedures.

Rather than elaborate upon this problem in this report, the Laboratory director should be made aware of forthcoming recommendations from the American Society of Crime Laboratory Directors on Crime Laboratory Management principles. Laboratory statistical data collection guidelines should be available from the ASCLD by January 1977.

Data on cases received, case type, and agency (i.e., State Police or other such as sheriff, city, municipal) are listed in Table 3-1. These data show a decrease in 1975 for cases processed by the Laboratory. By adjusting the data based for the first 4 months of 1976, the Laboratory should experience another decrease in 1976. A review of the monthly figures on cases received during 1973, 1974, and 1975, shows that a larger proportion of the cases are received by the Laboratory during the months of May through September. One might assume this to be expected because of the increase in tourism in the State during the summer months.

TABLE 3-1

Case Data

	Case Type		Agency		
Year	Drug	Criminalistics	State Police	Other	Total
1973	2,120	583	732	1,971	2,703
1974	2,163	564	634	2,093	2,727
1975	1,882	605	495	1,992	2,437
Jan.-Apr. 1976	555	183	147	591	738

There were no other statistics readily available that would indicate the further breakdown of how many cases in the drug category were marijuana and how many cases were controlled substances. There also was no breakdown on the types of criminalistics cases.

3.3.1.5 Budget

No information was available on budget. Although personal service funds are easily determined, no other line item amounts for operation of the Laboratory were available. The Laboratory director has no input into the budget process, but the requests for operating supplies are generally approved. Sixty percent of the instruments have been purchased through grant funds.

3.3.1.6 Workload

Additional information obtained indicated that the six professional staff members averaged 2,197 hours of assigned work for 1975. This amount of time appears excessive even considering vacation time and holidays, but the salary schedule makes allowance for 416 extra hours.

The Laboratory staff is subject to call for processing major crime scenes on a 24-hour-a-day basis. Laboratory staff responds to approximately 75 calls per year. A crime scene van equipped with cameras, physical evidence collection kits, latent fingerprint kit, casting kit, and basic tool kit is available to respond to the crime scene calls.

3.3.2 Agency (User) Evaluation of Current Service

Interviews with the limited number of users indicated that the Laboratory provides a very valuable service, which has improved in the past 4 to 5 years. The Laboratory staff members are very cooperative and very capable individuals. The major complaint was the length of time it takes to get Laboratory results. There are also some things the Laboratory is not capable of doing and, therefore, must be sent elsewhere for analysis. The Laboratory services were used almost on a daily basis, primarily for drug analysis.

3.3.3 Needs to Improve Crime Laboratory Service

Interviews with users in general indicated that the present facilities should be upgraded and the service capabilities improved. Serology (e.g., blood, hair, fibers) capability is needed. Document examination service is needed, as well as better toxicological analysis in cases of criminal interest. Although users interviewed have some crime scene capabilities and rely on State crime scene processing in homicide investigations, more assistance is needed in the crime scene area to improve the quality of gathering physical evidence. It was felt that this could be best accomplished by regional seminars involving both basic criminal investigation

and crime scene search. Homicide investigation seminars conducted in the past were well received, and it is felt that these should be continued.

Some users also indicated that assistance was needed in identifying suspects; this could best be provided at the State level through the use of an Ident-O-Kit.

A review of Laboratory services capabilities shows that the following services are provided:

- Crime scene processing.
- Latent fingerprint examinations and comparisons.
- Dangerous drug and marijuana identification.
- Firearms and toolmark comparisons.
- Arson examinations.
- Some trace evidence capabilities, such as paint and building materials.
- Seminal material identification.
- Photography.

It was also determined that the drug and marijuana backlog was approximately 4 weeks and the criminalistics backlog was 10 weeks. Cases received at the Laboratory are generally worked on a first-in-first-out basis except where results are necessary to determine bail, needed for investigative purposes, and in homicide investigations.

The following laboratory capabilities are not provided:

- Serological examination (i.e., blood determination and blood typing).
- Hair and fibers comparisons.
- Document examinations.
- Toxicology involving questionable deaths.
- Glass examination.
- Soil examination.
- Analysis of physical evidence for organic composition.

Toxicological analysis and blood alcohol analysis are currently being handled by the Department of Public Health. Users, as well as Laboratory staff, feel that more assistance is needed in cases of questionable deaths. Closer liaison is needed with the County Medical Referees to make them aware of what service is available in these investigations, but adequate service should first be made available at the State level in the area of toxicological analysis.

4. FINDINGS AND CONCLUSIONS

The Consultant's general observations were that the present level of the Crime Laboratory capabilities are well received, but more assistance is needed. This assistance is in the form of more crime scene capabilities, more laboratory capabilities, and faster response time on laboratory results.

This Laboratory, as well as most other laboratories in the United States, is buried in the drug identification problem. Of the caseload in the past 3 1/3 years, 77.6 percent was drugs. Figures for 1975 reflect a decrease in drug cases, while criminalistics cases show a steady increase.

Although 1974 UCR data for New Hampshire shows a 45-percent increase in Part I Offenses and a 22.1-percent increase in Part II Offenses over 1973, this increased criminal activity has not been reflected in the caseload of the Crime Laboratory. It is true that the large increase in Part I Offenses in New Hampshire in 1974 was due primarily to the increase in larceny, burglary, and auto theft and that evidence available in these types of offenses, other than burglary, does not normally go to the Laboratory for analysis. However, the increase in burglary cases alone should have reflected an increase in cases processed by the Laboratory for that type of service. One could conclude that: a) The evidence is being submitted to the FBI or some other laboratory for analysis, b) the local investigators are not aware of the potential physical evidence present at the crime scene, or c) if it is collected there are not adequate laboratory capabilities to provide analysis in a reasonable length of time. It is suspected to be a combination of b and c.

The recent Rand Report indicates that the increased capabilities of law enforcement agencies to properly collect physical evidence have not contributed significantly to the solution of the crime and the apprehension of the suspect(s). The Consultant believes the Rand Report has failed to address one of the most pressing problems in the criminal justice system. One could have the best crime scene specialists in the county, process every crime scene in a timely manner, and do a superior job in evidence collection and preservation; but if the scientific support is not available to totally support the crime scene specialists' efforts, then much of the activity at the crime scene is wasted.

The population centers and geography of New Hampshire do not warrant an additional crime laboratory(s) in the State. With the majority of the State's 824,000 persons living in the southern portion of the State, Concord is geographically located to provide easy access by the criminal justice agencies to the Crime Laboratory. It appears that approximately 90-percent of the population is within 1 1/2 hours driving time of the laboratory in its present location.

Decentralization of the Crime Laboratory, with its necessary specialized and costly equipment, could not be justified based on the population and the types and numbers of criminal offenses it normally serves.

It is concluded that the Crime Laboratory should be given the fiscal support necessary to upgrade its present capabilities and implement those capabilities that are needed but not presently readily available to the criminal justice agencies in New Hampshire.

Part of the problem will be resolved when the Laboratory moves into its new facilities. Immediate consideration should be given to the following, which are listed by priority:

- Implement serological service. This would require 3 to 4 months of extensive training for a criminalist to become qualified in blood identification; species identification; ABO blood typing; and enzyme identification of blood, saliva, seminal material, and other biological material. This individual should also be capable of doing hair and fiber identification and comparisons. This area of criminalistics has expanded rapidly in the last 5 years and would require the full-time efforts of one staff member to establish the necessary procedures.

- Improve the Laboratory capabilities in organic analysis of physical evidence items. This would require additional training of staff members who are well versed in instrumental analysis, as well as the purchasing of additional accessory items for instruments in the laboratory.

- Train staff member in glass and soil analysis.

- Provide toxicological analysis capabilities in cases of questionable deaths. This service would require a full-time staff member trained in toxicological procedures. The Laboratory possesses most of the basic instrumentation needed for this type of service, but would need additional instruments in the near future when the caseload justifies the need. One of the most useful instruments presently available is the Gas Chromatograph/Mass Spectrometer with computer access. This instrument can also be used on dangerous drug analysis, which would assist in increasing productivity in that service area.

- Provide, as a beginning, four crime scene specialist teams. These teams should consist of two men: Each man should be well versed in crime scene processing, latent fingerprint processing and comparison, photography and darkroom processing. These individuals should be interested in things, not people. A good investigator does not necessarily make a good evidence specialist. These individuals should be on call 24 hours a day, 7 days a week, provided with a vehicle that contains necessary equipment to process a crime scene, and be answerable to the Laboratory director. Recommended locations for these teams would be with Troop A, Troop C, Troop F, and with the laboratory in Concord. The three teams assigned to the troop locations could be utilized in patrol or other activities when not on a crime scene activity. The team assigned to the Laboratory could assist with other duties in the Laboratory when not on a crime scene activity.

- Hire a document examiner. The Laboratory presently has much of the microscopic capability needed for document examination.

5. RECOMMENDATIONS

5.1 General Recommendations

The Laboratory has grown because of a need for analysis of physical evidence. Although it appears the Laboratory is moderately well equiped with instrumentation, this instrumentation is not being used to its potential because of the pressing drug caseload. The staff does not have the time to develop capabilities and expertise in areas of criminalistics. The staff needs and requirements have not kept up with the potential physical evidence.

Additional staff is needed to provide capabilities to make the New Hampshire Crime Laboratory a full-service laboratory.

There is also a need to expand statistical gathering for management purposes. This would provide the director with budgeting information that would assist budget justification to the administration and would also provide a means of administrative control over the activities in the laboratory.

Because over 75 percent of the caseload is drug identification, most staff members should be capable of conducting drug analysis. The criminalist should develop a specialty in one or two other areas (i.e., firearms, trace evidence analysis, serology). With some cross-training between drug identification and some special area of criminalistics, the staff member would not feel "boxed-in" to one activity. This would also allow flexibility to cover vacations, illness, and peak periods or large influx of drug cases.

5.2 Specific Recommendations

- Train a staff member to conduct serological analysis.
- Hire an additional criminalist to replace the staff member to be trained in serology. This new staff member should be cross-trained in drug identification and one or two areas of criminalistics.
- Hire an additional staff member to provide more rapid turnaround time in drug analysis. This additional staff member should also be cross-trained in one or two areas of criminalistics.
- Cross-train those existing staff members in areas of criminalistics. The cross-training of present staff and the addition of two new Criminalists

should meet the current demands of the criminalistics backlog. It should be pointed out that criminalistics cases take more time to analyze than drug cases because of the variety of evidence and because of the complexity of the analytical techniques involved.

- Provide staff time for literature research and methods development.

- Upgrade the library to provide the necessary books and journals pertinent to the field of forensic sciences and criminalistics.

- Allow staff time and travel expenses to attend regional and national conferences and training sessions for self improvement.

- Add travel expenses for staff to visit other laboratories for in-service training in specific areas of criminalistics.

- Recruit and hire a toxicologist.

- Recruit from within and provide training for eight crime scene specialists and provide them with the necessary equipment for crime scene processing.

- Purchase necessary equipment and accessories to allow for in-depth analysis of physical evidence, which is not currently available in the laboratory.

- Recruit and hire a document examiner.

- Add clerical staff to type reports, file, and assist in the preliminary steps of evidence reception. Clerical staff could be used to assist submitting officers in filling out evidence receipts before the criminalist receives the evidence.

5.3 Action Plan

Personal services figures, although discussed with the Laboratory director, were not noted; therefore, they are not included in this report as costs for implementing the recommended steps.

Since serological capability is the first priority, necessary commodity items and equipment will be required. Additional trace evidence

analysis is the second priority. The following equipment would be needed to meet these priorities (also listed are the equipments' associated costs).

- Equipment Needs for Serology

- Stereo Microscope	$ 735
- Phase Contrast Microscope	2,157
- Comparison (Fiber) Microscope	5,390
- Rotator	320
- Incubator	380
- Oven (37° and 55°C)	125
- ph Meter	595
- Micro-Mixer (Shake)	82
- Heating Blocks (2 each at $56)	112
- Serofuge	262
- Ultrasonic Cleaner	360
- Electrophoresis Power Supply	188 to 600
- Electrophoresis Tanks (2 each at $230)	460
- Cooling Plates (2 each at $90)	180
- Water Cooling Unit	125
- U.V. Lite (short and long wave)	54
- Glassware Dryer	125
- Volt-Ohm Meter	50
- Magnetic Stirrer	124
- Refrigerator	250

- Equipment Needs for Upgrading Organic Analysis Techniques

- Pyrolysis Accessory for the Gas Chromatograph (see Appendix A)	$2,000

- Digital Electrometer Accessory for the Gas Chromatograph to Improve Spectra Data Collection (see Appendix B)	$2,000

- Other Equipment Needs

- Mettler Hot Stage and Monochromometer to conduct Refractive Index Measurements	$6,000
- Fiber Optics for Firearms Comparison Microscope	350
- Water Bullet Recovery Tank (see Appendix C)	1,000
- A Book and Journal Budget on a Yearly Basis	500
- Chemicals for Serology Start-Up	600
- Glassware for Serology Start-Up	840
- Anti-Serum for Serology Start-Up	185

Toxicological capability, other than some additional glassware and organic solvents and chemicals currently used in the Laboratory, should not require any large expenditures of money at this time other than personal services. Future consideration should be given to the purchase of a Gas Chromatograph/Mass Spectrometer with computer data bank as the caseload warrants. Current cost for such an instrument is approximately $125,000.

Since crime scene specialists and document examination capabilities are for consideration in the near future, no attempt will be made to cost these activities at this time.

The use of the criminalistic staff for processing crime scenes affects the operation of the Laboratory. At present a major crime scene investigation completely disrupts the operation of the Laboratory for several days. Although a criminalist's assistance may be needed on special occasions, the Laboratory staff should not be expected to respond to all crime scene investigations. A well-trained crime scene specialist could handle all crime scene investigations. Furthermore, the availability of trained crime scene specialists should provide more coverage of all types of crime scenes.

Since in-service training is an integral part of providing expanded service and in-depth capabilities of the Laboratory and staff members, the costs associated with such activities and other activities are as follows:

- Travel, Training, and Meeting Expenses

- In-service training for serologist -- Minimum of 16 weeks at $200 per week plus transportation	$3,200
- Regional seminars or conferences on matters of forensic interest -- per year for several staff members	1,200
- Staff member attendance at the American Academy of Forensic Sciences (San Diego, February 1977)	700
- Any other in-service training	200 per week plus transportation

Implementation of the recommendations in this report as fiscal funds become available would provide the criminal justice system of New Hampshire with full Crime Laboratory capability. The monitoring of Laboratory activities through sound statistical management data would provide the administration with support for additional operating funds and staff needs.

APPENDIX A

Pyrolysis - Gas Chromatographic Analysis of Automobile Paints

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Copyright
American Society for Testing and Materials
1916 Race Street, Philadelphia, Pa. 19103
1974

W. D. Stewart, Jr.,[1] *Ph.D.*

Pyrolysis-Gas Chromatographic Analysis of Automobile Paints

The problem facing the forensic scientist in the examination of paint as physical evidence is the limited amount of information that can be obtained from trace samples. Examination of the paint involves tests to determine the composition of the binder. These tests include spot tests which differentiate between binders by solubility and color reactions [*1*] and infrared spectroscopy which identifies the functional groups present in the sample [*2*]. Pyrolysis-gas chromatography can also be used to compare paint traces with the suspected source or, by reference to standard chromatograms, to identify the type of binder. In addition, the identity of the manufacturer of the paint smear and, in many cases, the make of automobile as well as the year, can be determined by the pyrolysis of small paint samples.

The method described in this report involves the pyrolysis-gas chromatographic analysis of the 1973 automotive finishes, and the classification of the finishes by manufacturer.

The majority of the binders, and almost all automotive finishes, are composed of polymers which are built up either during manufacture or during the drying process [*3*]. Pyrolysis-gas chromatographic techniques have been used extensively for the identification of copolymers and mixed polymers. Groten [*4*] examined over 150 different polymers, including synthetic resins, mixed polymers, and copolymers, and although similarities were found among some, he was able to distinguish all the samples. Strassburger et al [*5*] showed that copolymers of methyl methacrylate could be distinguished from polymer mixtures of the same composition by the differences in intensity and that constituents of copolymers in concentrations as small as 0.2 percent could be detected. O'Mara [*6*] demonstrated the qualitative and quantitative reproducibility of pyrolysis gas chromatography in the study of poly (vinyl chloride) using a combined gas chromatography-mass spectrometry system. Jain et al [*7*] examined 34 commercially available coatings, including house paints, automotive finishes, and primers, and were able to distinguish all but two of the coatings.

Experimental

Equipment

The analyses were made with a Fisher-Victoreen gas chromatograph equipped with a reactor tube pyrolyzer and a Model 4010 digital log electrometer. The full scale range of the

This paper describes part of the work done under Illinois Law Enforcement Commission Grant No. 2-08-24-0528-01, Criminalistics Fellowship.

Presented at the 25th Annual Meeting of the American Academy of Forensic Sciences, Las Vegas, Nev., 23 Feb. 1973. Received for publication 23 Feb. 1973; revised manuscript received 2 July 1973; accepted for publication 3 July 1973.

[1] Research criminalist, Department of Law Enforcement, Illinois Bureau of Identification, Joliet, Ill.

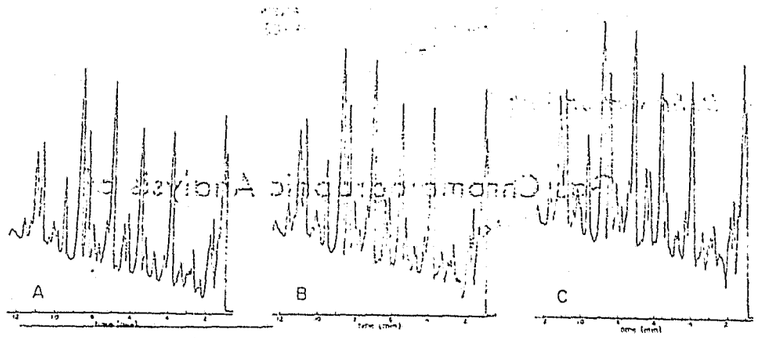

FIG. 1—*The effect of sample size: (A) 0.05 mg, (B) 0.10 mg, (C) 0.25 mg.*

recorder represents four decades of ion current from the hydrogen flame ionization detector, covering the range of 10^{-11}A to 10^{-7}A. The advantages of the logarithmic display for the analysis of complex mixtures have been demonstrated by Byrnes [*8*] and Chisum and Elzerman [*9*].

A combination column comprised of an 8 ft by ⅛ in. 15 percent Carbowax 20M, on 80/100 AW-DMCS treated Chromosorb W, followed by a 3 ft by ⅛ in. 10 percent silicone Dow Corning 200, on 80/100 AW-DMCS treated Chromosorb W, performed the separation of the thermal degradation products. The programming begins at the start of the pyrolysis and the column is held at 50°C for 2 min, at which time the column temperature is increased 15°C/min until 180°C and held there for 5 min.

Procedure

Paint panels received from the manufacturers were used for the analysis. These panels were representative of the production batches, and thus were the same quality as the automobile finish. The finish layer was scraped off the panel with a scalpel and weighed. A sample size of 0.1 mg was chosen for the analysis but, as shown in Fig. 1, a wide range of sample sizes gave essentially identical information. The reactor tube pyrolyzer design, which provided uniform heating at a rate of 200°C/s coupled with the logarithmic output, minimized possible variations due to sample size.

A pyrolysis temperature of 400°C was chosen to effect the thermal degradation of the paint sample. The chromatograms obtained upon pyrolyzing two different types of acrylic enamels at 300°C, 400°C, 600°C, and 800°C are shown in Fig. 2 and, as previously demonstrated by Lehmann and Brauer [*10*], show the increase in the number of products with temperature. This increase in degradation products does not imply an increase in the differences of the two enamels as shown by the nearly identical results at 800°C.

Columns with stationary phases of different polarity were also tried in an attempt to distinguish the paints. These included SE-30 (non-polar), Dinonyl phthalate (intermediate), and Carbowax 20M (polar) stationary phases, and the ability to distinguish the paints increased with increasing polarity. The column selected gave results similar to the Carbowax 20M column, but the rapidly eluted gaseous products were separated on the combination column.

FIG. 2—*Comparison of Chrysler Corp. Type 2 NAD (right) and American Motors Type 1 NAD (left) as a function of pyrolysis temperature: (A) 300°C, (B) 400°C, (C) 600°C, (D) 800°C.*

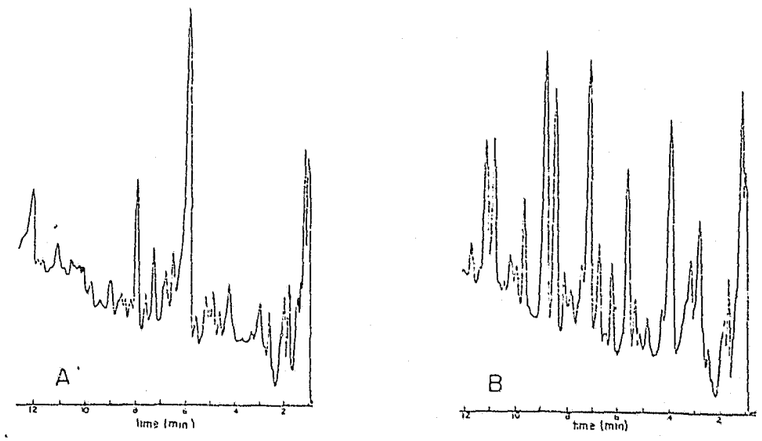

FIG. 3—*Difference between acrylic lacquer and acrylic enamel finishes: (A) General Motors Corp. lacquer, (B) Ford Motor Co. enamel.*

Results and Discussion

The binders in the automotive finishes currently used by American manufacturers are composed of either thermoplastic acrylic resins or thermosetting acrylic resins. General Motors automobiles have thermoplastic acrylic lacquer finishes and the remaining three manufacturers (Ford, Chrysler, and American Motors) have thermosetting acrylic enamel finishes. The chromatograms of a typical acrylic lacquer and enamel, shown in Fig. 3, are quite different.

Acrylic Enamel Finishes

For the 1973 model year, Chrysler Corp. and American Motors Corp. use the new dispersion finishes exclusively. These nonaqueous dispersion finishes (NAD) are different from the solution-type finishes in the nature of the vehicle, that is, the solvents and binders. The polymer, which is maintained in suspension in a liquid composed of solvents and non-solvents, is in the form of very small (<1 μm) particles. This solid suspension results in at least a 30 percent higher concentration of solids at the spray gun and enables two-coat application, rather than the current application of three coats, to achieve desired film thickness.

Cook Paint and Varnish Co. and Pittsburgh Plate Glass (PPG) Industries have both developed NAD finishes. The Cook formulation, or Type 1 NAD, is the basis for all American Motors automobiles. Regardless of supplier, the Type 1 formulation must be followed. Figure 4 shows examples of the Type 1 NAD finishes supplied to American Motors by the various manufacturers and, although slightly different, all three chromatograms have similar characteristics. The PPG formulation, or Type 2 NAD, is the basis for all Chrysler Corp. metallic finishes and the Type 1 formulation is used for all nonmetallics. Figures 5 and 6 demonstrate the adherence to this requirement by the manufacturers. As

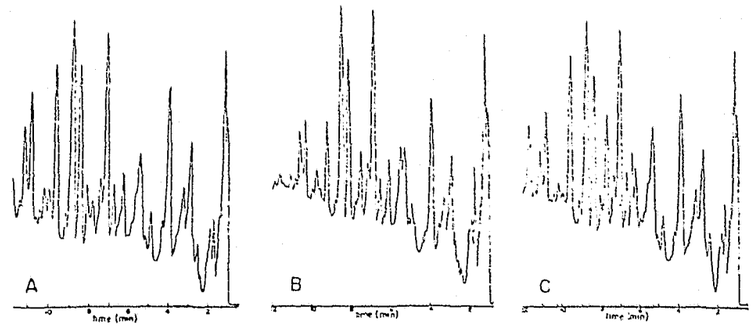

FIG. 4—*Type 1 NAD finishes supplied to American Motors Corp.: (A) Cook Paint and Varnish Co., (B) PPG Industries, (C) Celanese Coatings Co.*

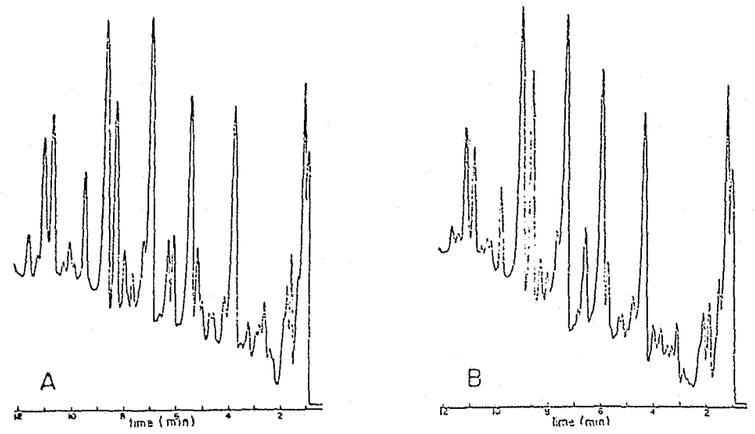

FIG. 5—*Type 2 NAD metallic finishes supplied to Chrysler Corp.: (A) PPG Industries, (B) Celanese Coatings Co.*

would be expected, the Chrysler Corporation nonmetallics are quite similar to the American Motors finishes.

The Paint and Vinyl Operations of Ford Motor Co., which supplies the majority of paint to Ford, has also developed an NAD-type finish. Three metallic blue dispersion finishes, one from each automotive manufacturer, are shown in Fig. 7. All three NAD finishes can be distinguished both by peak intensity and peak location. Ford Motor Co. also uses the solution-type enamel at a large number of the assembly plants. Three practically identical metallic brown finishes, one from each automotive manufacturer (but with the

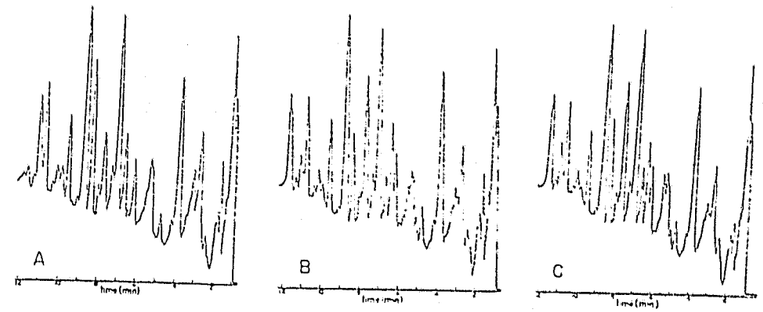

FIG. 6—*Type I NAD nonmetallic finishes supplied to Chrysler Corp.: (A) PPG Industries, (B) Celanese Coatings Co., (C) Cook Paint and Varnish Co.*

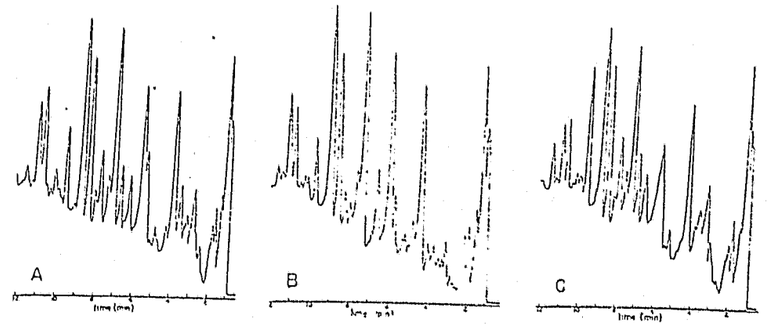

FIG. 7—*Comparison of similar blue metallic dispersion-type finishes: (A) Ford Motor Co., (B) Chrysler Corp., (C) American Motors Corp.*

Ford panel being a solution-type enamel supplied by Paint Operations), are shown in Fig. 8. All three are easily distinguished.

Ford Motor Co. paints automobiles in at least 17 different plants in the United States and Canada, and utilizes a number of suppliers for the same color. The six chromatograms of Fig. 9 represent different acrylic enamels used at the various plants for the white enamel finish. If a sufficient sample is present to identify color, the number of possible locations from which the automobile originated can be reduced and, coupled with the production schedule, the type of Ford Motor Co. automobile can be identified. Chrysler Corp. and American Motors Corp., which have fewer assembly plants, use a single supplier for a given color for all but a very few colors.

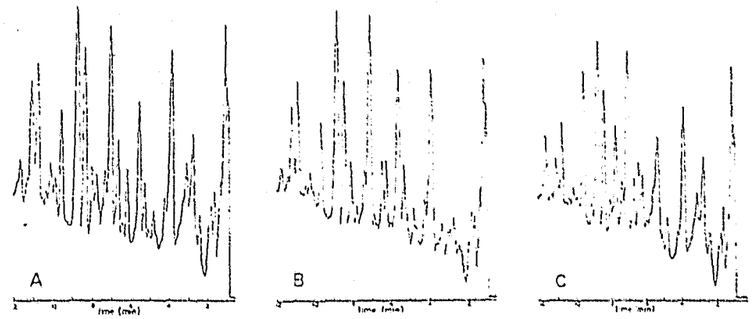

FIG. 8—*Comparison of similar brown metallic finishes: (A) Ford Motor Co. solution-type finish, (B) Chrysler Corp. dispersion-type finish, (C) American Motors dispersion-type finish.*

Acrylic Lacquer Finishes

E. I. du Pont de Nemours and Co., Inmont Corp., and PPG Industries supply automotive finishes to General Motors and identification of the three suppliers is possible, as shown in Fig. 10. The majority of the General Motors Assembly Division plants and the Fisher Body plants uses one source exclusively for all colors and thus, like Ford Motor Co., the number of possible locations from which the automobile originated can be reduced, and in some cases the make of the General Motors automobile can be determined. The common formulation for all the General Motors automotive division's finishes, added to the fact that du Pont is the major source for the majority of the plants, limits the amount of information that can be obtained.

Summary

A technique for the classification and comparison of automotive finishes using pyrolysis-gas chromatography has been presented. The 1973 model automotive finishes were studied and the ability to distinguish the finishes by automobile manufacturer was shown. The decision by Chrysler Corp. and American Motors Corp. to use different formulation NAD finishes for 1973 facilitates identification of their automobiles. Ford Motor Co. can also be distinguished since the majority of the finishes are Ford formulation solution or dispersion finishes. The remaining enamel finishes supplied to Ford Motor Co. can be identified by the manufacturer and distinguished from the Chrysler and American Motors automobiles General Motors Corp. uses a completely different binder system and is easily distinguished from the other manufacturers.

Further research is being undertaken to distinguish the earlier model years and to determine if the paint batches can be distinguished. Cryogenic cooling, which should result in better separation and analysis of the lighter molecular fragments, will be used in the attempt to distinguish the paint batches.

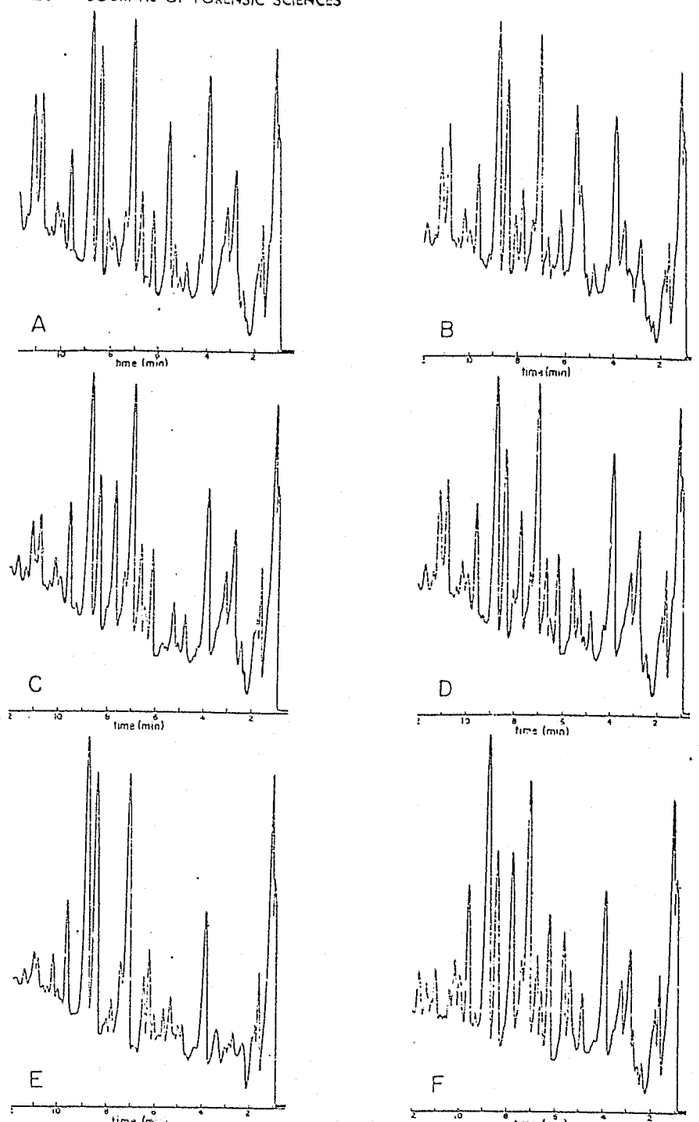

FIG. 9—*Ford Motor Co. white enamel finishes: (A) Ford solution-type, (B) Ford dispersion-type, (C) Cook heavy solids, (D) Cook solution-type, (E) Inmont solution-type, (F) Celanese solution-type.*

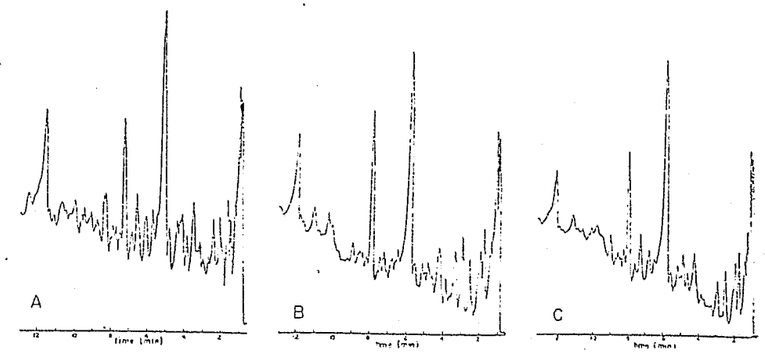

FIG. 10—*General Motors Corp. acrylic lacquer finishes: (A) Du Pont Co., (B) Inmont Corp., (C) PPG Industries.*

Acknowledgments

The author wishes to thank the following manufacturers for their cooperation and the donation of the paint panels: Chrysler Corp., Ford Motor Co., American Motors Corp., General Motors Corp., Cook Paint and Varnish Co., Pittsburgh Plate Glass Industries, Inmont Corp., Celanese Coatings Co., and E. I. du Pont de Nemours and Co.

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APPENDIX B

Identification of Arson Accelerants by Gas Chromatographic Patterns Produced by a Digital Log Electrometer

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Identification of Arson Accelerants by Gas Chromatographic Patterns Produced by a Digital Log Electrometer

The identification and comparison of accelerants is a problem which confronts the criminalist during the examination of evidence from suspected arson cases. The most common accelerants encountered in the investigation of arson are liquid hydrocarbons. The identification of these materials is complicated by the fact that they are not single chemical entities but complex mixtures of hundreds of different hydrocarbons.

A number of published articles have dealt with investigation, recovery, and identification of accelerants. Laboratory aspects of the investigation of arson cases were discussed [*1,2*] as well as recovery methods, which include vacuum distillation [*3,4*], steam distillation [*5*], air flushing [*6*], and solvent extraction [*7–9*]. Methods of identification were based on such properties as odor, boiling range, density, refractive index, and flash point [*4*]. Other methods of identification include absorption on paper and fluorescence [*10,11*] and infrared spectrophotometry [*6,7*].

With the advent of gas chromatography numerous articles have appeared which propose specific identification of the type of accelerants employed based on differences resulting from variations in the manufacturing process. These articles deal with use of the thermoconductivity detector (*12–16*] and the hydrogen flame detector [*9,17,18*] in characterizing the effluent from the column of the gas chromatograph and the amplification of the signal by a linear electrometer.

Electronic capabilities have progressed to the point where instruments are now commercially available which display chromatographic data in logarithmic form [*19*]. This paper will discuss the advantages of the digital log electrometer over the conventional linear electrometer.

Digital Log Electrometer

Wide current variations experienced in gas chromatography detectors frequently cause the loss of pertinent information. This condition is most noticeable with wide range detectors, such as of the flame ionization type, when small current peaks occurring close to large current peaks are obscured. This problem does not occur, however, when information is presented in logarithmic form covering three decades or more.

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Experimental results, obtained after analyzing a number of liquid mixtures with a gas chromatograph, indicate that logarithmic presentation of ion currents from a flame ionization detector is superior to linear presentation. The advantage is realized when mixtures are composed of components of widely differing concentrations. Since signal heights of 2 percent or less of full scale are barely detectable using linear electrometers, the range must be switched one or more times during a single analysis to detect all peaks or successive analyses must be made. Each succeeding analysis must employ greater sensitivity until all useful peaks are observed. The major disadvantage of the successive analysis method is that the epxerimental conditions cannot be exactly reproduced for each analysis and, thus, widely varying results may be obtained.

The minimum detectable signal height with a linear electrometer is about 2 percent of full scale. The minimum detectable signal with a four decade logarithmic electrometer is 0.01 percent of full scale. Thus, peaks up to one ten thousandth as high as the main peaks can be observed. The dynamic range of the electrometer is 10^{-11} to 10^{-7} A.

Figure 1 shows a sample of *n*-hexane with cyclohexane. The left side of the figure shows the *n*-hexane peak with only a small peak for cyclohexane for one set of conditions on a linear electrometer. The center of the figure shows a cyclohexane peak clearly; however, the *n*-hexane peak is off scale because of the change in attenuation of the linear electrometer required to make a clear presentation of the cyclohexane peak. The right side of the figure illustrates a single presentation of both peaks by the digital log electrometer. If other hexane isomers were present in the mixture, the center illustration would show the *n*-hexane peak to have a broader base. This could be misinterpreted as only one peak if the sample being analyzed were injected under one set of conditions only.

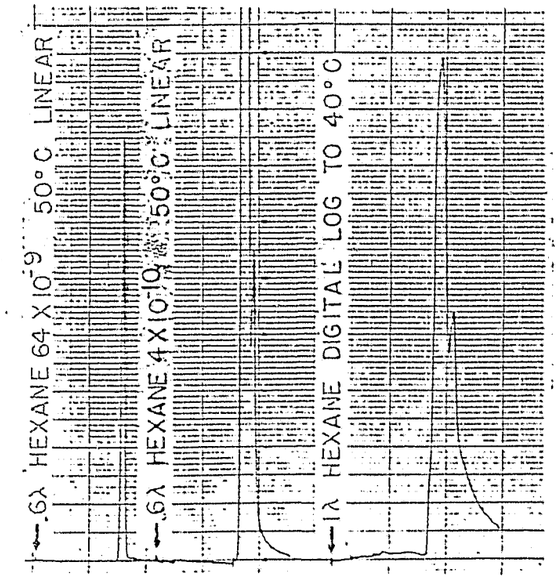

FIG. 1—*Comparison of linear electrometer and digital log electrometer presentation of n-hexane and cyclohexane analysis.*

Experimental

Equipment

The gas chromatographic analyses were made with a Varian Model 1740–1 chromatograph with a hydrogen flame detector. This model is equipped with a temperature programmer. The linear presentations were made using the Varian electrometer. The digital log presentations were made with a Victoreen Model 4010–2 digital log electrometer fitted to work on the chromatograph. A Varian Model 20 recorder was used.

Operating Conditions

The following operating conditions were implemented.

Program 1—High boiling hydrocarbons.
Injection temperature: 225 C; oven temperature: isothermal at 40 C; programming begins at time of injection, continues at 2 deg C/min for 20 min, at which time the program is increased to 10 deg C min, and ends at 250 C; detector temperature: 270 C.
Carrier gas: helium—22 psi inlet pressure, 25 ml min flow rate. Air—300 ml/min flow rate. Hydrogen—25 ml/min flow rate.
Column: 5 ft by ⅛ in. SS; 3 percent SE 30 on 100/120 Varaport 30.
Sample size: 1 μl.
Chart speed: 1 in./3 min.

Program 2—Low boiling hydrocarbons.
Injector temperature: 225 C; oven temperature: isothermal at 40 C for 6 min, after which it is programmed at 6 deg C min to 225 C; detector temperature: 270 C.
Carrier gas: helium—30 psi inlet pressure, 15 ml min flow rate. Air—300 ml/min flow rate. Hydrogen—25 ml min flow rate.
Column: 15 ft by ⅛ in. SS; 3 percent SE 30 on 100/120 Varaport 30.
Sample size: 1 μl.
Chart speed: 1 in./3 min.

Program 3—Capillary column.
Injector temperature: 200 C; oven temperature: isothermal at 40 C for 6 min, after which it is programmed at 2 deg C min to 125 C; detector temperature: 200 C.
Carrier gas: helium—35 psi inlet pressure; split, 2.5 ml/min flow rate; makeup, 22.5 ml min flow rate. Air—250 ml min flow rate. Hydrogen—25 ml/min flow rate.
Column: 200 ft by 0.01 in. inside diameter, SS, coated with Squalene.
Sample size: 1 μl.
Chart speed: 1 in./3 min.

Materials

Standards: C_6 to C_{18} paraffin hydrocarbons, Poly Science Qual-Kit No. 21.

Petroleum products: Full range of gasoline. Sixty-three specimens from Sacramento area collected in one day.

Procedure

To further illustrate the advantage of logarithmic display over linear display, a mixture of 10 paraffinic hydrocarbons, hexane through hexadecane minus pentadecane, was made up and injected into the gas chromatograph. Figure 2 illustrates the digital log electrometer display using a 1 μl sample. Figure 3 illustrates a linear electrometer display using a 0.6 μl sample. Both displays relate to samples run under the conditions of program 2. When only

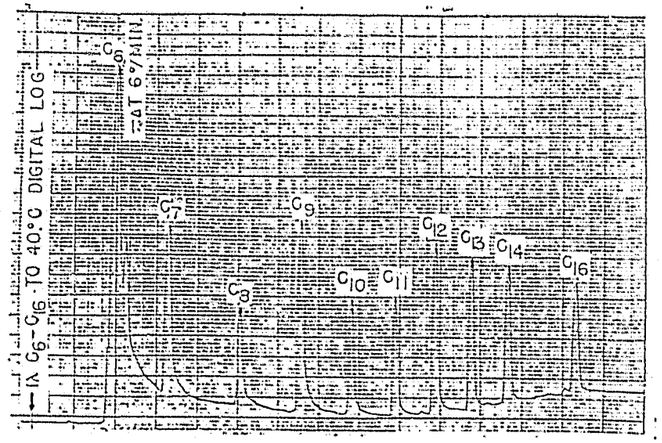

FIG. 2—*Injection of mixture of C_6 to C_{16} hydrocarbons.*

a small peak resulted from hexane in Fig. 3, it was realized that a much greater attenuation was necessary to be able to present the other hydrocarbon peaks. The sample was temperature programmed and, because of the increased sensitivity necessary to record the other hydrocarbons in the sample, there was an increase in base line drift. The same hydrocarbon mixture was again analyzed by the same procedure only this time a 1.5 μl sample was injected. Figure 4 illustrates this presentation. Note that three attenuation changes

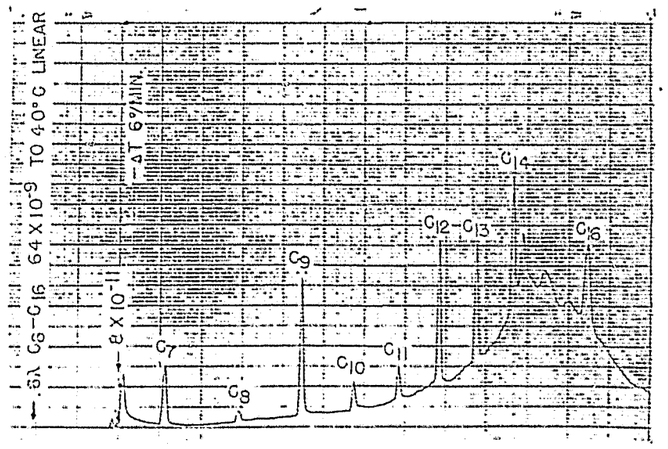

FIG. 3—*Injection of mixture of C_6 to C_{16} hydrocarbons.*

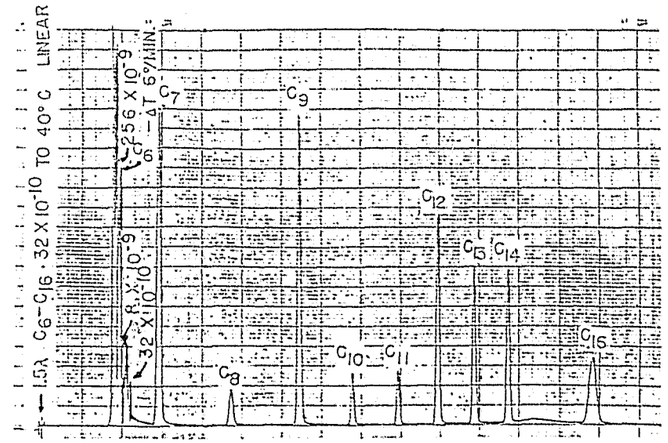

FIG. 4—*1.5 μl injection of mixture of C_7 to C_{16} hydrocarbons.*

were required to keep all peaks on scale. Although Fig. 4 presents a classical textbook gas chromatographic chart from the C_7 through C_{13} hydrocarbons, several minor peaks are not present which are visible on the digital log presentation of Fig. 2 between C_{11} and C_{12}, between C_{13} and C_{14}, and before C_{16}.

To illustrate in yet another way the advantage of the digital log electrometer over the conventional linear electrometer, 1 μl of Mohawk regular gasoline was mixed with 2.5 μl of the mixture of C_6 to C_{16} paraffinic hydrocarbons used for the displays given in Figs. 2–4 and injected into the gas chromatograph. The linear display appears in Fig. 5 and the digital log display in Fig. 6. For comparison, Figs. 7 and 8 illustrate the same gasoline without the C_6 to C_{16} paraffinic hydrocarbons added. Note that not only can the peaks be identified by injecting an internal standard with the sample (aromatic and olefinic standards are also available) but also the increased sensitivities of some of the minor components are visible because of the greater dynamic range allowed by the digital log electrometer for one analysis of the sample. Figure 5 again illustrates the loss of one peak due to the unchanged attenuation, giving one broad peak for hexane. Program 2 conditions were used to obtain the displays in Figs. 5 through 8.

Logarithmic presentation of gas chromatographic data is superior to linear presentation because it has a greater dynamic scope and does not require range switching between decades. Since the electrometer operates on an integrating principle, electronic integration of peak areas is easily obtained with greater accuracy and precision than by other methods. A complete qualitative and quantitative chromatogram and percentage composition is presented during one run and all component peaks within the 10^{-11} to 10^{-7} A range can be recognized at a glance.

Results and Discussion

Routinely a 1 μl sample of each gasoline was analyzed by program 2 using the digital log electrometer. Little or no difficulty was experienced in distinguishing between brands and grades of gasolines. Figures 9 and 10 are representations of two separate Shell regular

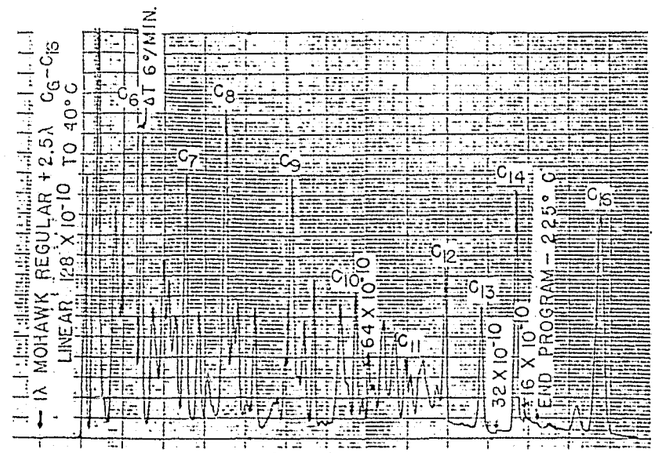

FIG. 5—*Linear electrometer presentation of an injection of a mixture of Mohawk regular gasoline and C_6 to C_{16} hydrocarbons.*

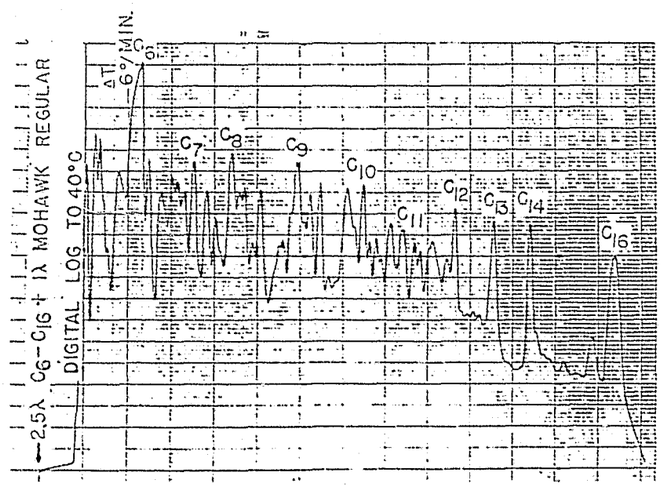

FIG. 6—*Digital log electrometer presentation of Fig. 5.*

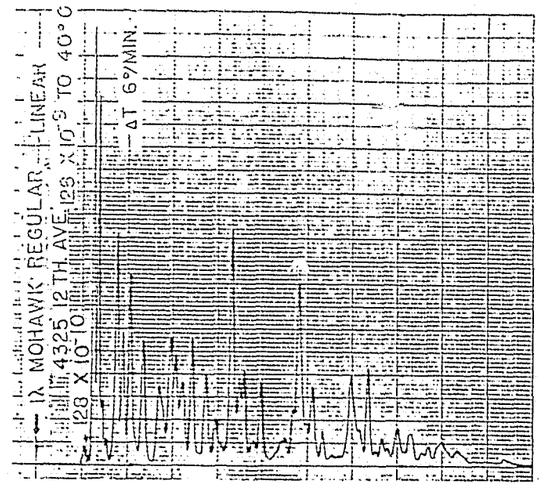

FIG. 7—*Linear electrometer presentation of an injection of a mixture of Mohawk regular gasoline without hydrocarbons.*

FIG. 8—*Digital log electrometer presentation of Fig. 7.*

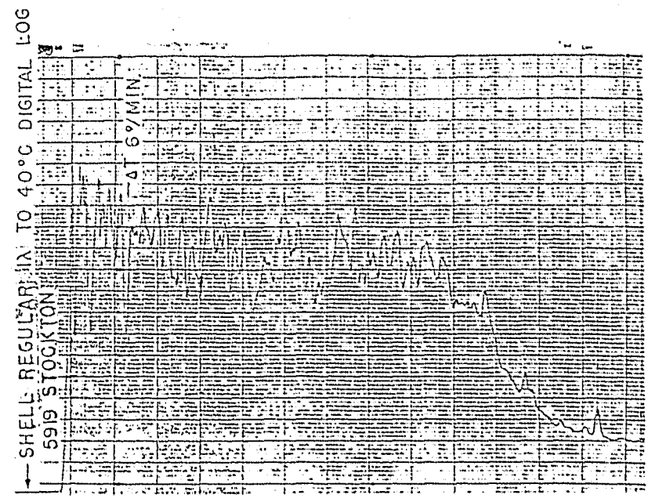

FIG. 9—*An injection of Shell regular gasoline from one gas station bulk tank.*

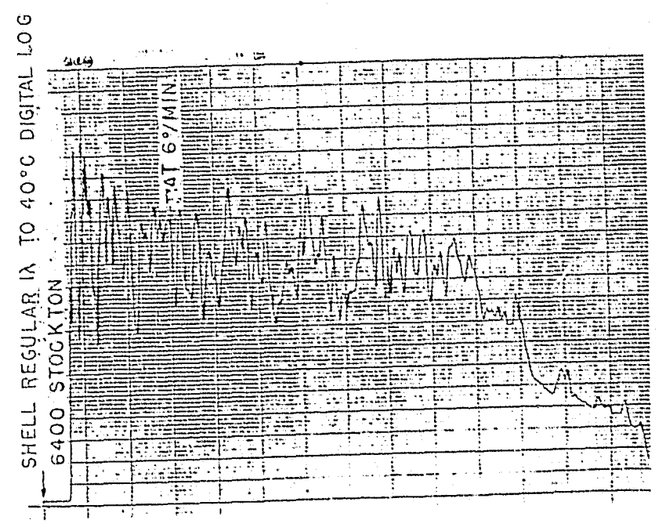

FIG. 10—*An injection of Shell regular gasoline from a different gas station bulk tank.*

gasoline samples taken from two stations about six blocks apart. It is not known whether the two stations received their fuel deliveries on the same day and from the same bulk truck. The charts suggest identification of the stations is possible, but a sufficient number of samples have not been analyzed to confirm this. Some off-brand gasoline samples gave results similar to the Shell samples, which suggests that they received their supply from the same refinery on the same bulk delivery truck.

Accelerants recovered by steam distillation from burned materials were also identified [5]. Figure 11 illustrates the recovery of 4½ ml of gasoline by steam distillation from 5 ml of Mohawk regular gasoline which had been added directly to water in the still. No appreciable loss of the low boiling fraction was noted. Figure 12 illustrates the results of an analysis of the 0.3 ml of distillate recovered from evaporation, under a hood for 1 h, of 5 ml of Mohawk regular gasoline that had been absorbed by a block of wood. When compared to Fig. 8, it can be seen that the low boilers are lost, as would be expected; however, sample recovered is readily identified as gasoline. Figure 13 illustrates the results of recovering 0.3 cm^3 of distillate by steam distillation from a block of wood which absorbed 5 cm^3 of Mohawk regular gasoline and burned for 2 min. The results are similar to those in Fig. 12. Program 2 was used during the analyses shown in Figs. 11 through 13.

Other types of hydrocarbons were also analyzed. Examination of the charts showed that the background, which is ignored in the linear electrometer in favor of peaks, was helpful in identifying the type of accelerant.

Several gasoline samples were analyzed by using the capillary column [*20–23*] and program 3. Figure 14 illustrates the results of one such analysis of a sample of the Mohawk gasoline used in previous analyses. One hundred and forty-two peaks were recorded by the capillary column, as compared to 57 peaks recorded by the 3 percent SE 30 column. However, the analysis time was more than doubled, namely, 102 min was required for elution from the capillary column as compared to 45 min for the 3 percent SE 30 column.

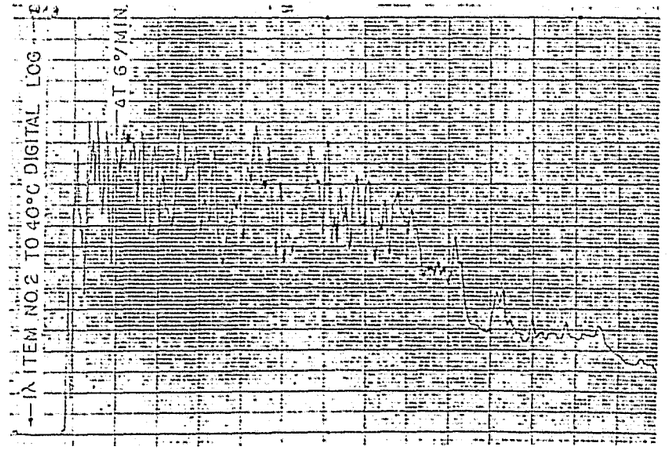

FIG. 11—*An injection of a gasoline recovered by steam distillation.*

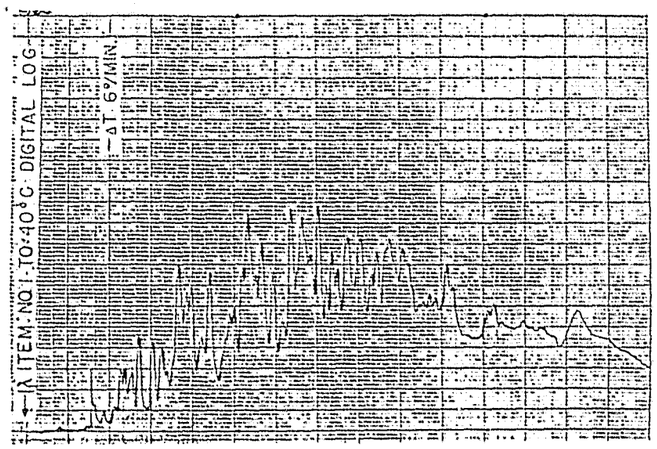

FIG. 12—*An injection of a gasoline distillate recovered from wood after allowing it to evaporate for 1 h.*

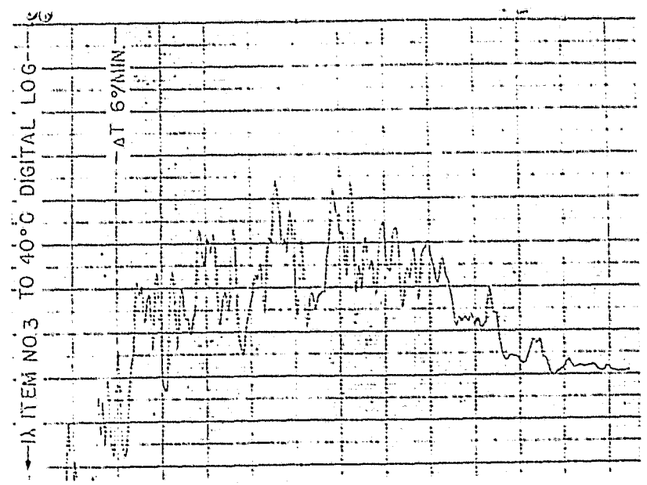

FIG. 13—*An injection of a gasoline distillate recovered from wood after burning for 2 min.*

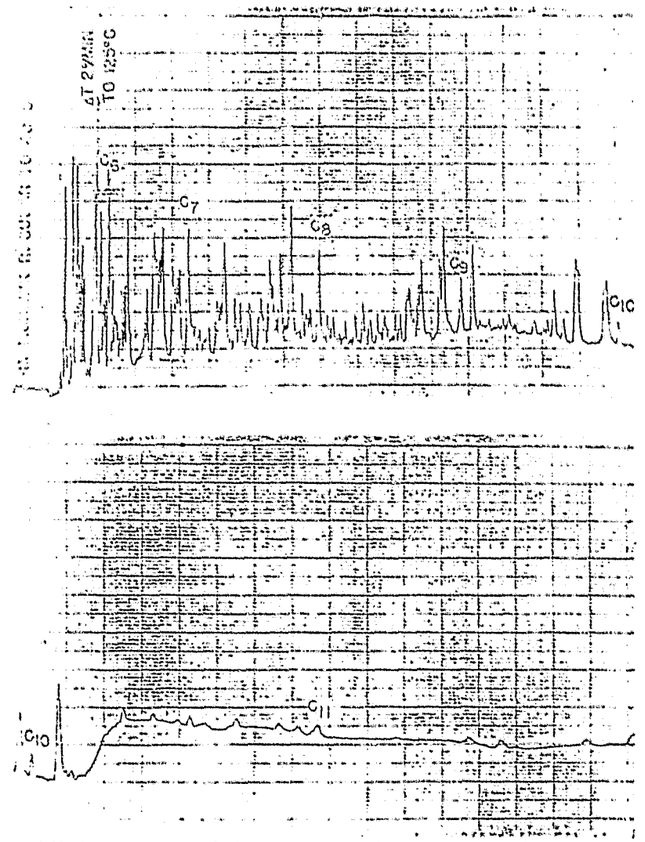

FIG. 14—*An injection of Mohawk regular gasoline employing a capillary column.*

Thus, employing the digital log electrometer with capillary columns, cryogenic temperature programming, a printout integrator with log display [*24–26*], and computer data analysis and retrieval considerably improves identification. Furthermore, the wide variance in signal intensities presented by samples analyzed by the technique offer advantages over the linear electrometer in pyrolysis gas chromatographic analyses.

Summary

The digital log electrometer presents a chromatographic pattern which provides a better means for identifying and distinguishing hydrocarbons commonly encountered as accelerants in arson. Only part of its potential has been revealed thus far using conventional columns.

Whereas transients generated by a range change in a linear electrometer may destroy valuable data, logarithmic type electronics can cover four decades of signals without a range change and provide a continuous line graph showing all of the component peaks resolved by the column. Preliminary studies using a capillary column have also been made which indicate that higher resolution is better exhibited by use of logarithmic electronics.

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APPENDIX C

Reasons for Design of a Horizontally Mounted Water Filled Bullet Recovery Chamber

Reasons for Design of a Horizontally Mounted Water Filled Bullet Recovery Chamber:

In identifying a firearm that has fired an evidence bullet, a comparison of the microscopic tool marks impressed on the bullet by the rifling in the bore of the firearm, must be made with the markings left on a test bullet fired through the barrel of a firearm suspected of firing the evidence bullet.

These test bullets must be recovered, after firing, in the most perfect condition possible. There are three acceptable mediums into which bullets can be fired, which leave the bullet in a condition to be properly examined; there are: 1) cotton, 2) oiled sawdust, and 3) water. Other mediums have been used but have usually caused bullet deformation and/or "wiping" of the rifling marks on the bullet or the recovery of the bullet has been too difficult or the medium has been too expensive, too messy or not readily available.

Favorable Points of this Design:

Of the three mediums mentioned, water is generally accepted as the best in regard to its effect on the fired bullet, bullet recovery is simple and the water is available and inexpensive. Firing on a horizontal plain closely approximates the common firing attitude..

Aluminum was used because, like Stainless Steel, it is rust proof but it is cheaper to form and weld and is considerably lighter. This chamber will accomodate the recovery of high velocity rifle bullets a factor seldom found in other chambers.

Description of the Chamber Follows:

CHAMBER, BULLET RECOVERY, WATER, HORIZONTAL, MK1
(Horizontal Bullet Recovery Water Chamber)

This chamber is a 20-inch diameter tube with an overall length of 12-feet. It is constructed entirely of 6061-T6 aluminum, which is a specially hardened aluminum, with the exception of the four carrying handles and the hatch hinges and hatch handles which are of a different grade. All the sheet aluminum is .250-inch (¼-inch) thick with the exception of the rear end (closing plate) and the baffle plate which are .500-inch (½-inch) thick.

Welded in position 16½-inches in from the firing end of the chamber, is an aluminum plate with a 9½-inch diameter hole (firing aperture) in the center of it. This is the Diaphragm Plate. A second, removable plate, with an 8½-inch hole, (firing aperture) in the center of it is located in front of the Diaphragm Plate. This is the Diaphragm Retainer Plate. This plate is held in position by eight aluminum bolts, 3-inches long by 3/8-inches in diameter which protrude from the Diaphragm Plate equally spaced around the firing aperture. The nuts used on these bolts are a special self-locking type that will not jar or vibrate loose.

Sandwiched between these two plates, and held firmly in place by the eight nuts and bolts, is a rubber Diaphragm. This rubber Diaphragm is 2-inches thick and is manufactured by Uniroyal, Inc., Engineered Systems Dept., Mishawaka, Ind. (Number 41301) It was developed

by Uniroyal for NASA as a shielding material for space vehicles. Test bullets are fired through this rubber diaphragm into the water filled chamber. As the bullet passes through the rubber, the rubber closes behind the bullet, effectively sealing the bullet hole to retain the water in the chamber.

Lengthwise on top of the chamber are three hatches (openings) closed by flush fitting hinged hatch covers. These hatches are 8-inches wide; the first and third hatches are 16-inches long, the second or middle hatch is 32-inches. Two ½-inch diameter holes are drilled in the first hatch cover to relieve any excessive hydrostatic pressure at this point. After firing a test bullet into the chamber, the appropriate hatch is opened and the fired bullet is picked up from the bottom of the chamber where it has come to rest.

Inside of the chamber, positioned 8-inches ahead of the rear end plate is a "baffle" plate. This plate is hung from a cross pin through the chamber walls and is free to swing rearward. In the unlikely event that a bullet would traverse the full length of the chamber without being sufficiently slowed by the water to drop to the bottom of the tank, it would strike this baffle plate. This baffle plate when struck by the bullet would swing rearward slightly, cushioned by the water surrounding it, absorbing the residual energy of the bullet, and allowing the bullet to drop to the bottom of the tank, virtually undeformed. Without the baffle plate, a high velocity bullet, impinging against the rear end plate, would probably suffer unacceptable deformation.

The support stand is constructed of 2-inch by 3/16-inch angle iron. The front-to-rear sway braces are bolted to the upright legs with special "silo" bolts which will not vibrate loose. The aluminum angles welded to the chamber above each upright leg eliminate any horizontal movement of the chamber in the support stand. The stand holds the chamber at a five-foot centerline height.

The front section of the chamber, ahead of the diaphragm, where the firing takes place, is lined with rubber backed nylon carpeting used in space vehicles to absorb sound. A 3-foot long extension tube can be locked onto the firing end of the chamber to accomodate the firing of rifles. This extension is also carpet lined. Special gun holding fixtures can be mounted in the firing section of the chamber to hold handguns or rifles for remote firing.

The volume of the chamber is 23.36 cubic feet. The weight of the empty chamber with the extension tube attached is approximately 297 pounds. The weight of the support stand is approximately 145 pounds. Total in-place empty weight approximately 442 pounds. When filled with water to the proper firing level, the tank will contain 145 gallons of water, weighing 1,160 pounds. Total weight in-place with extension tube, approximately 1,602 pounds.

The chamber is filled and drained by a hose attached to a valve located at the bottom of the rear end of the chamber.

CONTINUED

1 OF 2

The support stand is constructed of 2-inch by 3/16-inch angle iron. The front-to-rear sway braces are bolted to the upright legs with special "silo" bolts which will not vibrate loose. The aluminum angles welded to the chamber above each upright leg eliminate any horizontal movement of the chamber in the support stand. The stand holds the chamber at a five-foot centerline height.

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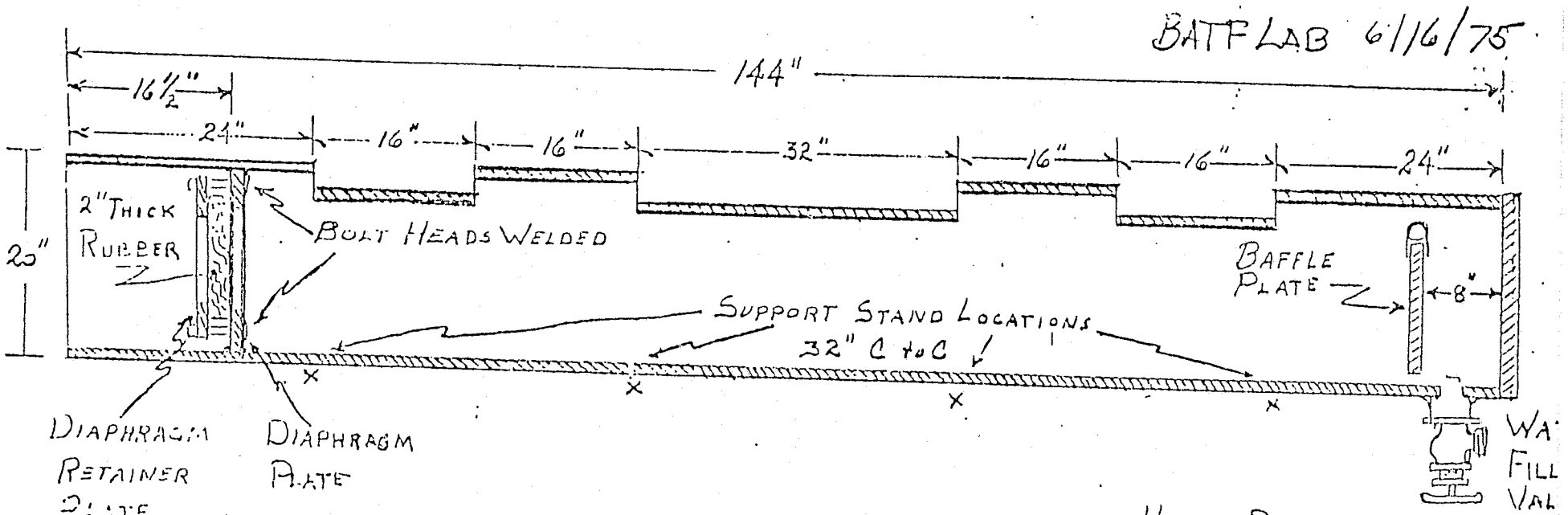
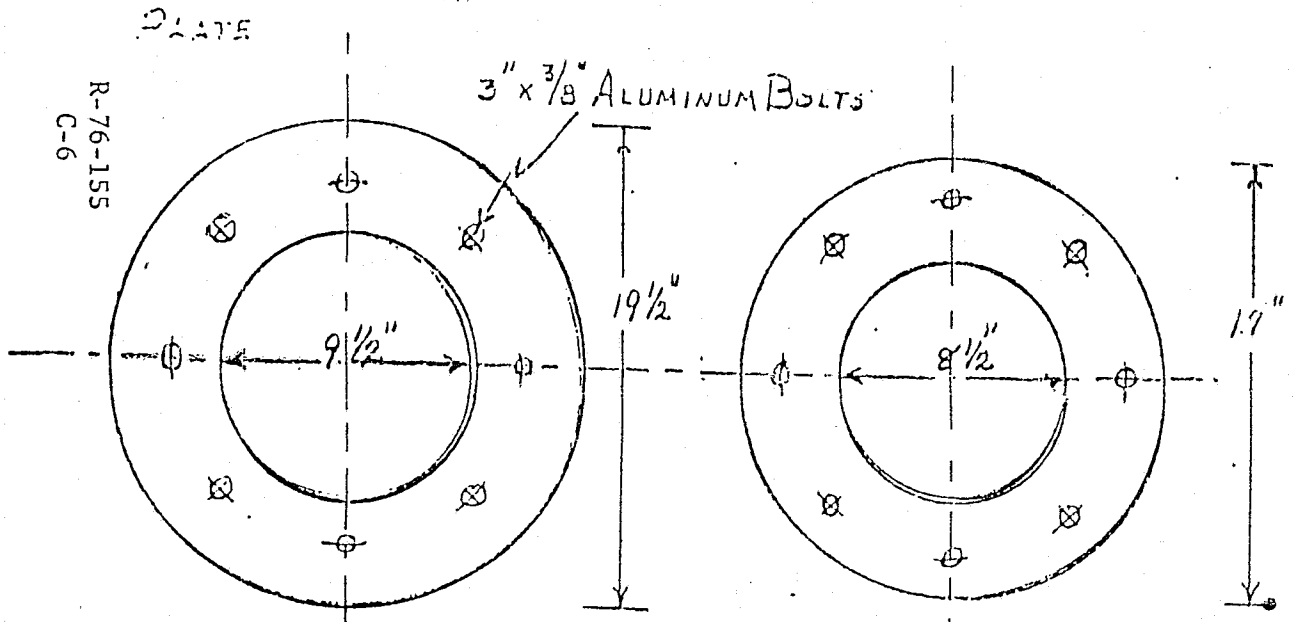
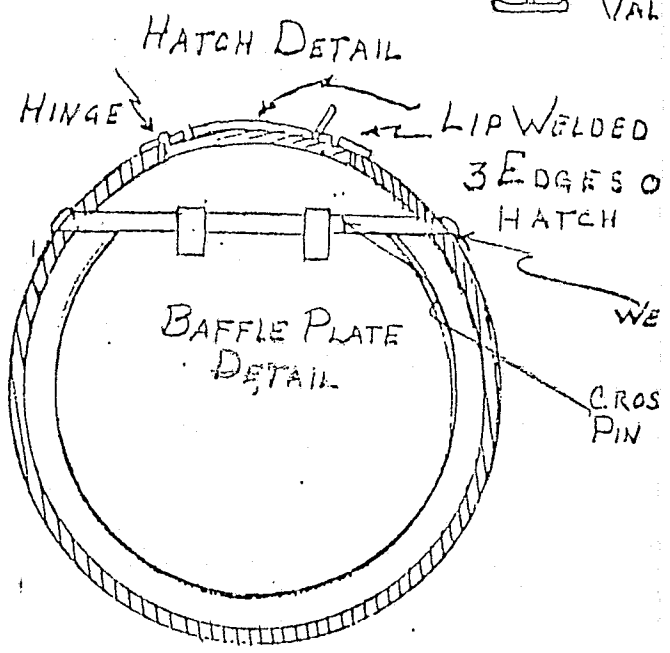
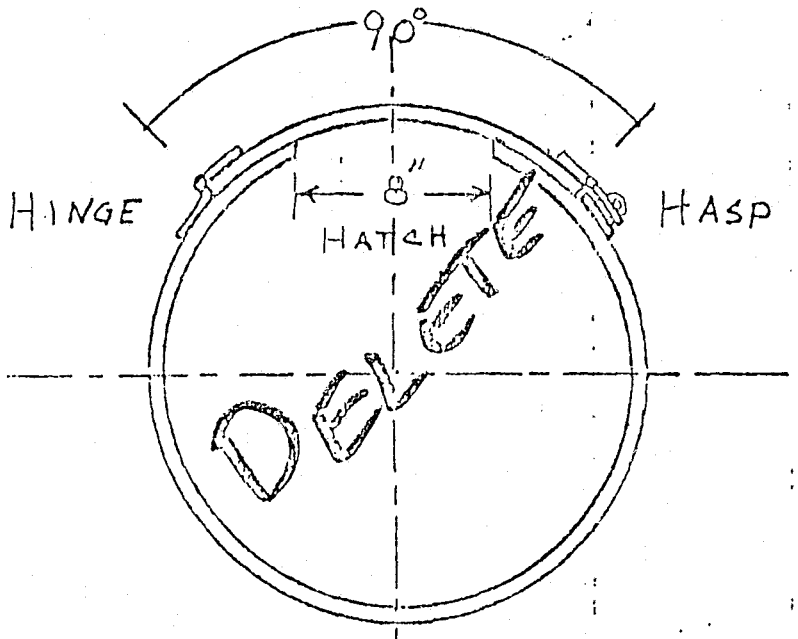
BATF LAB 6/16/75



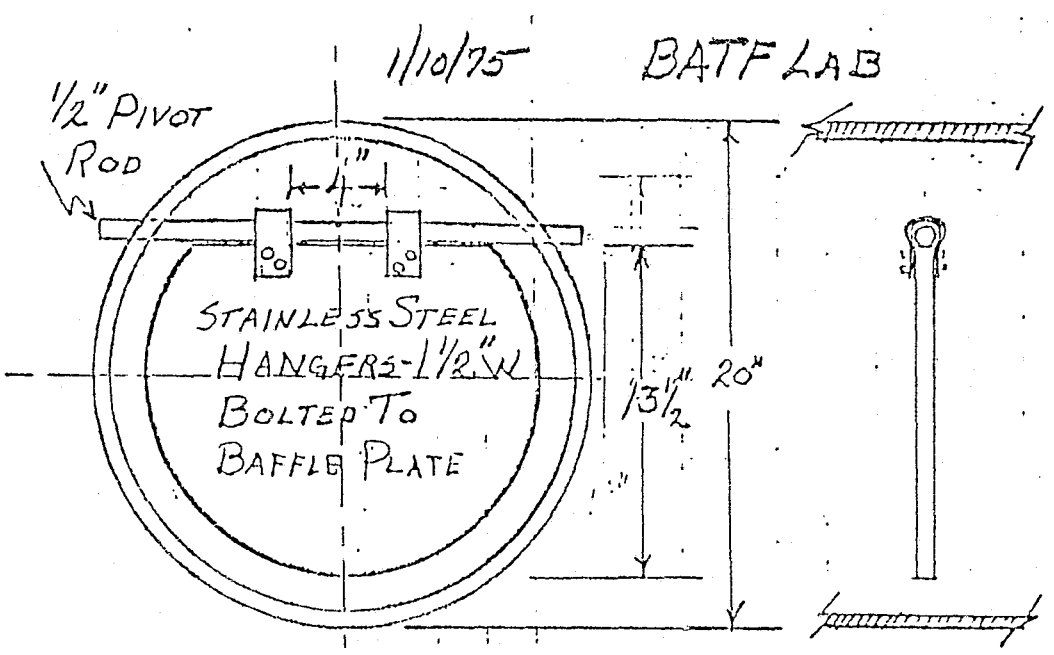




HATCH COVERS ARE MADE FROM PIECES CUT OUT TO FORM HATCH

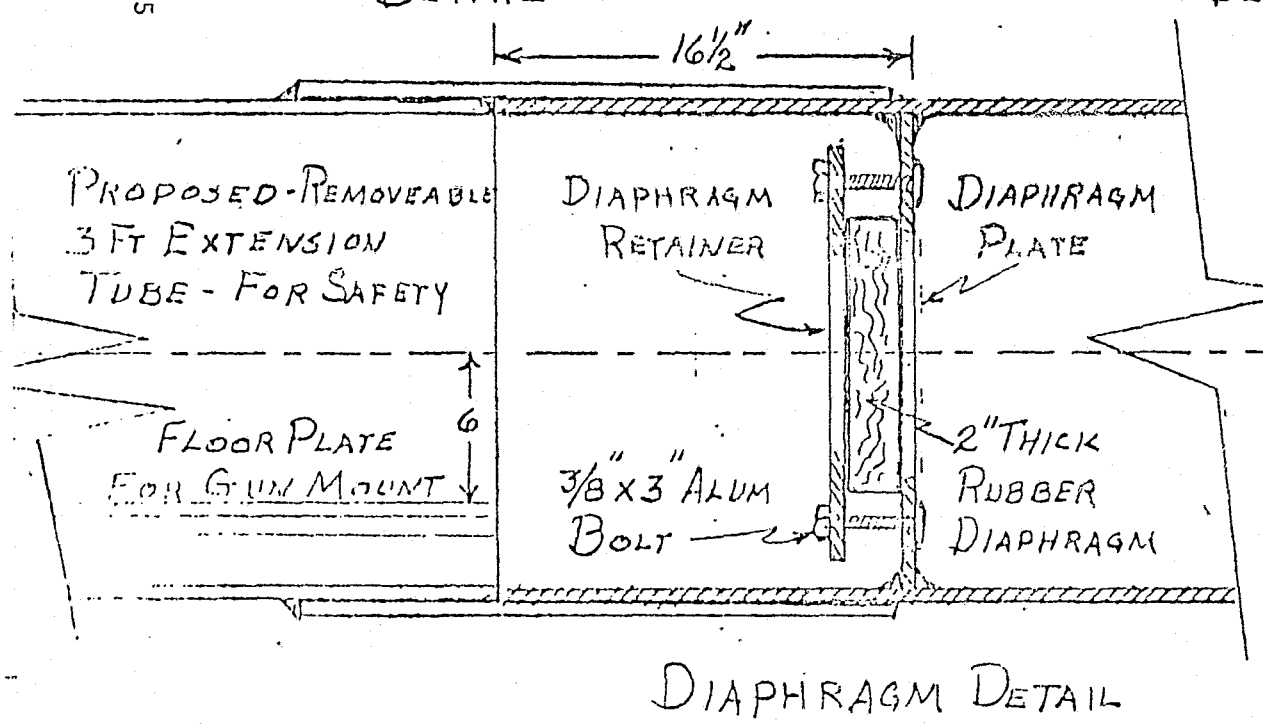


HATCH COVER DETAIL

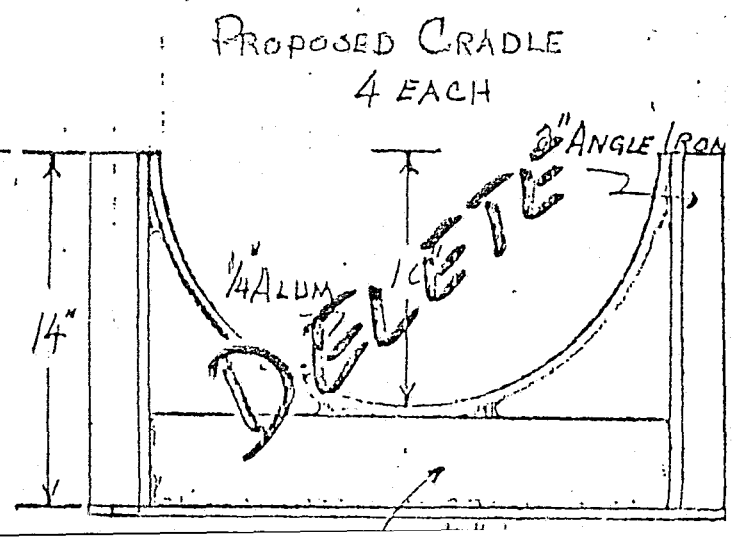


BAFFLE PLATE DETAIL

R-76-155
C-7

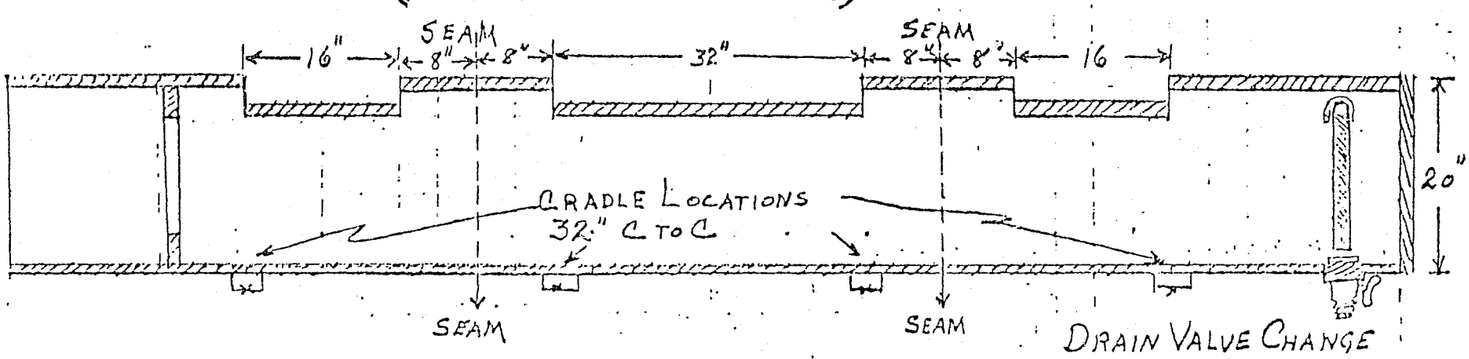


DIAPHRAGM DETAIL



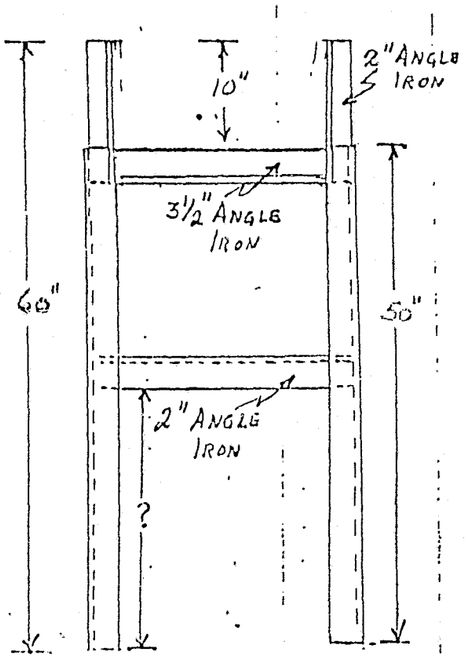
HATCH CHANGE - 3 INSTEAD OF 4
(MEASUREMENTS FROM SEAMS)

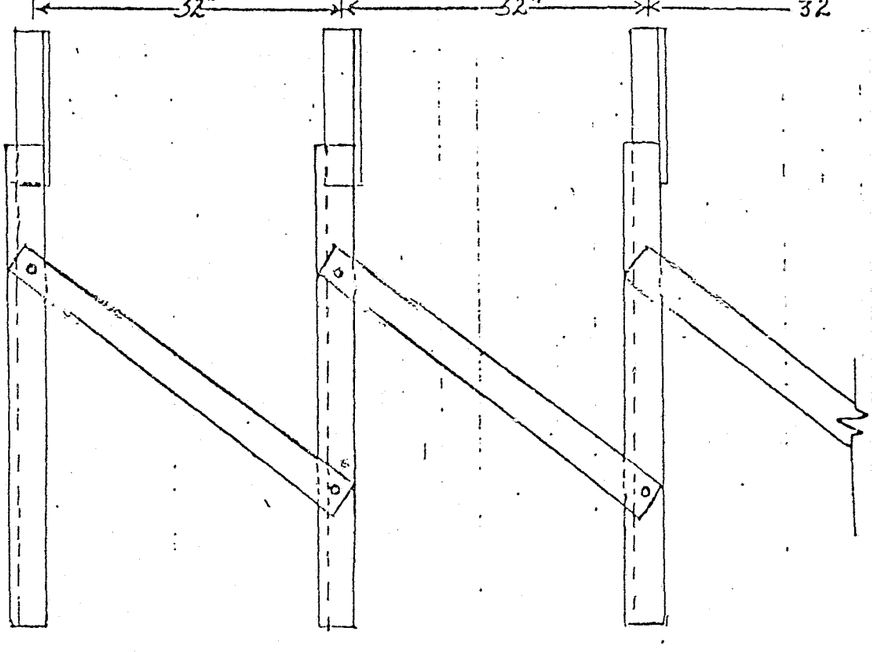
BATF LAB 6/3/75



DRAIN VALVE CHANGE
REAR INSTEAD OF FRONT

R-76-155
C-8





CRADLE CHANGE - LEGS ATTACHED

CRADLE SPACING

END