AEROSPACE REPORT NO.

EQUIPMENT SYSTEMS IMPROVEMENT PROGRAM

SYMPOSIUM SYNOPSIS
DETECTION OF GUNSHOT RESIDUE

Law Enforcement Development Group

December 1975

Prepared for

National Institute of Law Enforcement and Criminal Justice

LAW ENFORCEMENT ASSISTANCE ADMINISTRATION

U.S. DEPARTMENT OF JUSTICE

The Aerospace Corporation

Report No.
ATR-76(7915)-2

EQUIPMENT SYSTEMS IMPROVEMENT PROGRAM

SYMPOSIUM SYNOPSIS: DETECTION OF GUNSHOT RESIDUE

SUMMARY OF PROCEEDINGS AND COLLECTION OF BRIEFING CHARTS, SYMPOSIUM ON DETECTION OF GUNSHOT RESIDUE BY PARTICLE ANALYSIS, 22-24 OCTOBER 1975

Prepared by

J. E. Wessel and G. M. Wolten,
with contributions by
P. F. Jones, M. H. Mach, R. S. Nesbitt, A. R. Calloway, and A. Pallos
Laboratory Operations

December 1975

Law Enforcement Development Group
THE AEROSPACE CORPORATION
Washington, D. C.

Prepared for

National Institute of Law Enforcement
and Criminal Justice
LAW ENFORCEMENT ASSISTANCE ADMINISTRATION
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Report No.
ATR-76(7915)-2

EQUIPMENT SYSTEMS IMPROVEMENT PROGRAM

SYMPOSIUM SYNOPSIS: DETECTION OF GUNSHOT RESIDUE

Summary of Proceedings and Collection of Briefing Charts, Symposium on Detection of Gunshot Residue By Particle Analysis, 22-24 October 1975

Approved

S. Siegel, Director
Chemistry and Physics Laboratory

John O. Eylar, Jr., General Manager
Law Enforcement and
Telecommunications Division

ABSTRACT

On 22-24 October 1975, The Aerospace Corporation, at the request and with the assistance of the Law Enforcement Assistance Administration of the U.S. Department of Justice, sponsored a demonstration-familiarization seminar on the LEAA/Aerospace-developed particle analysis method of gunshot residue detection. Twenty persons from 18 forensic laboratories participated.

This report briefly summarizes the background and proceedings of the seminar, as well as some of the comments and conclusions of the participants. The appendices contain all the briefing charts used in the seminar, but no attempt is made to re-create the concomitant oral presentations. The principal purpose of this report is to provide the participants with a permanent record of the vugraphs presented.

ACKNOWLEDGMENTS

The support and encouragement of the National Institute of Law Enforcement and Criminal Justice, in particular Messrs. John Sullivan, Joseph Kochanski, George Schollenberger and Lester Shubin, are acknowledged with special thanks.

Thanks are due to Mr. David Epley and the Philips Corporation for the loan of a second standby EDAX unit.

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I. INTRODUCTION

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Crimes involving firearms, because of their large number and their seriousness, constitute a large workload for every crime laboratory and coroner's office. Frequently, the detection of gunshot residue on a suspect's hands or clothing is an important link in the chain of evidence that can tie the suspect to the crime. Unfortunately, present methods for the identification of gunshot residue often give inconclusive results.

Since January 1974, The Aerospace Corporation, under contract to the Law Enforcement Assistance Administration of the U.S. Department of Justice, has investigated improved methods for the detection of gunshot residue on suspects' hands. Actual and potential methods were evaluated, and the opinions, practices, and needs of crime laboratories were canvassed —leading to a survey and assessment report (Ref. 1).

Luminescence methods for the detection of lead and antimony were developed and described in two reports (Refs. 2 and 3). Further developments in this area may be forthcoming.

An additional result of the Aerospace studies was that the organic constituents of gunpowder were determined and sometimes detected in residue. This work is still incomplete and unpublished.

In the opinion of The Aerospace Corporation developers, the method that presently offers the best prospects for the identification of gunshot residue with a far greater degree of certainty than any scheme for elemental analysis alone, is the particle analysis method (Ref. 4) using scanning electron microscopy coupled with elemental x-ray analysis. It was shown that the barium, antimony, and lead content of residue is concentrated in discrete particles, often spherical in shape, and that particles of similar appearance having this composition have not been found in the environment to-date.

By the summer of 1975, Aerospace had examined the results of about 200 test-firings; a similar number of handblanks were also collected and examined. No false positives were obtained at any time. No false negatives were found when the residue was collected promptly, and very few were found when collection was delayed for up to four hours.

In order to firmly establish the utility of the method for police investigative use, the Aerospace group deemed it necessary to proceed further along several lines:

1. Gather data on a much larger number of test firings, using a greater variety of guns and ammunition
2. Greatly extend the survey of environmental contaminants that might possibly resemble gunshot residue
3. Explore much further the question of the persistence of residue on the hands for different types of guns and ammunition--possibly based on more quantitative data, such as number of particles (and their size distribution) as a function of time
4. Consider in greater detail the problems of evidence collection, transportation, and examination in actual field use.

In March 1975, Aerospace briefed the National Institute of Law Enforcement and Criminal Justice of the Law Enforcement Assistance Administration on the then current status of the program. It was decided that the most expeditious way to achieve the extensive objectives outlined above was through a cooperative program between Aerospace and a number of the ultimate potential users of the method, i.e., practicing crime laboratory personnel.

To initiate such a joint effort, crime laboratory analysts who were willing and able (i.e., equipped to practice the method) to cooperate were invited to a demonstration-familiarization seminar held at The Aerospace Corporation. With the aid of Mr. John O. Sullivan of the National Institute of Law Enforcement and Criminal Justice, the announcement was drafted and mailed to about 300 crime laboratory directors, department heads, and coroners on 8 September 1975.

Many expressions of interest were received, and it developed that the availability of scanning electron microscopes in the crime laboratory community was somewhat more widespread than had been anticipated. When the symposium took place on 22-24 October 1975, it was attended by 19 persons representing 17 laboratories for the full symposium and one additional person attending the first day as a guest. Since that time, two additional laboratories have indicated that they are acquiring the equipment and desire to be kept informed. A list of the participants appears in Section III of this report.

II. SUMMARY OF PROCEEDINGS

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A. SUMMARY

The symposium began with the firing of a variety of handguns by the participants in order to provide gunshot residue for subsequent testing and to demonstrate the current collection method developed under this program.

The remainder of Wednesday morning was taken up with a brief introduction to The Aerospace Corporation, a description of the Corporation's overall forensic programs, and an introduction to the particle analysis method of gunshot residue detection (see the Appendices). The morning session concluded with a brief talk and demonstration of computer processes for image enhancement and a demonstration of the equipment and technique for placing a conductive coating over the gunshot residue specimens for examination in the scanning electron microscope.

In the afternoon, the samples and handblanks collected that morning were analyzed on the scanning electron microscope in the presence of the participants in order to demonstrate most of the features of gunshot residue and of handblanks that are used in the analysis. This was done in two alternating groups. While one half of the participants were using the microscope, the other half was given a tour of selected laboratory facilities, and then the groups exchanged places.

The description of the particle analysis method was concluded on Thursday morning. Work on elemental analysis for lead and antimony by luminescence methods was described, as well as the present status of our work on organic constituents of gunshot residue.

The remainder of Thursday as well as Friday morning were devoted largely to group discussions which explored all aspects of the particle analysis method, its relation to other methods, the additional tasks that should be performed, and the tasks that the participants might undertake. Highlights of the discussions and conclusions are presented below.

During the demonstration on the scanning electron microscope, particular emphasis was placed on attempting to locate the particles of interest quickly and on performing an elemental analysis.

The current Aerospace operating criteria were stressed repeatedly, namely that the simultaneous presence of any two of the elements—lead (Pb), antimony (Sb) and barium (Ba)—in spheroidal particles of 1-10 micrometer diameter is reliable evidence for gunshot residue, provided that other elements characteristic of other environmental origins are absent. The simultaneous presence of bromine (Br) with lead identifies automobile exhaust particles.

Photographs of representative gunshot residue particles and some non-residue (environmental) handblank particles were distributed; these are reproduced in Appendix C of this report.

During the discussions, it was suggested that the criteria for selecting particles for analysis, and for classifying them as either gunshot residue or not, still contain much "art" and have not yet been defined with enough objectivity and precision. The development of more firmly based criteria was recognized as one important goal of the cooperative effort. In support of this cautious view, participants recalled the premature use of neutron activation analysis data. In response to this concern, it was emphasized to the participants that (in our view) one of the most important tasks was collection of extensive handblank data representing all geographic regions and occupations. There was general agreement that court tests of particle analysis results should be avoided until the participants were satisfied that the range of possible handblank particles had been adequately explored.

To illustrate the point just made, in firing samples collected after considerable delay, 1-10 micrometer particles containing only lead predominate, often with no indication of barium or antimony (at least for the gun-cartridge combinations used in the Aerospace work). Although such particles have not been found in handblanks to date, their occurrence from environmental sources does seem possible. If indeed they do not occur, much more extensive data are needed to prove it; if they do exist then it will be important to be able to differentiate these environmental lead particles from similar gunshot residue particles.

These considerations may become even more important when the present fragmentary information on the persistence of particles on the hand becomes more complete. Recently, it was discovered--and the participants were so informed--that particles less than 1 micrometer in size are far more numerous than those larger than 1 micrometer, but that these smaller particles are largely non-spherical. Since it appears that the persistence of particles may be inversely related to their size, more reliance may have to be placed on these smaller particles as the time between firing and collection is lengthened.

The ability to reliably identify gunshot residue if apprehension of a suspect, and hence collection of evidence, is delayed for many hours is a most important aspect of any method. One criminalist asserted that the particle analysis method would stand or fall on this ability. No one disagreed with the importance of this aspect, but some felt that the criminalist may have overstated the case, since (at least in some experiments) the particles have already shown a slower decline with time than the amounts of metals found by elemental analysis methods.

Both the Federal Bureau of Investigation laboratory (V.S. Matricardi) and The Aerospace Corporation committed themselves to emphasize studies of particle persistence in their future work; some other participants indicated similar intentions. Aerospace further agreed to perform analyses of handblanks sent by cooperating laboratories. This would enable them to collect more specimens than they might be able to analyze themselves.

B. BLIND FIRING TESTS

As a test, six criminalists were given the opportunity to select guns and fire them in the absence of Aerospace personnel. Specimens were collected from three participants immediately after firing and the remaining three were sampled two hours after firing. These specimens were then analyzed by Aerospace personnel and the results were reported at the end of the symposium. Detailed results are reported in Appendix B, pages B-22 through B-24. The particle counts and analyses were performed "blind" without any knowledge of what transpired at the range. The brief interpretations given in the charts were made subsequent to disclosure and are therefore limited to stating whether the observations are consistent with the known facts.

Criminalists were impressed with the difficulty of deciding whether a person had fired a gun, based on the mere presence of residue on the hand. All agreed to pursue development of methods to make this determination. Therefore, all laboratories agreed to collect specimens from both firing and non-firing hands in their future work; the differences between these hands may be helpful in making this assessment. Several criminalists asserted that the mere presence of residue is normally sufficiently strong evidence for use in the typical court situation. The Aerospace results, however, point to the danger of deposit of residue on bystanders. Presumably the spatial distribution does differ significantly, and participating laboratories will study this effect. A highly significant point emphasized by this demonstration was that valid handblanks must be obtained from persons who have not been exposed to firing range or gun contamination. Recent Aerospace tests have shown that residue is widely deposited in the firing range vicinity, and that it is retained by clothes, for example. Therefore it is advised that personnel participating in test firings or firing practice not be included in handblank surveys.

During discussion sessions, participants related their own experiences with scanning electron microscope analysis of residue. Mr. Matricardi of the Federal Bureau of Investigation had already examined particles from a handsample obtained using a .45 caliber handgun. He reported that the majority of particles were less than 5 micrometers in diameter. The web area of the hand was richest in particles for the .45 automatic pistol, whereas the back of the hand showed more particles for the .38 caliber revolver. The samples were collected directly on tape adhesive attached to the hand. Mr. Matricardi also discussed problems associated with secondary excitation of x-rays. If a particle being analyzed is near another particle, high energy x-rays emitted by the former particle may excite lower energy x-ray transitions in the surrounding material. This can generate false elemental lines. Therefore attention should be given to analysis of well separated particles.

After observing the Aerospace demonstrations, some criminalists indicated that the time and skill requirements may be drawbacks to the method. Although it was shown to be exceedingly rapid and reliable for immediately-collected firing samples, extensive analysis by a highly trained operator was required for sparse specimens. Some observers suggested the appealing alternative of automated scanning. This would be highly desirable, but rather expensive in terms of instrumentation. It was suggested that use of backscattered electron detection could provide better differentiation of heavy elements in the rapid scan mode, and thus speed analysis. Evaluation will be undertaken by one of the participating laboratories.

C. OTHER RELATED WORK

In addition to the main activity on scanning electron microscopy detection, a general outline of the Institute-sponsored program for detection of gunshot residue was presented, and other work at Aerospace related to inorganic photoluminescence, molecular luminescence, and organic component residue detection methods was discussed.

The major emphasis in the program has been to develop a systems approach to achieve rapid analysis at the small laboratory level combined with conclusive detection at the regional laboratory level. Most participants did not seem to appreciate the importance of a low cost screening technique. They would choose to screen with the most powerful technique available to avoid false negatives. Some suggested that elemental detection should be performed first. If positive, the results should be allowed to stand without confirmation by the scanning electron microscope. This position was based on the current acceptability of element analysis positive results. Those expressing this view would propose that negative specimens be subjected to further analysis by the microscope. Clearly an optimum approach is to compare performance of this method with the elemental methods as applied to actual case situations. This will be a product of the cooperative program.

The elemental detection method based on inorganic photoluminescence that has been developed at Aerospace was discussed in some detail because it might serve in the role of a low cost screening procedure. In addition to extensive firing data, these Aerospace studies included an evaluation of residue transfer from the firing to the non-firing hand or to the pocket, and an examination of how residue deposit depended on the time delay between firing and sample collection. Although it was possible to detect antimony above background levels on the hand up to three hours after firing, it would not be possible to obtain positive results based on current Bureau of Alcohol, Tobacco and Firearms criteria for the antimony threshold. This suggests that success could be obtained by lowering the threshold level separating positives and negatives from 0.2 microgram to about 0.01 microgram antimony. Then about 80 percent of .32 caliber pistol firings could be identified four hours after firing (none of the one-hour firing samples would be judged positive using current Bureau criteria). This approach becomes even more compelling when extrapolated to .22 caliber pistols and for .22, .32, and 38 caliber revolvers, which typically produce less antimony than the Bureau threshold immediately after firing.

Several laboratories, including the L.A. Coroner's Office, expressed interest in testing and evaluating the molecular luminescence method. They were provided with detailed explanations of procedures and will borrow necessary supplementary equipment.

Current efforts to develop detection methods based on organic components of residue were also discussed. This approach may lead to a low cost detection method which is highly specific for residue. Recent results show that nitroglycerine and other characteristic organic compounds can be detected in partially burned smokeless powder particles. Also, there is some evidence that these materials can be found as a film on the hand. Criminalists were interested in the potential ability to detect brand differences in the residue from gunpowder. A potentially severe limitation to the general use of organic components may be that they frequency occur only in low concentrations.

D. MISCELLANEOUS

Mr. Lentini of the Georgia Bureau of Investigation wondered to what extent existing data on the particle analysis method would apply to long guns (rifles and shotguns). Dr. Krishman of the Canadian Ministry of the Solicitor General said that they would study this aspect. In Canada, the ratio of handguns to long guns encountered in firearms cases is approximately the inverse of the corresponding ratio for the United States.

Miss Campbell of the Cuyahoga County (Cleveland) Coroner's Office raised the question of analyzing gunshot residue in the presence of blood. Her laboratory will make available a body of statistical data on firearms cases with respect to distribution of types of weapons used.

Mr. Lentini of the Georgia Bureau of Identification will survey the present availability of scanning electron microscopes and x-ray analysis in crime laboratories.

The Aerospace Corporation presented a few preliminary results of an electron diffraction analysis of gunshot residue. Elemental lead and graphite, and the compounds PbS, $PbO \cdot PbSO_4$, and $BaSb_2O_6$ and possibly Sb_2O_4 were identified.

All participants were urged to publish their results and to participate in a panel discussion on the subject that is scheduled for the Washington, D.C., meeting of the American Academy of Forensic Sciences in February 1976. It was agreed that the participants would maintain communications by means of a newsletter. The Aerospace Corporation agreed to handle the mechanics of distributing it.

At the conclusion of the symposium the participating criminalists expressed appreciation to the National Institute of Law Enforcement and Criminal Justice for its generous support and encouragement.

III. PROGRAMMATIC SYMPOSIUM DATA

Copy of Symposium Announcement

List of Participants

Agenda

Letter by Participants to J. O. Sullivan

Equipment List

THE AEROSPACE CORPORATION

Post Office Box 92957, Los Angeles, California 90009, Telephone: (213) 648-5000

8 September 1975

Dear

A potential method for identifying gunshot residue based on scanning electron microscopy combined with x-ray elemental analysis has been developed under research supported by the National Institute of Law Enforcement and Criminal Justice. The research was conducted by The Aerospace Corporation under contract to the Institute, the research center of the Law Enforcement Assistance Administration.

The combination of morphological features of micron-sized particles found on the hand of someone who has fired a gun, with information on the composition of these particles may provide a specific and sensitive method of positively identifying gunshot residue.

An evaluation of the usefulness of this technique to practicing crime laboratories has been authorized by the National Institute. Crime laboratories equipped for scanning electron microscopy with elemental x-ray analysis are invited to send their electron microscopist to a familiarization/demonstration seminar at The Aerospace Corporation, Los Angeles, California on October 22-24, 1975. One of the goals of this meeting is to enlist the cooperation of the participants to, help generate sufficient data to determine if this method is valid for court purposes. Funds for travel and accommodations can be provided for a limited number of candidates who would not otherwise be able to attend.

Participants are expected to report their findings at a special seminar to be held at the 1976 Annual Meeting of the American Academy of Forensic Sciences in Washington, D.C.

Interested parties should immediately contact:

Dr. G. M. Wolten
The Aerospace Corporation
P.O. Box 92957
Los Angeles, California 90009

FINAL LIST OF PARTICIPANTS, GUNSHOT RESIDUE SYMPOSIUM, OCTOBER 22-24, 1975

Name	Organization	Address
Baxter, Linda	See Jao, Dr. Lucy	–
Camp, Dr. Michael J.	State of Wisconsin Department of Justice Crime Laboratory Bureau	4706 University Ave. Madison, Wisconsin 53702
Campbell, Barabara	Coroner's Office County of Cuyahoga	2121 Adelbert Rd. Cleveland, Ohio 44106
Culbreth, Ken	North Carolina Bureau of Investigation	421 N. Blount St. Raleigh, N. C. 27601
Fletcher, Larry	Southwestern Institute of Forensic Sciences	(5230 Medical Center Drive) P. O. Box 35728 Dallas, Texas 75235
Gonzalez, Gary	Criminalistics Laboratory Orange County Sheriff's Office	P. O. Box 449 Santa Ana, Ca. 92702
Hanger, John	See Taylor, Marc	–
Heideman, Dale	Criminal Investigation Bureau Florida Dept. of Law Enforcement	P. O. Box 1489 Tallahassee, Florida 32302
Hodgkin, Dr. Norman	(Consulting Laboratory) Cooperating with Crime Lab. Orange County Sheriff's Office	3855 Birch St. Newport Beach, Ca. 92660
Horan, Cpt. James	Crime Laboratory New York City Police (also represents John Jay College of Criminal Justice)	235 E. 20th St. New York, N. Y. 10003

Name	Organization	Address
Jao, Dr. Lucy and Baxter, Linda	Criminalistics Laboratory Los Angeles Police Dept.	Parker Center 150 N. Los Angeles St. Los Angeles, Ca. 90012
Kopina, Michael	Bureau of Identification State of Illinois	515 E. Woodruff Rd. Joliet, Illinois 60432
Krishnan, Dr. Chris	Ministry of the Solicitor General The Centre of Forensic Sciences Public Safety Division	25 Grosvenor St. Toronto, Ontario M7A 2G8
Lentini, John	State Crime Laboratory Georgia Bureau of Investigation	P. O. Box 1456 Atlanta, Georgia 30316
Matricardi, Victor R.	Criminalistics Laboratory Federal Bureau of Investigation	9th and Pennsylvania Aves, N.W. Washington, D. C. 20535
Rosansky, Stuart	New York State Police Scientific Laboratory	State Campus Albany, N. Y. 12226
Saferstein, Dr. Richard	Forensic Science Bureau New Jersey State Police	P. O. Box 7068 W. Trenton, N. J. 08625
Stumbaugh, Nicholas P.	Office of the Sheriff San Mateo County	Hall of Justice and Records Redwood City, Ca. 94063
Taylor, Marc and Hanger, John	Dept. of Chief Medical Examiner-Coroner, Los Angeles County	1104 N. Mission Rd. Los Angeles, Ca. 90033
First Day Only: Howard, Dr. A. John	Dept. of Industrial and Forensic Science	180 Newtownbreda Rd. Belfast, Ireland, BT8 4QR

ADDITIONAL LABORATORIES NOW ACQUIRING EQUIPMENT
AND WISHING TO BE KEPT INFORMED

Name	Organization	Address
Smith, D. D.	Region 2 Crime Laboratories State of Missouri	321 E. Chestnut Traffic Way Springfield, Missouri 65802
Briner, Dr. R. (Longwell, Mr. R.)	LEAC Crime Laboratories State of Missouri	Southeast Missouri State University Cape Girardeau, Missouri 63701

SYMPOSIUM AGENDA

Symposium on Detection of Gunshot Residue

Aerospace Corporation, El Segundo, Ca.

October 22-24, 1975

Wednesday

8:30 A.M.	Bus Departs from Quality Inn
8:45	Arrival at Aerospace, Building A1, Badges Issued
9:00	Test Firing and Sample Collection, Room 151, A1 Basement
9:15	Coffee, A1-3032
9:30	Briefing: A1-3032
	Welcoming Address, Dr. Seymour Siegel, Director Chemistry and Physics Laboratories
	Introduction, Dr. Peter F. Jones
	Review of Past Gunshot Residue Work Based on Scanning Electron Microscope (SEM)
11:00	Demonstration of Image Enhancement, A3-2218
11:15	Walk to Laboratories, Building 130
11:30	Observe Carbon Coating Operation Applied to Gunshot Resideu
12:00	Lunch, Officer's Club
1:00 – 5:00 P. M.	SEM Demonstration and Tour (2 Groups Alternating)
5:15	Bus Departs for Quality Inn

Thursday

8:30 A. M.	Bus Departs from Quality Inn for Building 130
8:45	Review of Previous Day and Report by Participants of Detection Experience, Room 428
9:30	Coffee
9:45	Briefing and Demonstration of Molecular Photoluminescence of Residue and Organic Constituents of Residue
10:45	Discussion of Tasks to be Undertaken by Laboratories
12:00	Lunch, Officer's Club
1:00 P. M.	Division of Tasks, 130-428
3:00	Coffee
3:15	Hands on SEM Experience (Other activities such as Molecular Photoluminescence, GC/MS Analysis, and Blood Analysis will be available to those interested)
5:15	Bus Departs for Quality Inn
6:15	Pick-up for Dinner and Business Meeting
8:15 (Approx)	Return to Hotel

Friday

8:30 A. M.	Pick-up from Hotel
9:00	Discussion Finalizing Tasks, Work Plans, and Reporting Procedures
12:00	End of Symposium, Lunch

At the request of the participants, the Agenda was modified to include additional test firings, with sample collection delayed for some, to be analyzed blind. This was done Thursday morning at 11:30. The analyses were performed Thursday afternoon and evening. The results were reported and discussed in the Friday morning session; they can be found in Section II.

LABORATORY TOURS, Wednesday, Oct. 22.

At the conclusion of the morning briefing in A1-3032, Claude Patterson will give a brief description of a computer image enhancement process (11:00 A.M.). We will then proceed to his laboratory, A3-2218, to view a demonstration of the process, using examples from ERTS (Earth Resources Technology Satellite).

AFTERNOON TOUR, Oct. 22.

Time	Location	Subject/Personnel
1:15 and 3:00	120-2842	FAR INFRARED LASER IMAGING. F. Foote or S. King. Detection of hidden objects – hard.
1:25 and 3:10	120-2024	ACOUSTIC HOLOGRAPHY. W. Fenner, G. Stewart Detection of hidden objects – soft. Imaging of interior structure.
1:40 and 3:25	120-2438/ 2426	ESCA and Auger Electron Spectroscopy. R. Phillips and G. Stupian. Capabilities, lateral and vertical resolution of these two complementary techniques.
1:55 and 3:40	130-755/ 770/ 339	FORENSIC SCIENCE, Research and case work. P. F. Jones and Staff.
2:30 and 4:15	130-388	FAILURE ANALYSIS LAB. (INTEGRATED CIRCUITS) J. H. Richardson and Staff. Micro radiography, optical and SEM examination of circuitry.
2:45 and 4:30	130-1310	"IMMA" (Ion Molecular Mass Analyser) W. Stuckey. Capabilities, applications; P. F. Jones, Forensic Applications.

These tours take place concurrently with the SEM demonstration of gunshot residue detection. One half of the group will tour first and then go to the SEM, the other half of the group will do the reverse.

THE AEROSPACE CORPORATION

Post Office Box 92957, Los Angeles, California 90009, Telephone: (213) 648-5000

28 October 1975

Mr. John O. Sullivan
NILECJ
U. S. Dept. of Justice
Washington, D. C.

Dear Mr. Sullivan:

The participants in the symposium on gunshot residue detection that was held at The Aerospace Corporation on 22-25 October 1975 drafted the attached statement during the final session, coupled with a request to us that we have it typed and forwarded to you.

Yours very truly,

P. F. Jones

PFJ:km

Attachment

cc: Participants (19)

ATTACHMENT
Ltr. 10/28/75

Evaluation of Seminar on Gunshot Residue Detection

We wish to thank Mr. John O. Sullivan of the National Institute of Law Enforcement and Criminal Justice of the LEAA for allowing us the opportunity of learning and evaluating this technique.

Special thanks are due The Aerospace Corporation for having provided a valuable input by developing and presenting this methodology.

We feel that this technique of determining gunshot residue is one that has promise of becoming useful. We feel that the final success and applicability depends on the outcome of further investigation in the following areas:

1) Criteria have to be verified and further defined before a set of particles can be attributed to gunshot residue.
2) The persistence of these particles on the hands has to be studied.
3) Collection methods have to be optimized.
4) Comparisons of firing and non-firing hands have to be performed.
5) Environmental sources of handblank particles have to be identified.

We cannot yet reach any conclusions on the possible overlap or relative merits of this technique and other existing techniques. We highly recommend that this study be continued.

L. Baxter, M. J. Camp, B. Campbell, M. Kopina, K. Culbreth, L. Fletcher, G. Gonzalez, J. Hanger, D. Heideman, N. Hodgkin, J. Horan, L. Jao, C. Krishnan, J. Lentini, V. R. Matricardi, S. Rosansky, R. Saferstein, N. P. Stumbaugh, M. Taylor

PARTIAL LIST OF PARTICIPANTS' EQUIPMENT

Laboratory	Location of Equipment	SEM	X-Ray	Computer
Los Angeles, City of Los Angeles Police Department	Own	Hitachi HHS 2R	EDAX 707A	
New York City NYPD	John Jay College of Criminal Just.	JEOL JSM-35	None	
Dallas County (Texas SW Inst. For. Sc.	Univ. Texas SW Med Sc. (2 SEMs, 1 Analy.) Crime Lab. (1 SEM)	Hitachi	Tracor Northern 880	32K
Los Angeles County Coroner	Own	Cambridge Stereoscan S-4	EDAX	Nova (4K)
Orange County (Calif.) Sheriff	Dr. N. Hodgkin Newport Beach	Cambridge 2A	North. Scient. 880	Yes
San Mateo County (Calif.) Sheriff	Stanford Research Institute	Cambridge 2A, updated to S-4	EDAX 505	
State of Florida Crim. Invest. Bur.	Own	AMR-1000A	EDAX 707B	Nova 11 (8K)
State of Georgia Bur. of Invest.	Scan-Atlanta Corp. Atlanta	CWIKSCAN 100	EDAX	

PARTIAL LIST OF PARTICIPANTS' EQUIPMENT (Continued)

Laboratory	Location of Equipment	SEM	X-Ray	Computer
State of Illinois Bur. Identif.	Own	AMR 1000	ORTEC 6200	
State of New York State Police Sc. Lab.	Own	AMR 1000	EDAX	
State of North Carolina Bur. Invest.	Own	ETEC	EDAX	
State of Wisconsin Dept. of Justice	State Air and Water Pollution Lab.	CWIKSCAN 100	North. Scient. 880	Yes
State of Wisconsin Dept. of Justice	Midwest Research Microscopy	JEOLCO JSM-U3	North. Scient. 880	Yes
FBI Laboratory	Own	ETEC	Both energy and wavelength disp.	Vistascan, etc.
Aerospace Corp.	Own	JEOL JSM-U3 JSM-35	EDAX 707A	
FUTURE: State of Missouri Region 2 Crime Lab.	State University	ISI Super Mini SEM	Princeton Gamma Tech	

IV. REFERENCES

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1. Gunshot Residue Detection Survey and Assessment and Identification of Alternative Concepts, ATR-75(7915)-1, The Aerospace Corporation, El Segundo, Calif. (September, 1974).

2. P. F. Jones and R. S. Nesbitt, A Photoluminescence Technique for the Detection of Gunshot Residue, ATR-74(7915)-1, The Aerospace Corporation, El Segundo, Calif. (June, 1974).

3. P. F. Jones, R. S. Nesbitt, J. E. Wessel, and G. M. Wolten, Gunshot Residue Detection Using Inorganic Luminescence, ATR-76(7915)-1, The Aerospace Corporation, El Segundo, Calif. (September, 1974).

4. R. S. Nesbitt, J. E. Wessel, and P. F. Jones, Conclusive Detection of Gunshot Residue by the Use of Particle Analysis, ATR-74(7915)-2, The Aerospace Corporation, El Segundo, Calif. (December, 1974).

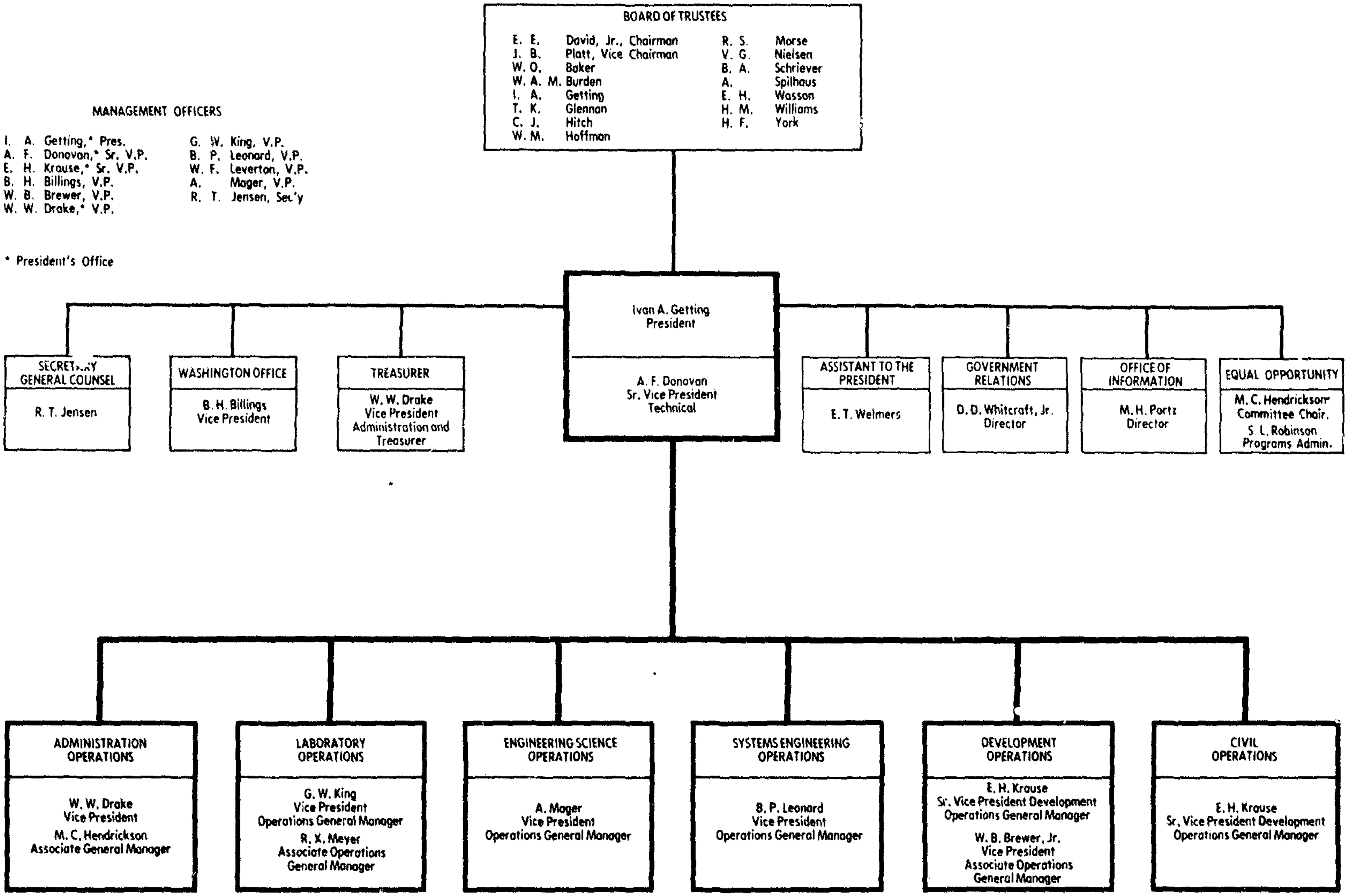
APPENDIX A

OVERVIEW OF THE AEROSPACE CORPORATION AND ITS ROLE IN THE FORENSIC SCIENCES

MANAGEMENT OFFICERS

I. A. Getting,* Pres.
A. F. Donovan,* Sr. V.P.
E. H. Krause,* Sr. V.P.
B. H. Billings, V.P.
W. B. Brewer, V.P.
W. W. Drake,* V.P.
G. W. King, V.P.
B. P. Leonard, V.P.
W. F. Leverton, V.P.
A. Mager, V.P.
R. T. Jensen, Sec'y

* President's Office



Background

AEROSPACE LABORATORIES PROVIDE

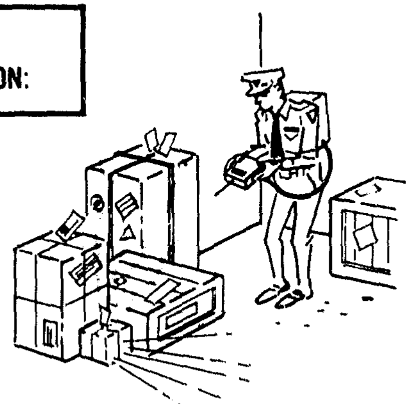
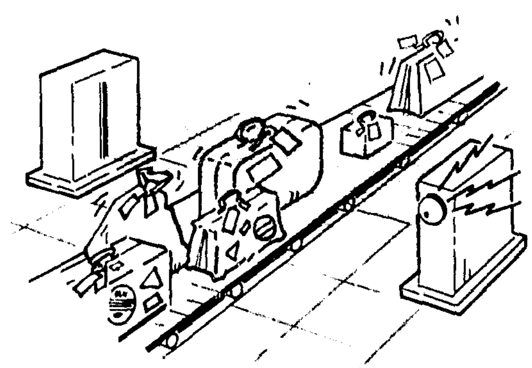
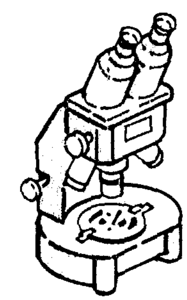
- DIRECT PROGRAM/SYSTEMS SUPPORT
  - QUICK RESPONSE FOR "BRUSH FIRES"
  - LONG TERM TECHNICAL SUPPORT
  - SOURCE SELECTION/TECHNICAL EVALUATION
  - ASSIST IN TECHNICAL DIRECTION
- ADVANCED SYSTEMS PLANNING AND TECHNOLOGY SUPPORT
  - CONCEPTUAL SYSTEMS
  - DEVELOPMENT PROGRAMS
  - FEASIBILITY DEMONSTRATIONS
  - ASSIST IN TECHNICAL DIRECTION
- RESEARCH SUPPORT
  - SCIENTISTS WITH BACKGROUND AND CAPABILITY TO PERFORM PROGRAM SUPPORT
  - LABORATORY FACILITIES TO SOLVE CRITICAL SYSTEMS PROBLEMS
  - FUNDING AND PLANNING BASE TO ACCOMPLISH OTHER SUPPORT

Laboratory Operations Technical Disciplines

LABORATORIES

- ELECTRONICS
  - QUANTUM ELECTRONICS
  - ANTENNAS AND PROPAGATION
  - COMMUNICATION SCIENCES
- AEROPHYSICS
  - MECHANICS RESEARCH
  - CHEMICAL KINETICS
  - AERODYNAMICS AND HEAT TRANSFER
- MATERIALS SCIENCES
  - MATERIAL ANALYSIS
  - NON-METALLIC MATERIALS
  - METALLURGY
- SPACE PHYSICS
  - SPACE PARTICLES AND FIELDS
  - SOLAR PHYSICS
  - ATMOSPHERIC PHYSICS
  - CLIMATOLOGY AND METEOROLOGY
- CHEMISTRY AND PHYSICS
  - CHEMICAL PHYSICS
  - CHEMICAL PROCESSING
  - ATMOSPHERIC KINETICS
  - URBAN ATMOSPHERES
  - FORENSIC SCIENCE

Explosive Detection and Identification

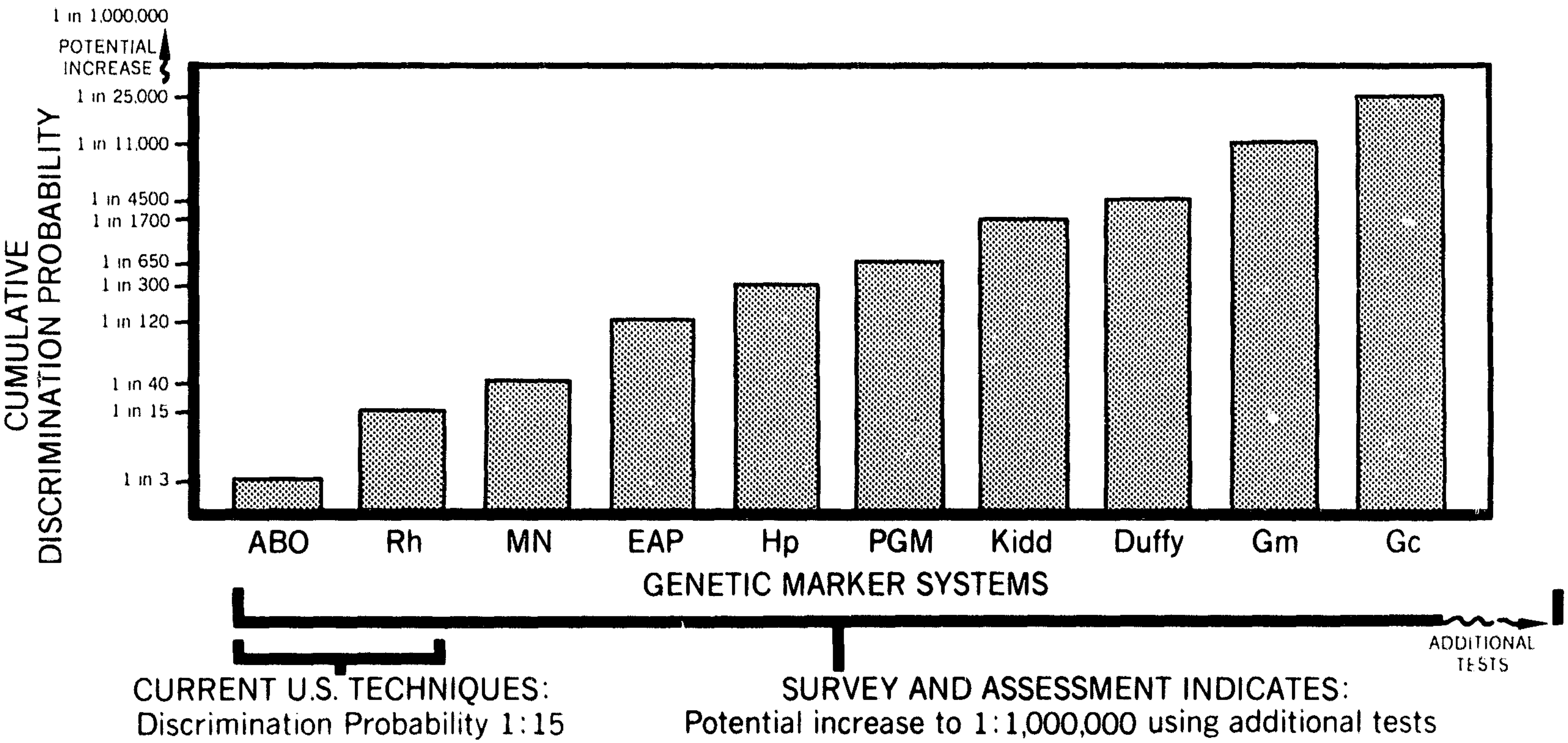
	VOLUMETRIC DETECTION	COOPERATIVE SEARCH	POST-DETONATION IDENTIFICATION
SYSTEM APPLICATION:			
PROBLEM EXAMPLE:	• AIRLINES RECEIVE 2000 TELEPHONE THREATS/yr • LOS ANGELES POLICE DEPARTMENT HAD 740 BOMB THREAT CALLOUTS IN 1972	• AIRLINES SEARCH 170 MILLION PIECES OF LUGGAGE PER YEAR • 87 BILLION LETTERS AND PARCELS (50:1) THROUGH POST OFFICE IN 1972	• BOMBING INCIDENTS IN FY 71 897 EXPLOSIVE (non-military) 56 MILITARY ORDNANCE 59 OTHER
PRIORITY SOLUTIONS: (interagency defined)	• LASER OPTOACOUSTIC VAPOR DETECTION • SF_6 TAGGANT	• X-RAY FLUORESCENCE TAGS	• CODED TAGGANTS MICROSPHERES PHOSPHOR GRAINS RARE EARTHS

BLOOD AND BLOODSTAIN ANALYSIS

OBJECTIVE

Facilitate Utilization of Modern Techniques of Identification from Blood Clue by Developing Statistical Data Base and Reliable, Easy-to-Use Blood Analysis Method

POTENTIAL IMPROVEMENTS



SEMI-AUTOMATIC ANALYSIS METHODS FOR HIGH ID PROBABILITY UNDER DEVELOPMENT

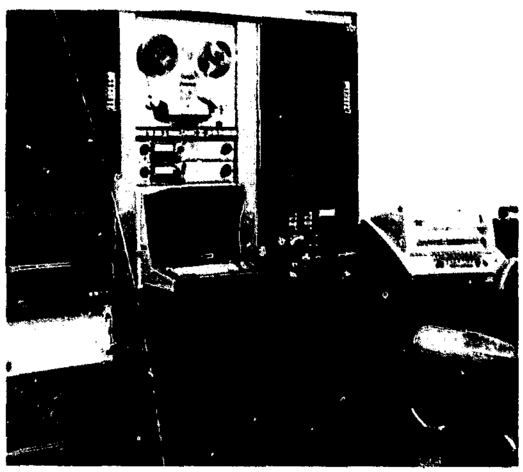
SPEAKER IDENTIFICATION PROGRAM

OBJECTIVE

Develop computer assisted speaker identification system to accurately identify specific individuals from recorded speech

SYSTEM CONCEPT

CRIMINAL RECORDING IS COMPARED WITH SUSPECT EXEMPLARS USING QUANTITATIVE STATISTICAL TECHNIQUES



COMPUTER CALCULATES PROBABILITY THAT SUSPECT'S VOICE MATCHES CRIMINAL RECORDING

ADVANTAGES:

- **Repeatable**
- **Quantitative**
- **Objective**
- **Faster and Cheaper**

SYSTEM PRESENTLY UNDERGOING FEASIBILITY TESTS

Areas of Accomplishment

METHODOLOGY RESEARCH

- GUNSHOT RESIDUE DETECTION
- HAIR INDIVIDUALIZATION
- GLASS INDIVIDUALIZATION
- SEMEN DETECTION AND IDENTIFICATION

CASE WORK

- TOOL MARK MATCHING
- HAIR COMPARISON
- CHECK IDENTIFICATION
- SEMEN AND BLOOD DEPOSITION TIMES
- POLYMER BOMB FRAGMENT ORIGIN

APPENDIX B

PARTICLE ANALYSIS METHOD, SCANNING ELECTRON MICROSCOPY WITH ELEMENTAL X-RAY DETECTION

DETECTION OF GUNSHOT RESIDUE

- OVERVIEW
  - OBJECTIVE
    - TO DEVELOP FAST, RELIABLE AND INEXPENSIVE TECHNIQUES AND EQUIPMENT TO DETECT GUNSHOT RESIDUE IN GUN-RELATED CRIMES
    - SUITABLE FOR CRIMINALISTIC AND PRIVATE LABORATORIES
  - BACKGROUND
    - GUNSHOT RESIDUE CAN BE KEY EVIDENCE
      - HANDS - CLOTHING - WOUNDS
      - FIRING DISTANCE
      - SUICIDES VS HOMICIDES
    - MOST PREVIOUS METHODS NO LONGER USED
      - LACK OF SENSITIVITY/RELIABILITY
        - PARAFFIN TEST FOR NITRATE - KNOWN TO BE UNRELIABLE AS EARLY 1935
        - COLOR TEST FOR Sb, Ba, Pb
    - NEUTRON ACTIVATION CURRENTLY USED BY FBI AND BUREAU OF ALCOHOL, TOBACCO AND FIREARMS (Ba, Sb)

- LITTLE USED BY POLICE DEPARTMENTS
- EXPENSIVE - TIME CONSUMING - NOT FOR INHOUSE USE
- CANNOT DETECT LEAD, SUBJECT TO BACKGROUND INTERFERENCE
- SOME LABORATORIES BEGINNING OPERATIONAL USE OF ATOMIC ABSORPTION

SURVEY OF CRIMINALISTICS LABORATORIES

1974

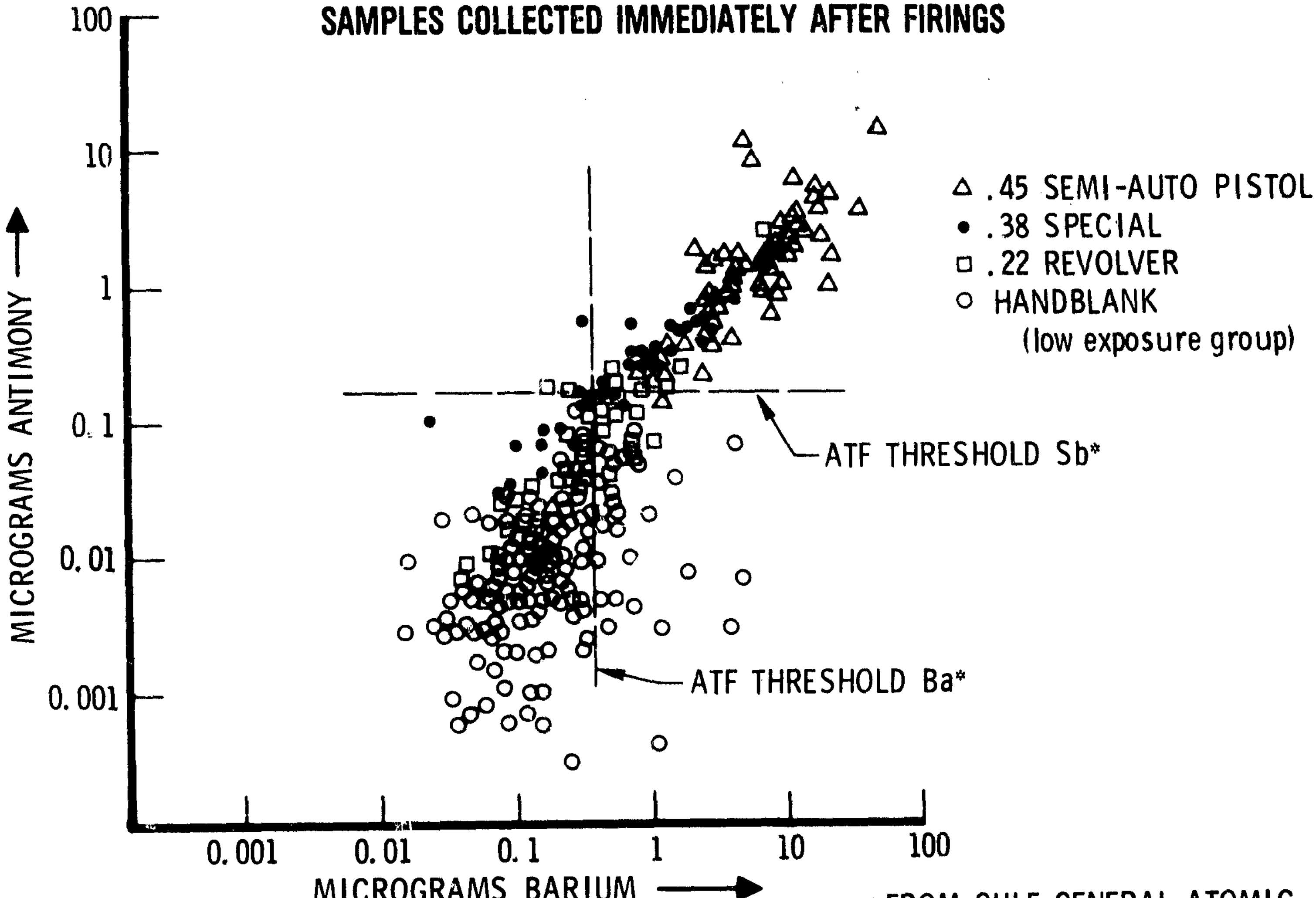
	FREQUENCY IN FIREARMS CASE-WORK
• HANDGUNS ENCOUNTERED IN	93%
• .38 AND .22 CALIBER ENCOUNTERED IN	70%
• REVOLVERS ENCOUNTERED IN	82%
• PRESENCE OF RESIDUE ON SUSPECT	MOST IMPORTANT
• TYPICAL TIME DELAY BETWEEN FIRING AND COLLECTION - PROJECTED	2 HRS.
• LIMITATIONS	
• EQUIPMENT COST	$10K
• MAX. FREQ. INCONCLUSIVES	30%

- 5% OF CLASS D HANDBLANKS (HIGH EXPOSURE) EXCEED A.T.F. CRITERIA

* GOLEB AND MIDKIFF, JR., J. FORENS. SCI., 20, 701 (1975); APPL. SPEC., 28, 382 (1974); ALSO KINARD AND LUNDY, A.C.S. SYMP. SERIES 13, "FORENSIC SCIENCE," PGS. 97-107 (1975).

Neutron Activation Analysis Results**

SAMPLES COLLECTED IMMEDIATELY AFTER FIRINGS



*Goleb and Midkiff, Jr, J. Forensic Sci. 20(4), 701-707 (1975)

**FROM GULF-GENERAL ATOMIC REPORT GA 9829

CONTINUED

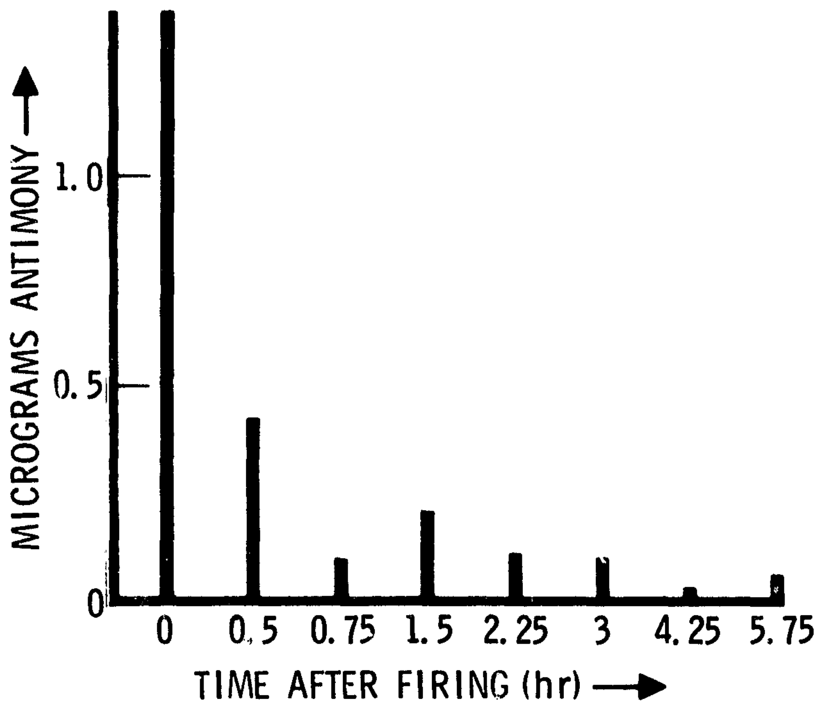
1 OF 2

Persistence of Residue For .45 Pistol

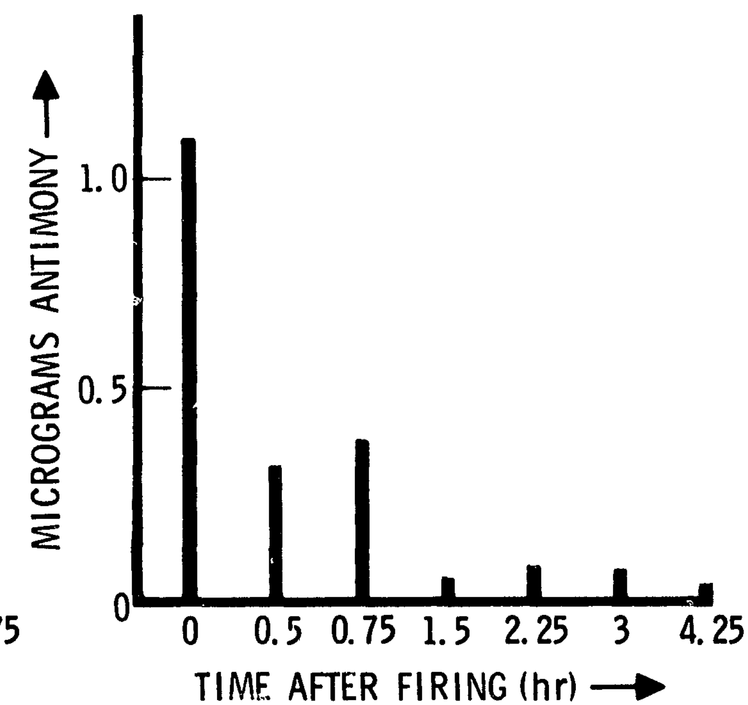
MEASURED BY KILTY* USING NEUTRON ACTIVATION ANALYSIS

- RESIDUE COLLECTED FROM FIRING HAND

SUBJECT A



SUBJECT E



*J. W. Kilty, J. Forens. Sci.. 20(2), 219-230(1975)

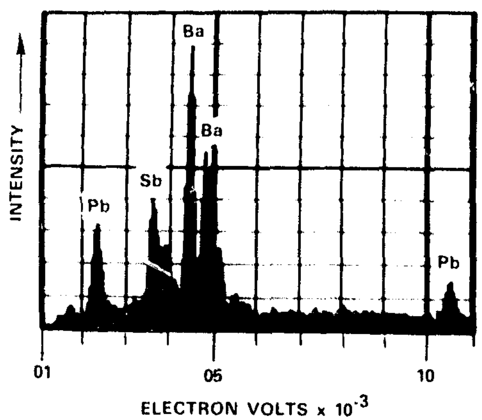
PROGRAM

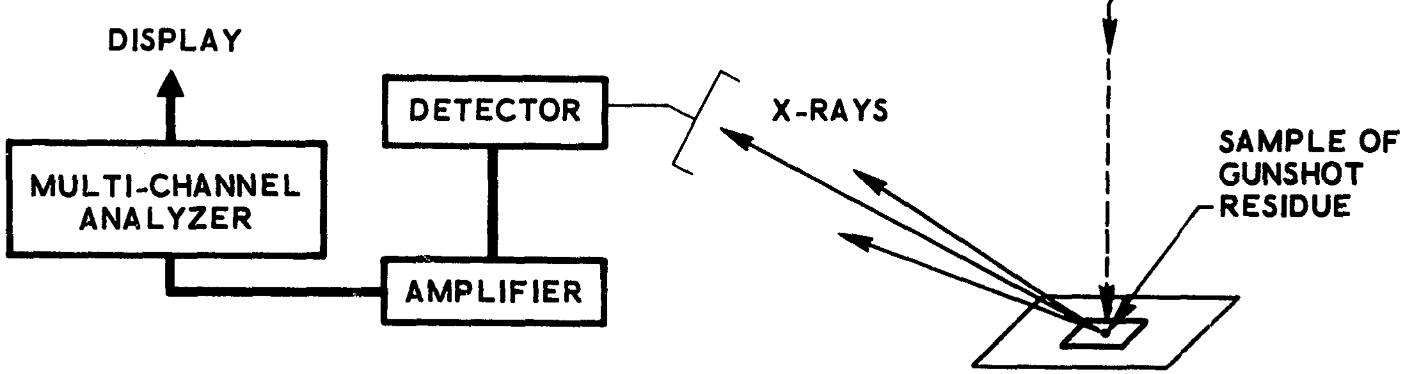
- OBJECTIVE
    - CONCLUSIVE IDENTIFICATION OF RESIDUE COMBINED WITH A MINIMUM OF FALSE NEGATIVE DETERMINATIONS UNDER FIELD CONDITIONS
    - LOW COST AND SHORT TURN-AROUND TIME
- APPROACHES
    - EXPLORE POTENTIAL LOW COST ORGANIC DETECTION METHODS
        - CHARACTERIZE UNIQUE ORGANIC COMPONENTS OF RESIDUE USING MOST POWERFUL ANALYTICAL METHODS: MASS SPECTROMETRY
        - EXPLORE LOW COST METHODS SUITABLE FOR TYPICAL CRIMINALISTICS LAB
            - GC
            - TLC
            - MICROCRYSTAL TESTS
    - COMBINE SOPHISTICATED METHODS OF HIGH POTENTIAL RELIABILITY (EXPENSIVE) WITH SCREENING METHOD (INEXPENSIVE)
        - MOLECULAR PHOTOLUMINESCENCE FOR LOW COST SCREENING AT SMALLER LABS
        - SCANNING ELECTRON MICROSCOPE (SEM) FOR BACK-UP ANALYSES AT REGIONAL LABS

Detection of Gunshot Residue

PARTICLE ANALYSIS

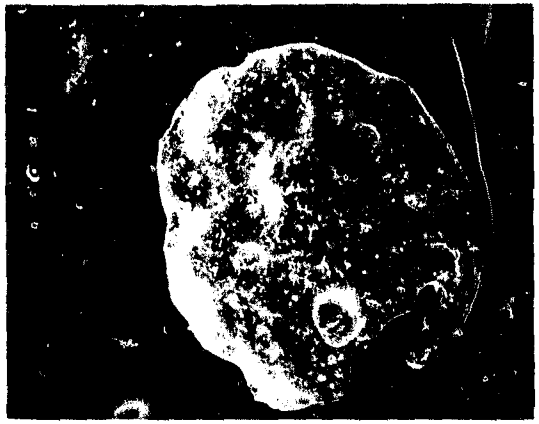
- ANALYSIS METHODS
  - PARTICLE ANALYSIS-SCANNING ELECTRON MICROSCOPE



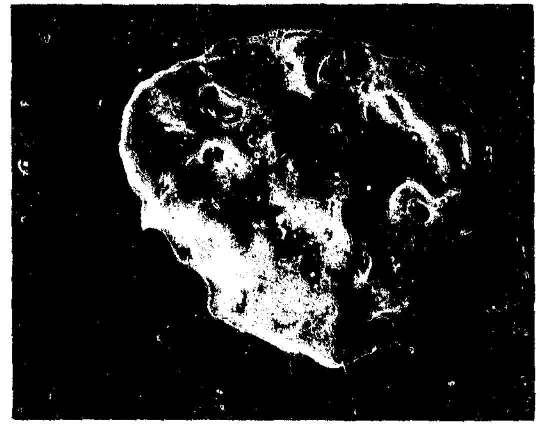


Detection of Gunshot Residue
PARTICLE ANALYSIS

SECONDARY ELECTRON MICROGRAPHS OF TYPICAL PARTIALLY BURNED SMOKELESS POWDER PARTICLES



DIAMETER 0.06 cm
BROWNING .380 PISTOL



DIAMETER 0.07 cm
BROWNING .380 PISTOL

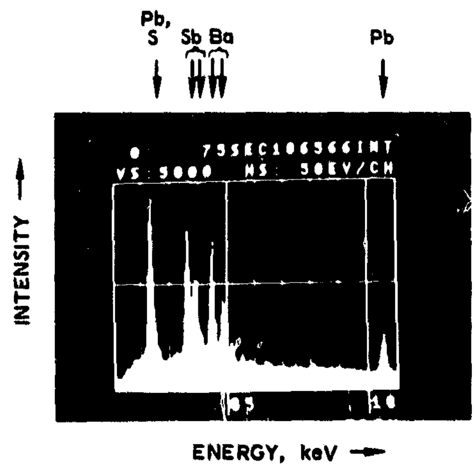
DIAMETER 0.06 cm
BROWNING .380 PISTOL

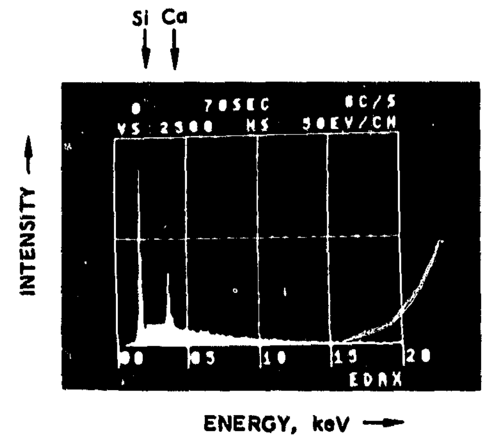
DIAMETER 0.07 cm
COLT .22 REVOLVER

Energy-Dispersive X-Ray Spectra of Particles by SEM

a.

ANALYSIS OF THE SPHERICAL GUNSHOT RESIDUE HANDSAMPLE PARTICLE



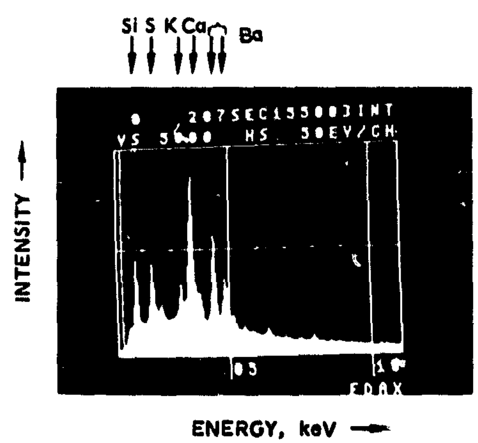


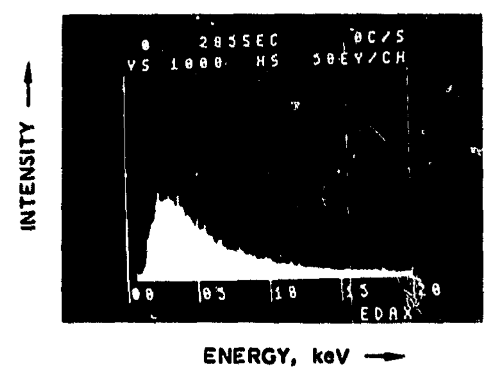
b.

ANALYSIS OF THE TYPICAL ENVIRONMENTAL HANDSAMPLE PARTICLE

c.

ANALYSIS OF NONDESCRIPT GUNSHOT RESIDUE PARTICLE FROM HANDSAMPLE. CALCIUM AND SULFUR ARE PROMINENT, AND LEAD IS NOT OBSERVED IN THIS ATYPICAL PARTICLE.





d.

ANALYSIS OF EPITHELIAL PARTICLE FROM HANDBLANK. THE X-RAY EMISSION IS DUE TO BREMSSTRAHLUNG RATHER THAN DISCRETE ELEMENTAL LINES.

X-RAY INTERFERENCES
GUNSHOT RESIDUE

Pb

L_α = 10.550
L_{β_1} = 12.612
L_{β_2} = 12.621
L_γ = 14.762
M = 2.380

S

K_α = 2.307
K_β = 2.465

As

K_α = 10.542
K_β = 11.722

Ba

K_α = 32.062
K_β = 36.504
L_α = 4.465
L_{β_1} = 4.829
L_{β_2} = 5.193
M = 0.972

Ti

K_α = 4.508
K_β = 4.931
L_α = 0.452

V

K_α = 4.949
K_β = 5.426
L_α = 0.511

Sb

K_α = 26.271
K_β = 29.805
L_α = 3.604
L_{β_1} = 3.843
L_{β_2} = 4.100
M = 0.733

Ca

K_α = 3.690
K_β = 4.012
L_α = 0.341

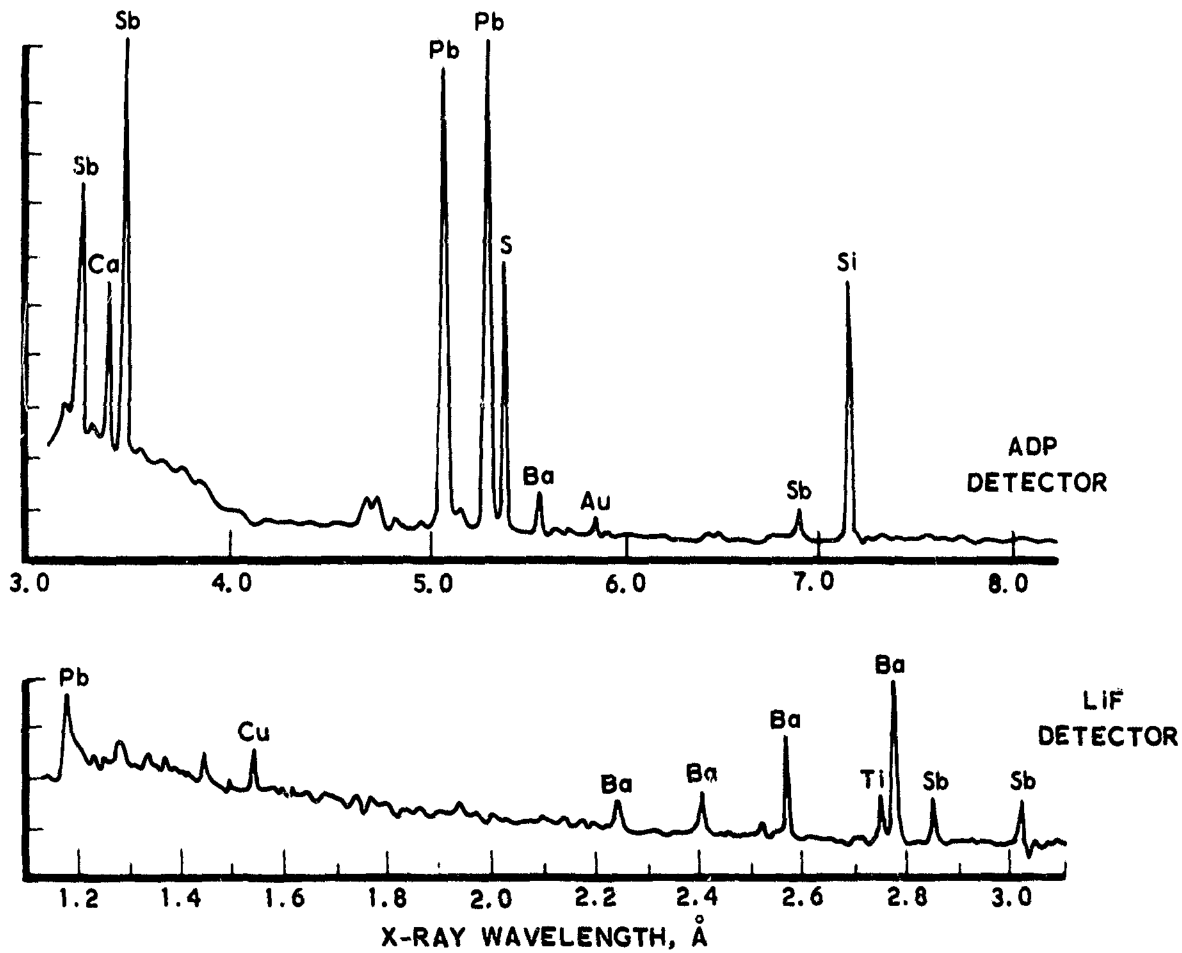
K

K_α = 3.312
K_β = 3.589

Sn

K_α = 25.191
K_β = 28.564
L_α = 3.443
L_{β_1} = 3.662
L_{β_2} = 3.909
M = 0.691

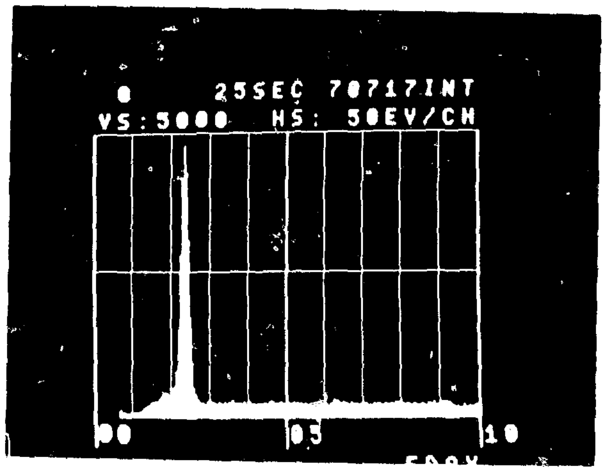
Electron Microprobe Analysis of Gunshot Primer Residue



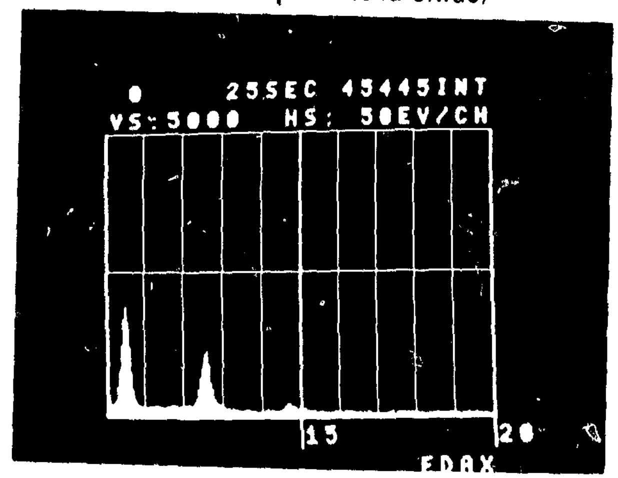
Potential Interference in Lead X-Ray Analysis Using Energy Dispersed Detection

LEAD

INTENSITY →

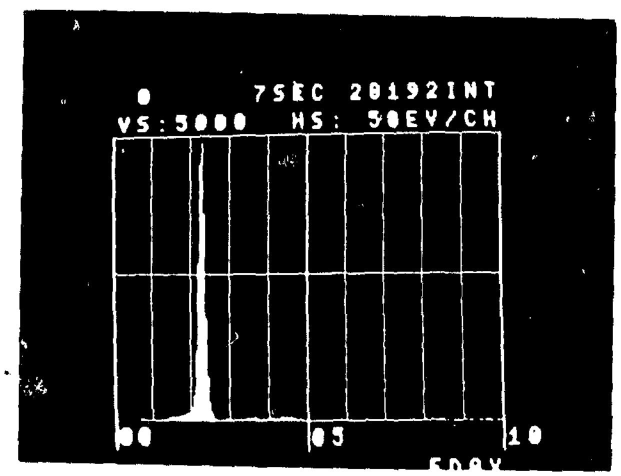


LEAD (in pure lead oxide)



ENERGY (kiloelectron volts) →

INTENSITY →

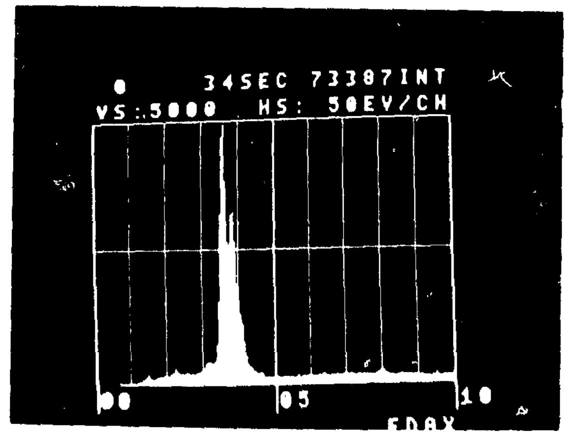


SULFUR

ENERGY (kiloelectron volts) →

Potential Interference in Antimony X-Ray Analysis Using Energy Dispersed Detection

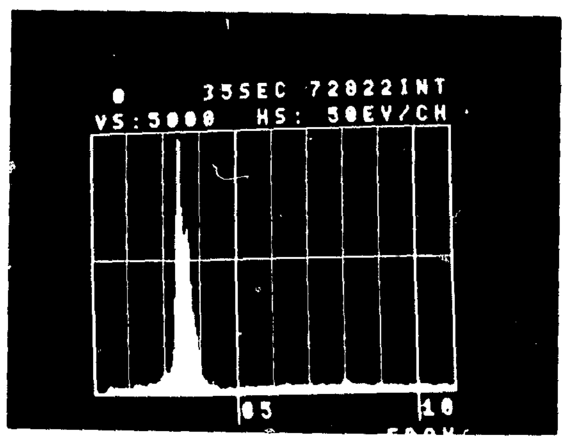
INTENSITY ⟶



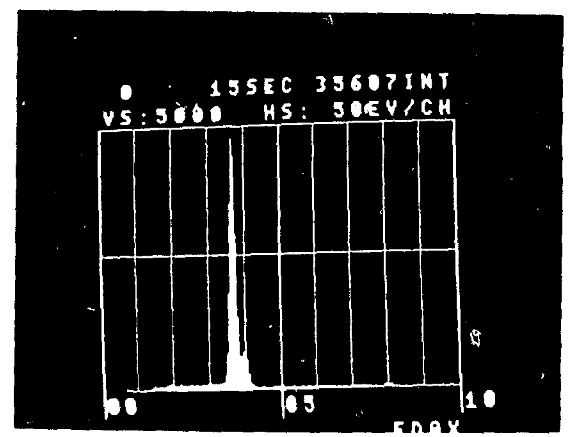
ANTIMONY

ENERGY (kiloelectron volts) ⟶

INTENSITY ⟶



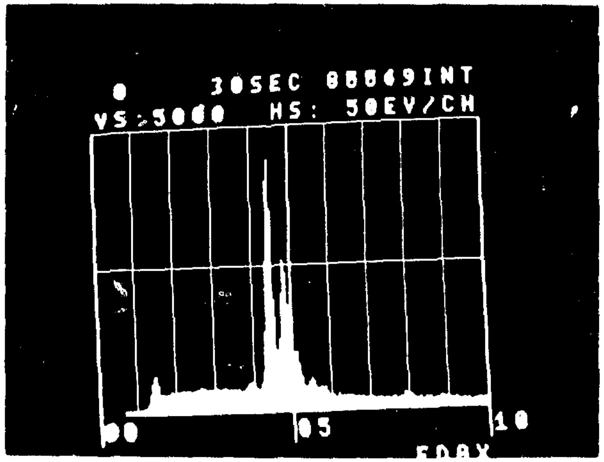
ENERGY (kiloelectron volts) ⟶
TIN
(in pure stannic oxide)



ENERGY (kiloelectron volts) ⟶
CALCIUM
(in pure calcium carbonate)

Potential Interference in Barium X-Ray Analysis Using Energy Dispersed

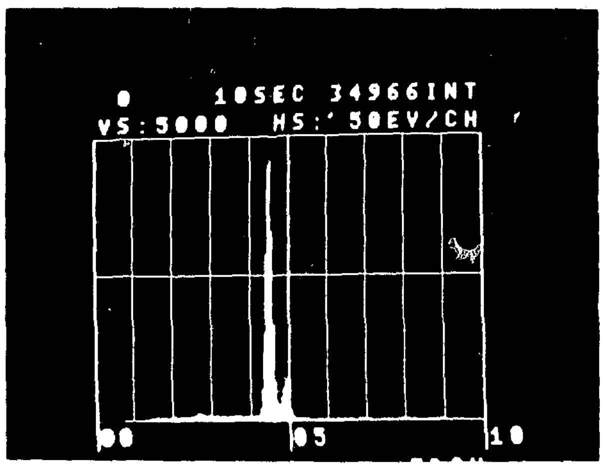
INTENSITY ⟶



ENERGY (kiloelectron volts) ⟶

BARIUM
(in pure barium nitrate)

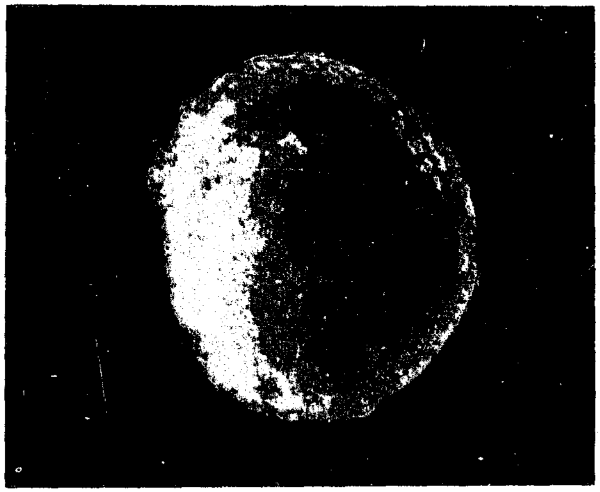
INTENSITY ⟶



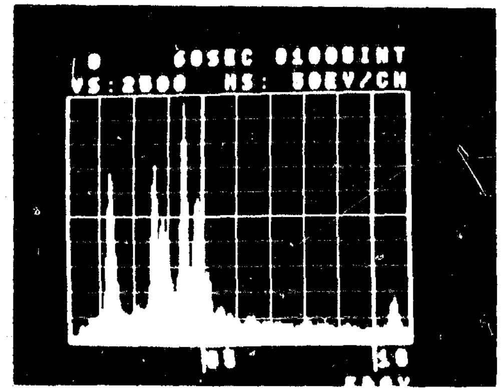
ENERGY (kiloelectron volts) ⟶

TITANIUM
(in pure titanium dioxide)

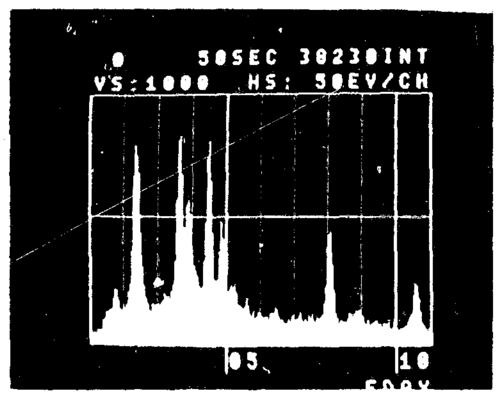
SEM Analysis of Gunshot Residue



GUN .38 Special Smith & Wesson Revolver
AMMUNITION Super Vel
MAGNIFICATION 2,500 X



GUN .38 Special Smith & Wesson Revolver
AMMUNITION Western
MAGNIFICATION 10,000 X



COMPARISON OF SEM DETECTION WITH ELEMENTAL ANALYSIS

- BLIND TEST PERFORMED ON A RANDOM SET OF 35 "UNKNOWNS"
- IMMEDIATE SAMPLE COLLECTION

TYPE	NUMBER TESTED	NUMBER IDENTIFIED CORRECTLY
HANDBLANKS	18	18
.22 CALIBER REVOLVER FIRING SPECIMENS	10	10
.38 SPECIAL REVOLVER FIRING SPECIMENS	7	7

- ELEMENTAL ANALYSIS RESULT TAKEN FROM GULF-GENERAL ATOMIC DATA
- IMMEDIATE SAMPLE COLLECTION
  - 89% OF .22 CALIBER REVOLVER FIRINGS DO NOT MEET THE ATF CRITERIA* FOR A POSITIVE FIRING (MORE THAN .2 μg Sb and .3 μg Ba)
  - 34% OF .38 SPECIAL REVOLVER FIRINGS COLLECTED IMMEDIATELY DO NOT MEET A. T. F. CRITERIA* (MORE THAN .2 μg Sb and .3 μg Ba)

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* GOLEB AND MIDKIFF, JR., J. FORENSIC SCIENCES, 20, 701 (1975); APPLIED SPECTROSCOPY 28 (4) 382 (1974); ALSO KINARD AND LUNDY, ACS SYMPOSIUM SERIES 13, "FORENSIC SCIENCE," PG. 97-107 (1975).

SEM RESULTS

PERSISTENCE TESTS

.32 SEMI-AUTOMATIC PISTOL

	FIRING HAND					NON-FIRING HAND
DELAY (hours)	AV. NUMBER PARTICLES PER SAMPLE*	AV. NUMBER PARTICLES WITH Pb ONLY, PER SAMPLE	NUMBER SAMPLES	SAMPLES WITHOUT GSR, SEM DETECTION	SAMPLES BELOW ELEMENTAL** THRESHOLD	AV. NUMBER PARTICLES
0	77	26	6	0	2	53
1	44	32	5	0	5	32
2	27	17	5	1	5	25

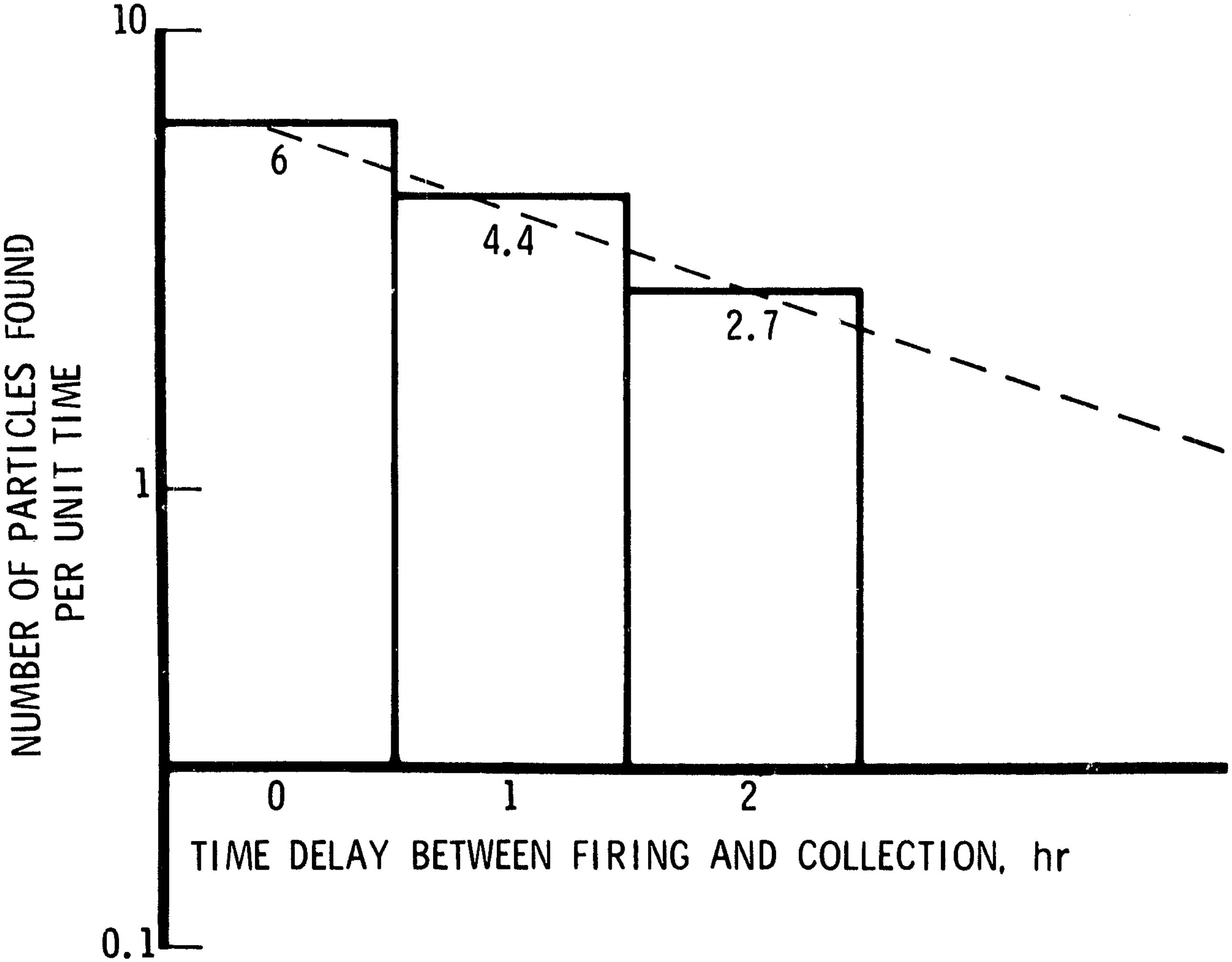
* ROUGH ESTIMATE OF TOTAL NUMBER PARTICLES ON SPECIMEN EXTRAPOLATED FROM NUMBER IDENTIFIED IN TEN MINUTES. (MORE RECENT INVESTIGATIONS INDICATE THAT MORE THAN ONE THOUSAND SMALL PARTICLES ARE FOUND IMMEDIATELY AFTER FIRING.)

** USING ANTIMONY THRESHOLD OF 0.2 MICROGRAMS, SUGGESTED BY ATF (WITHOUT USING THE ADDITIONAL BARIUM CRITERION).

Detection of Gunshot Residue

RESULTS TO DATE - SCANNING ELECTRON MICROSCOPY

- PERSISTENCE OF RESIDUE DETECTED BY SEM



SEM
OTHER INFORMATION

	MEDIAN NUMBER OF PARTICLES*	NUMBER OF SAMPLES
GSR ON SLEEVES	112	2
ON HANDS-AFTER HANDS IN POCKET 3 TIMES	110	7
ON HANDS-AFTER HANDS WIPED	80	7
IN POCKETS	130	8
HOLD AND LOAD GUN, NO FIRING	20	6

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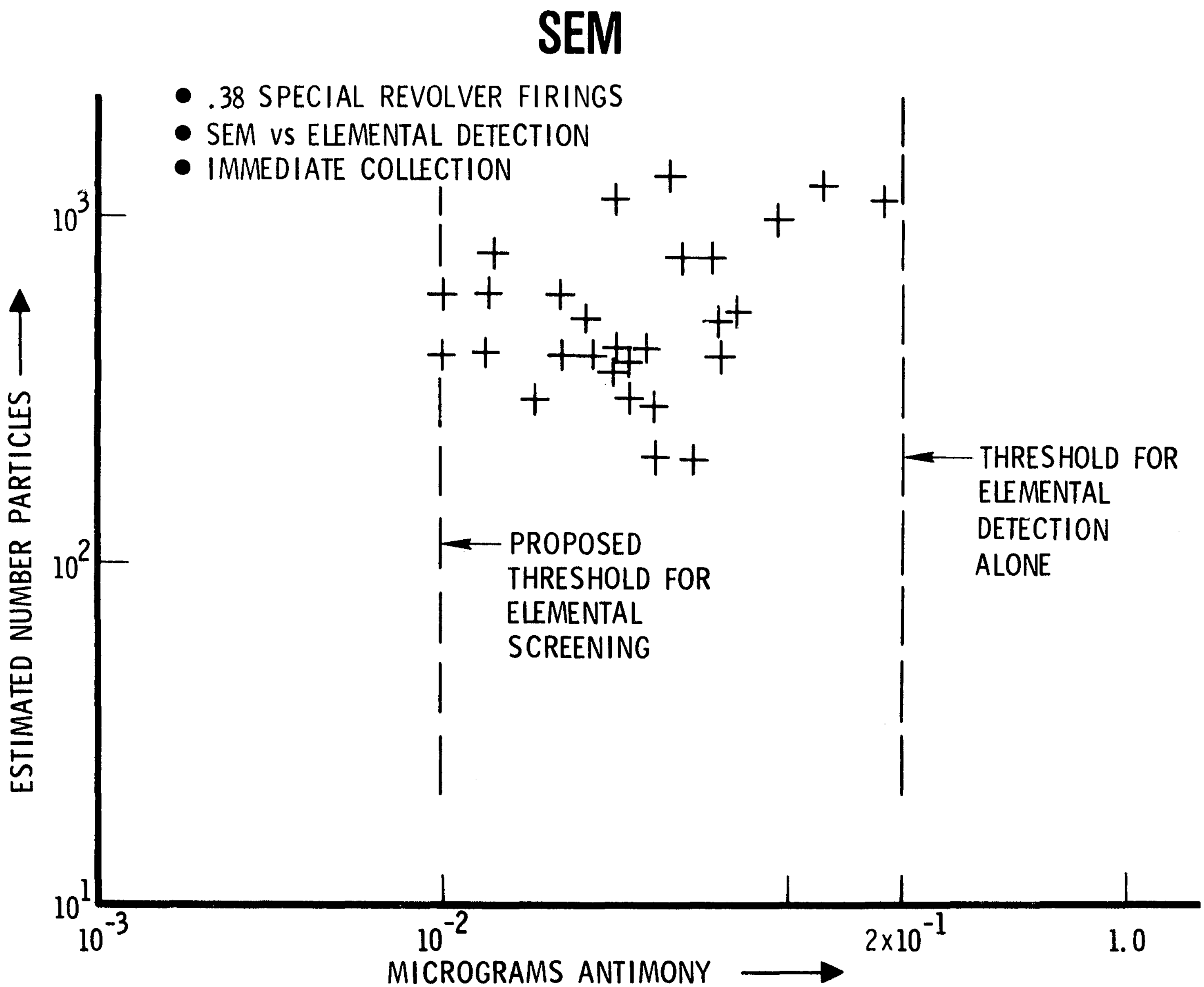
* ROUGH ESTIMATE BASED ON EXTRAPOLATION FROM NUMBER IDENTIFIED IN TWENTY MINUTES


SEM
.38 SPECIAL REVOLVER FIRINGS
SEM vs ELEMENTAL DETECTION
IMMEDIATE COLLECTION
10^3
10^2
10^1
ESTIMATED NUMBER PARTICLES
PROPOSED THRESHOLD FOR ELEMENTAL SCREENING
THRESHOLD FOR ELEMENTAL DETECTION ALONE
10^{-3}
10^{-2}
2×10^{-1}
1.0
MICROGRAMS ANTIMONY

SEM

BLIND TEST DEMONSTRATION (SYMPOSIUM)

KRISHNAN PROMPT COLLECTION	**SEM RESULT**
FIRING DATA **.22 SEMIAUTOMATIC PISTOL** **3 CARTRIDGES FIRED** **CLEAN HANDS** INTERPRETATION: **GUNSHOT RESIDUE PARTICLES EXTREMELY PLENTIFUL, CONSISTENT WITH FIRING HAND SAMPLE. ONLY BRIEF ANALYSIS REQUIRED.**	**Pb 10 μ SPHERE** **Pb Cu 200 μ** **Pb 5 μ SPHERE** **Ba Pb 25 μ SPHERE** **Ba Ca Si Pb 20 μ SPHERE** **Pb 30 μ SPHERE** **5 MINUTES ANALYSIS**
FLETCHER PROMPT COLLECTION	**SEM RESULT**
DID NOT FIRE **PRESENT IN RANGE** **WIPED HANDS ON CAR** INTERPRETATION: **PARTICLES THAT MIGHT BE GUNSHOT RESIDUE ARE EXTREMELY SPARSE. NOT CONSISTENT WITH FIRING.**	**Pb 7 μ** **Pb Cu 2 μ SPHERE** **15% SPECIMEN**

LENTINI FIRING DATA COLLECTION DELAYED 2 HOURS FIRED .22 SEMIAUTOMATIC INTERPRETATION: 1 GSR PARTICLE WAS FOUND AFTER AN EXTENSIVE SEARCH. THIS IS CONSISTENT WITH EITHER DELAYED COLLECTION, A VERY CLEAN SMALL CALIBER GUN, OR MERE PRESENCE IN THE VICINITY OF A FIRING.	SEM RESULT Ba S* 1.8 μ Pb Sb Ti 2 μ ~ 15% SPECIMEN **SINCE THE DEMONSTRATION, BaS ENVIRONMENTAL PARTICLES HAVE BEEN FOUND**
CAMPBELL FIRING DATA COLLECTION DELAYED 2 HOURS NO FIRING COSMETICS ON HAND STOOD FAR TO REAR INTERPRETATION: ALL PARTICLES AND SUBSTRATE BACKGROUND GAVE A STRONG X-RAY LINE FOR Ti. STRONG INDICATION OF INTERFERING CONTAMINATION. IT IS POSSIBLE THE POTENTIAL GSR PARTICLE LOCATED AFTER EXTENSIVE SEARCH IS FROM COSMETICS. RECOMMEND COSMETICS HANDBLANK STUDY. UNFORTUNATELY SUBJECT WAS PRESENT AT RANGE, SO POSSIBILITY OF GSR CONTAMINATION EXISTS.	SEM RESULT Cu Pb Ti Sb 2.5 μ SPHERE (Ca K Ti IN EVERYTHING) ~ 75% SPECIMEN

MATRICARDI FIRING DATA DID NOT FIRE HAND HELD 3 FEET FROM DISCHARGING GUN INTERPRETATION: AFTER EXTENSIVE SEARCH, 2 GSR PARTICLES AND SEVERAL THAT MIGHT BE GSR WERE FOUND. RESULT CONSISTENT WITH PRESENCE IN VICINITY OF DISCHARGING GUN.	SEM RESULT Ba Ca Pb 2.5 μ Pb 1.4 μ SPHERE Ba S Pb 4 μ SPHERE Pb 1.4 μ SPHERE Pb 1.6 μ SPHERE Pb 2 μ SPHERE Pb 3 μ SPHERE Pb 1 μ SPHERE ~ 25% SPECIMEN
SAFERSTEIN FIRING DATA COLLECTION DELAYED 2 HOURS FIRED .38 SPECIAL DIRTIED HANDS AFTER FIRING INTERPRETATION: AFTER EXTENSIVE SEARCH, 1 GSR PARTICLE AND 6 PARTICLES THAT MIGHT BE GSR WERE FOUND. THIS IS CONSISTENT WITH AN EARLIER FIRING OR PRESENCE NEAR A DISCHARGING GUN.	SEM RESULT Pb 2.5 μ SPHERE Pb 2 μ SPHERE Pb Cu 1.7 μ SPHERE Pb 2 μ SPHERE Pb 2 μ SPHERE Pb Fe Ca 7 μ SPHERE Ba Si Ca Pb 1.7 μ ~ 20% SPECIMEN

APPENDIX C

ATLAS OF RESIDUE PARTICLES

ELECTRON MICROGRAPHS AND X-RAY ANALYSIS
SPECTRA OF REPRESENTATIVE GUNSHOT RESIDUE
PARTICLES AND SIMILAR ENVIRONMENTAL PARTICLES

PREPARED FOR

SYMPOSIUM ON DETECTION OF GUNSHOT RESIDUE

AT

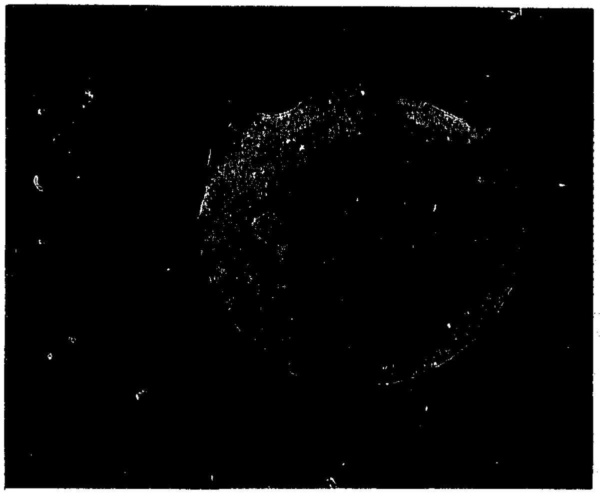
THE AEROSPACE CORPORATION
EL SEGUNDO, CALIFORNIA

OCTOBER 22-24, 1975

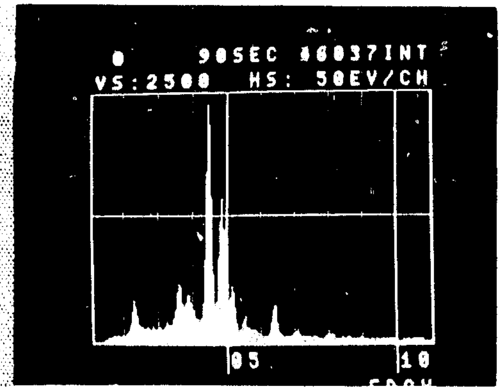
THE ASSISTANCE OF THE NATIONAL INSTITUTE OF
LAW ENFORCEMENT AND CRIMINAL JUSTICE IS
GRATEFULLY ACKNOWLEDGED.

REVOLVERS

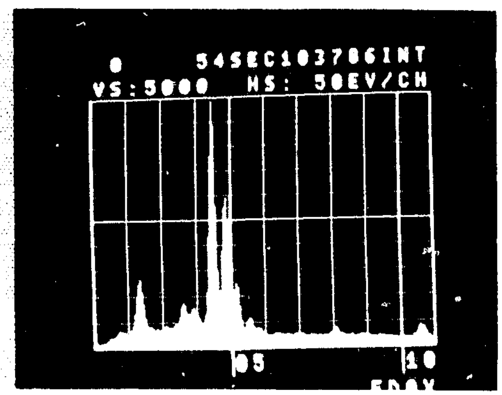
SEM Analysis of Gunshot Residue



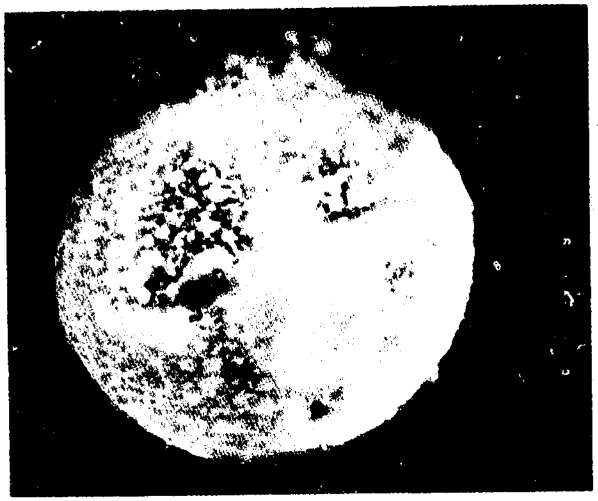
GUN .22 Colt Revolver
AMMUNITION Western Super X .22 Long Rifle
MAGNIFICATION 5,000 X



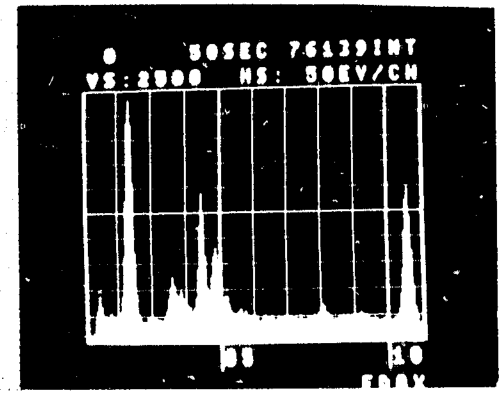
GUN .22 Colt Revolver
AMMUNITION Federal .22 Long Rifle
MAGNIFICATION 6,250 X

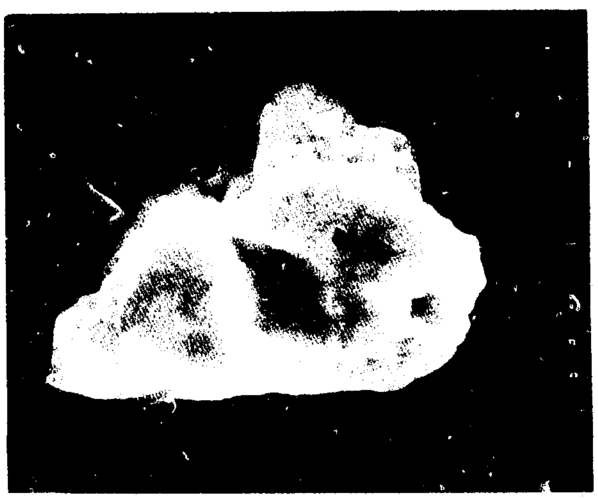


SEM Analysis of Gunshot Residue

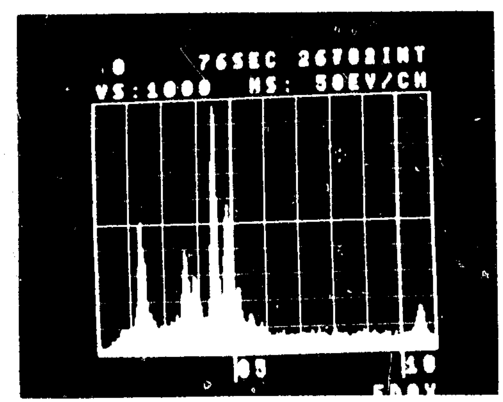


GUN .22 Colt Revolver
AMMUNITION Federal .22 Long Rifle
MAGNIFICATION 5,000 X

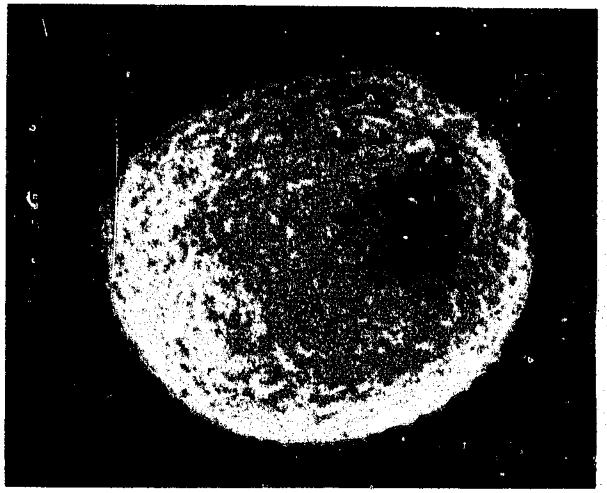




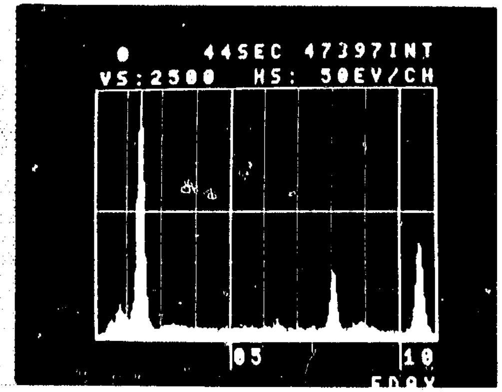
GUN .22 Ruger Revolver
AMMUNITION Federal .22 Long Rifle
MAGNIFICATION 4,000 X



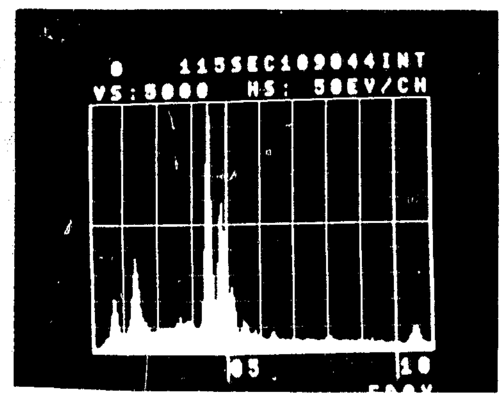
SEM Analysis of Gunshot Residue



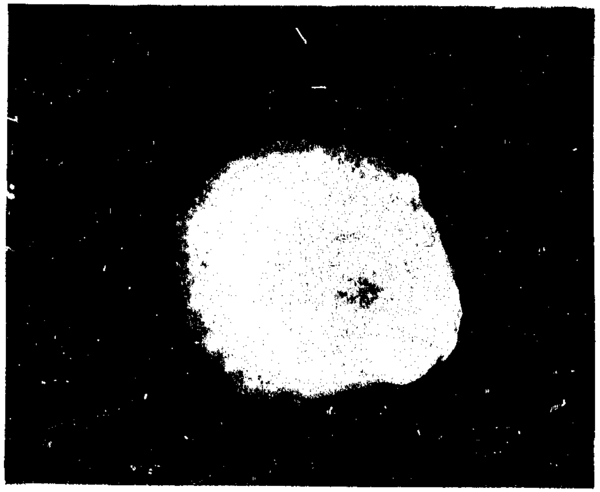
GUN .22 H & R Revolver
AMMUNITION Remington .22 Long Rifle
MAGNIFICATION 4,500 X



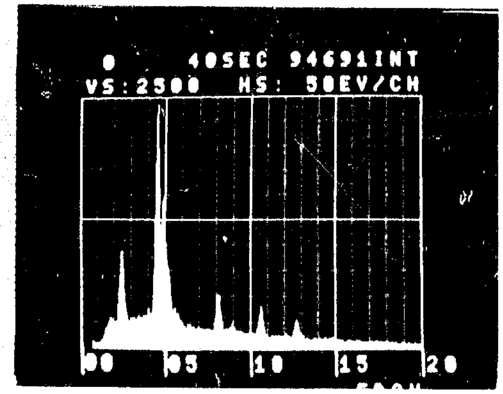
GUN .22 Colt Revolver
AMMUNITION Federal .22 Long Rifle
MAGNIFICATION 7,500 X

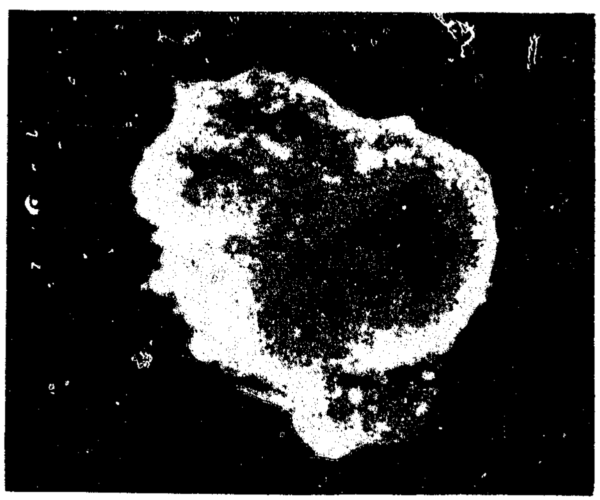


SEM Analysis of Gunshot Residue .

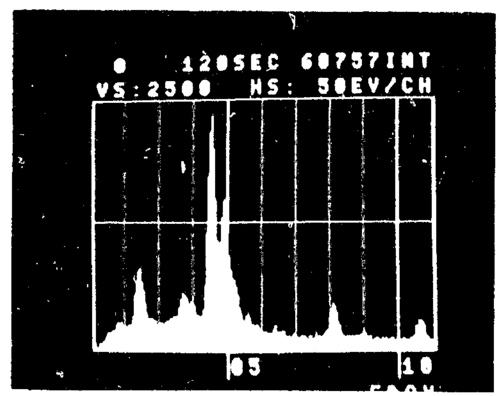


GUN .22 H & R Revolver
AMMUNITION Browning .22 Long Rifle
MAGNIFICATION 6,000 X



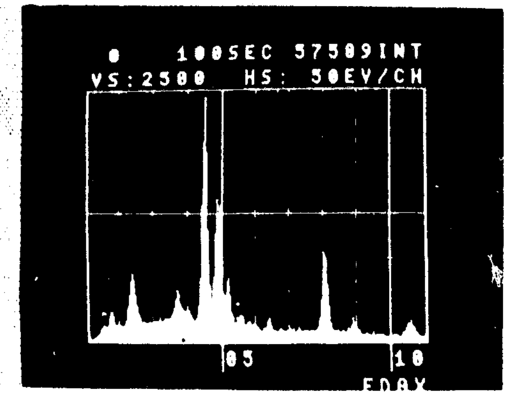


GUN .22 H & R Revolver
AMMUNITION Browning .22 Long Rifle
MAGNIFICATION 3,600 X

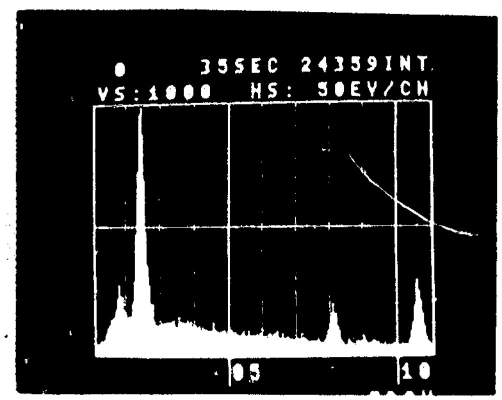


SEM Analysis of Gunshot Residue

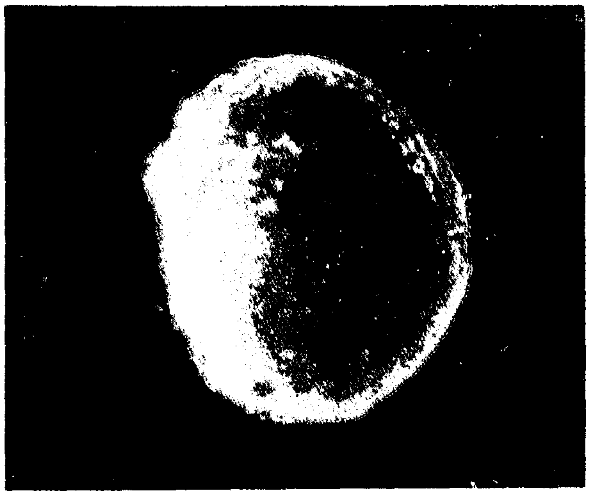
GUN .38 Special Smith & Wesson Revolver
AMMUNITION Western
MAGNIFICATION 9,000 X



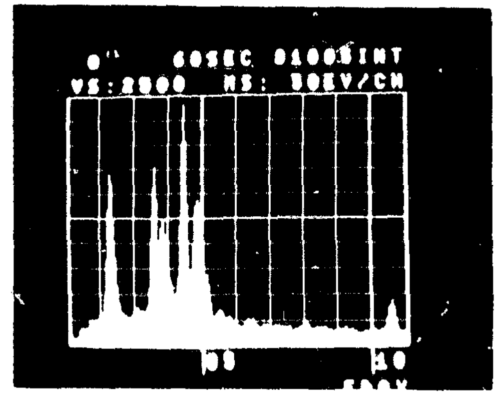
GUN .38 Special Smith & Wesson Revolver
AMMUNITION Remington (lead nose)
MAGNIFICATION 20,000 X

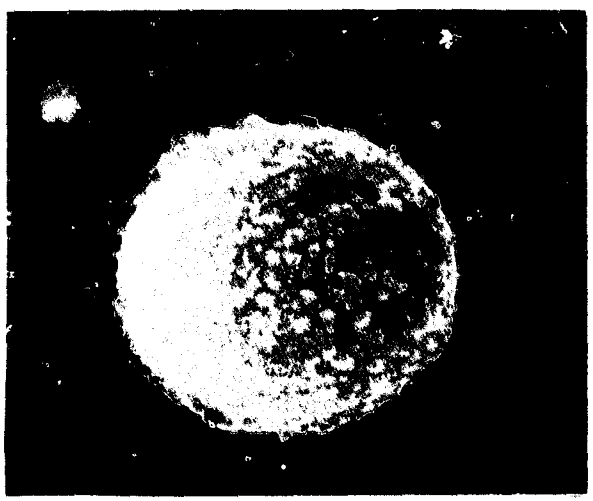


SEM Analysis of Gunshot Residue

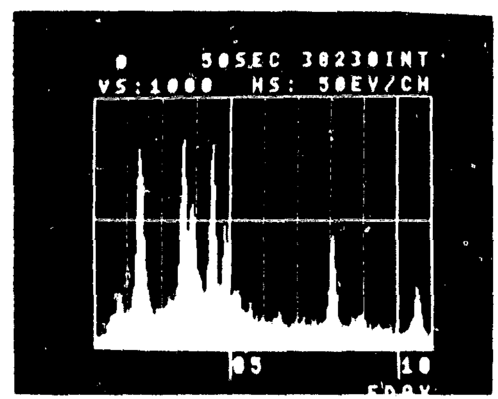


GUN .38 Special Smith & Wesson Revolver
AMMUNITION Super Vel
MAGNIFICATION 2,500 X

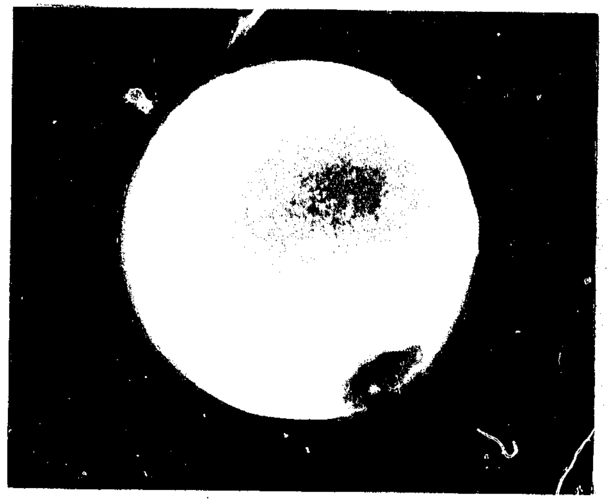




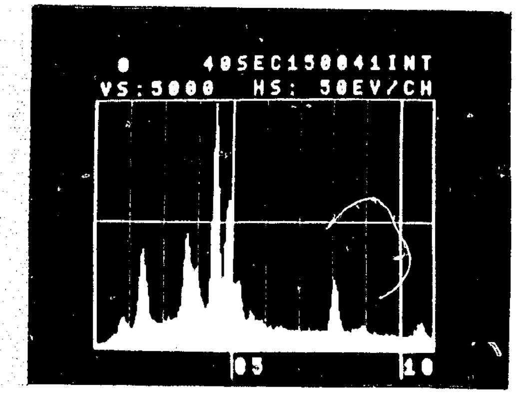
GUN .38 Special Smith & Wesson Revolver
AMMUNITION Western
MAGNIFICATION 10,000 X

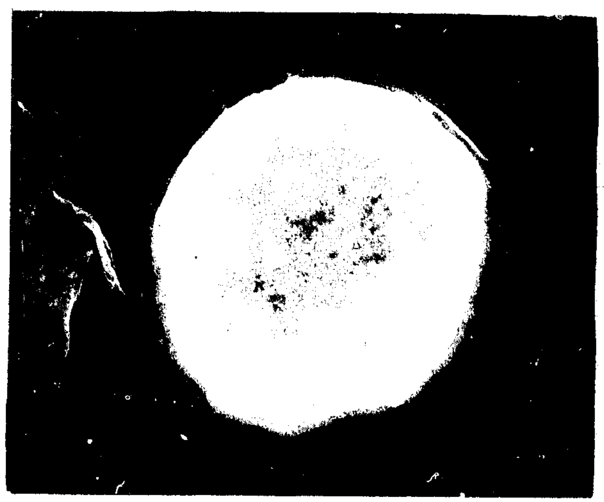


SEM Analysis of Gunshot Residue

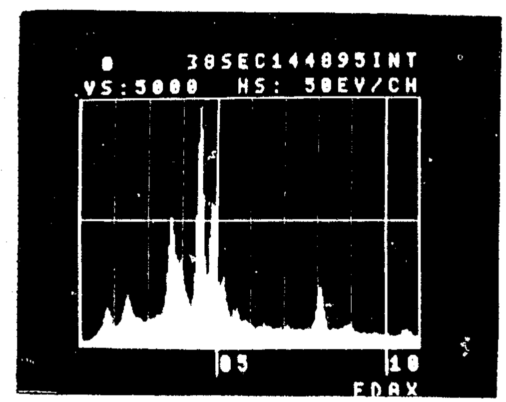


GUN .38 Special Smith & Wesson Revolver
AMMUNITION Norma (lead nose)
MAGNIFICATION 6,000 X



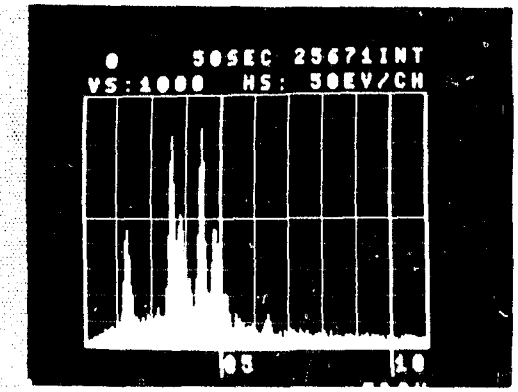


GUN .38 Special Smith & Wesson Revolver
AMMUNITION Norma (lead nose)
MAGNIFICATION 2,500 X

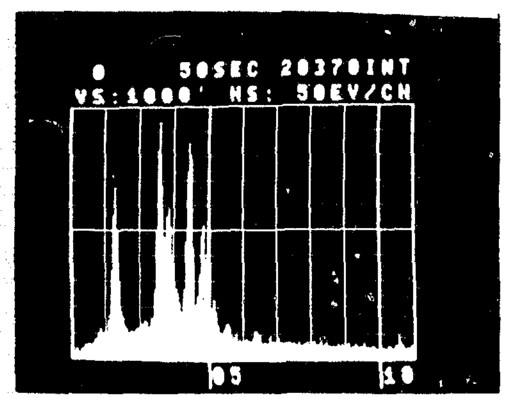


SEM Analysis of Gunshot Residue

GUN .38 Special Smith & Wesson Revolver
AMMUNITION Norma
MAGNIFICATION 6,750 X

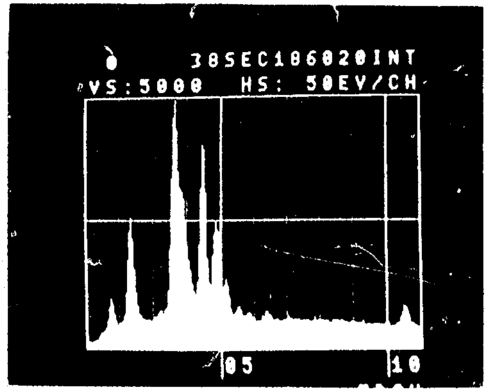


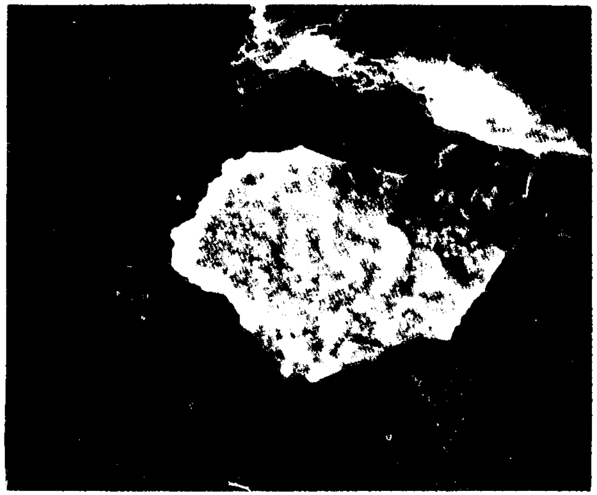
GUN .38 Special Smith & Wesson Revolver
AMMUNITION Norma
MAGNIFICATION 2,600 X



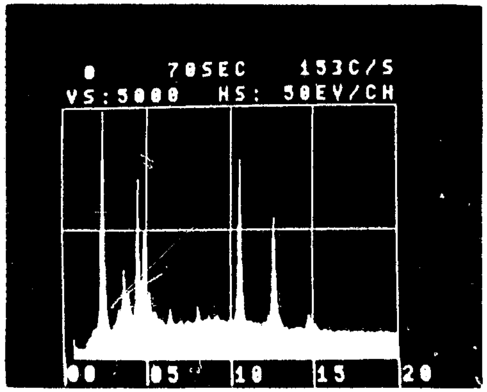
SEM Analysis of Gunshot Residue

GUN .38 Special Smith & Wesson Revolver
AMMUNITION Western
MAGNIFICATION 3,000 X





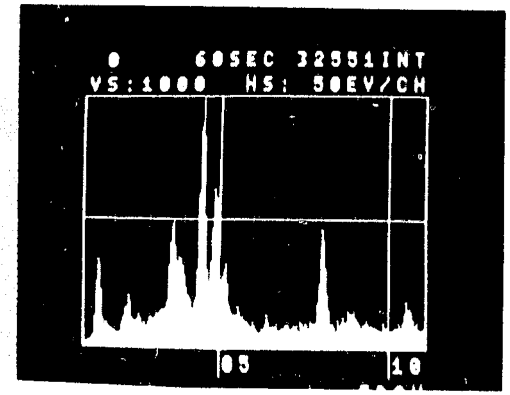
GUN .38 Special Smith & Wesson Revolver
AMMUNITION Remington (hollow point)
MAGNIFICATION 900 X

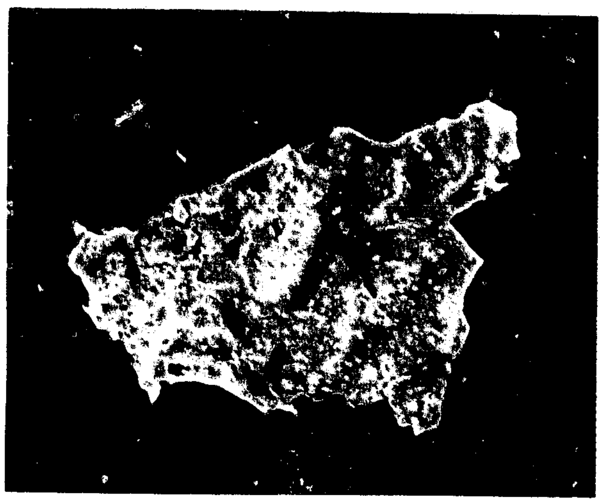


SEMIAUTOMATIC PISTOLS

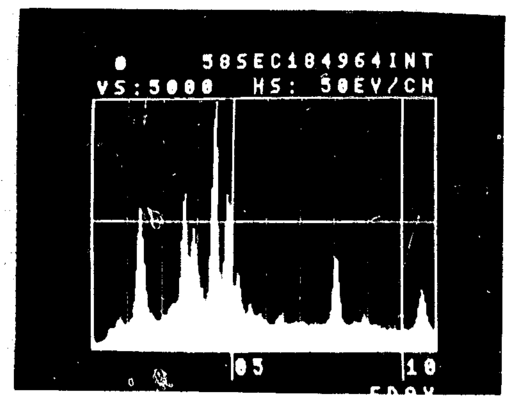
SEM Analysis of Gunshot Residue

GUN .32 Llama Semiautomatic Pistol
AMMUNITION Federal
MAGNIFICATION 1,000 X



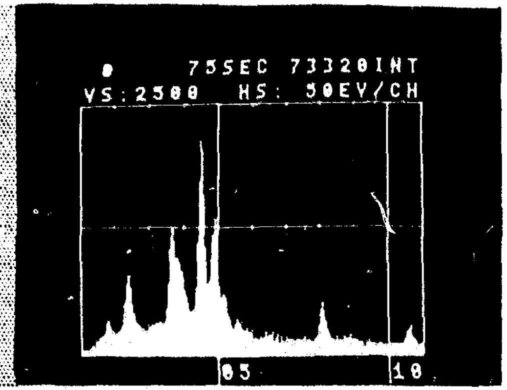


GUN .32 Llama Semiautomatic Pistol
AMMUNITION Western
MAGNIFICATION 500 X

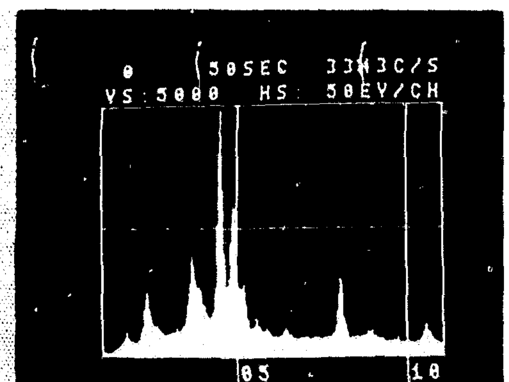


SEM Analysis of Gunshot Residue

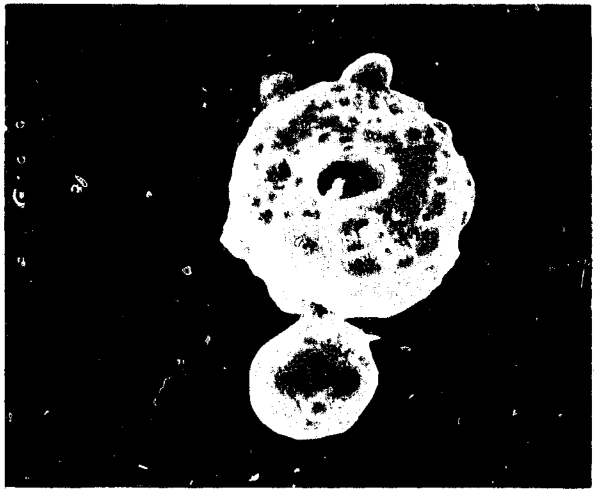
GUN .32 Llama Semiautomatic Pistol
AMMUNITION Federal
MAGNIFICATION 1,000 X



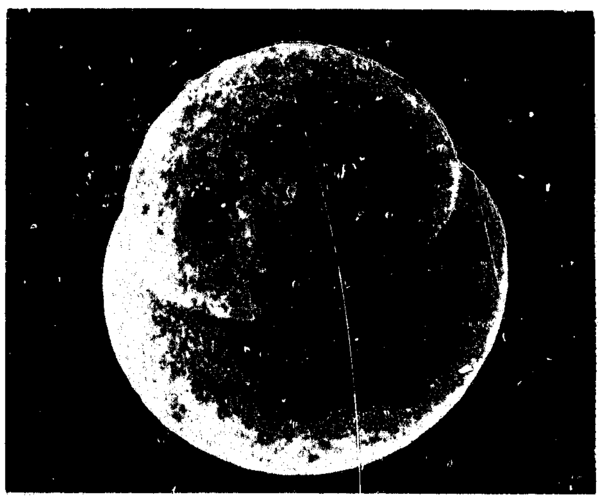
GUN .32 Semiautomatic Pistol
AMMUNITION Federal
MAGNIFICATION 140 X



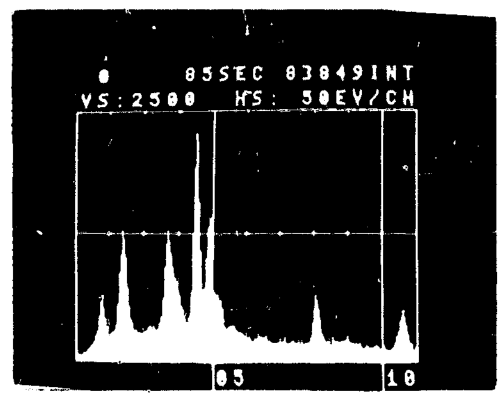
SEM Analysis of Gunshot Residue



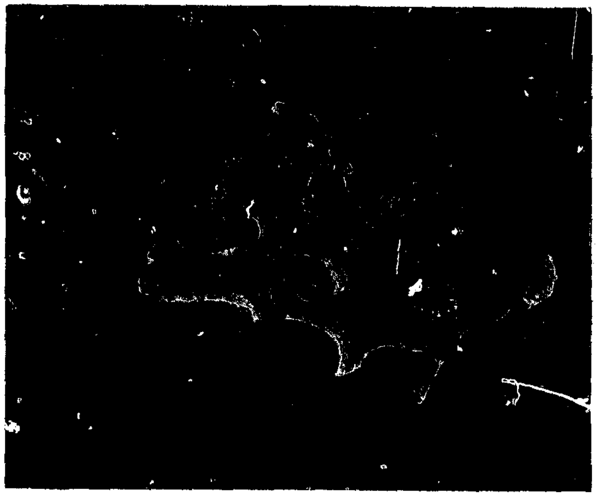
GUN .32 Llama Semiautomatic Pistol
AMMUNITION Federal
MAGNIFICATION 1,100 X



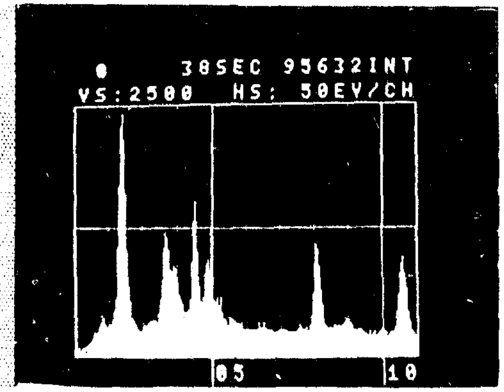
GUN .32 Llama Semiautomatic Pistol
AMMUNITION Federal
MAGNIFICATION 1,000 X



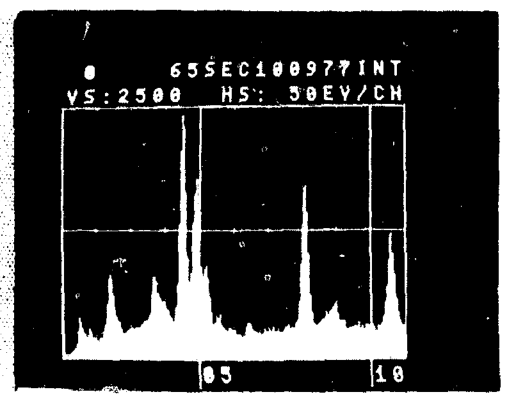
SEM Analysis of Gunshot Residue



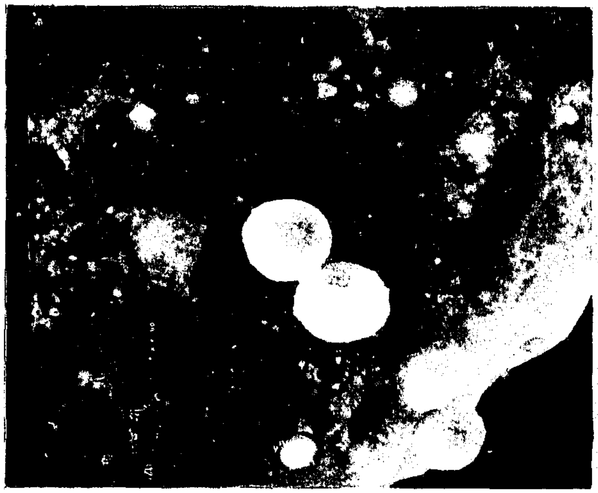
GUN .32 Llama Semiautomatic Pistol
AMMUNITION Federal
MAGNIFICATION 300 X



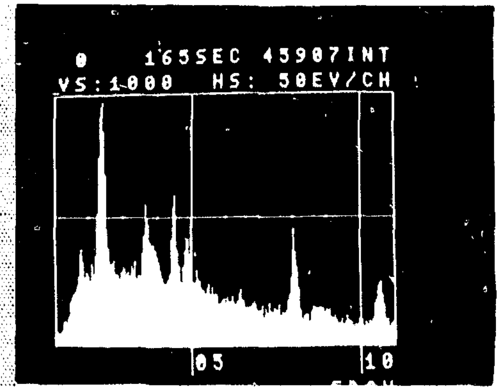
GUN .32 Llama Semiautomatic Pistol
AMMUNITION Federal
MAGNIFICATION 300 X



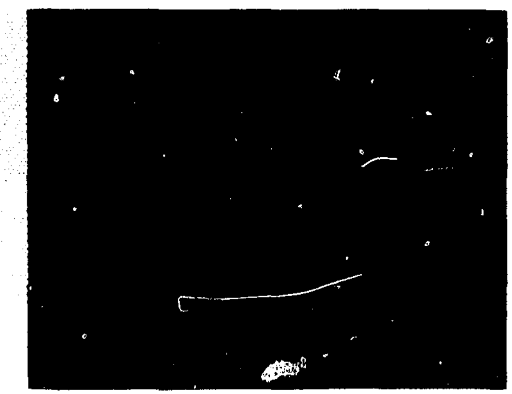
SEM Analysis of Gunshot Residue



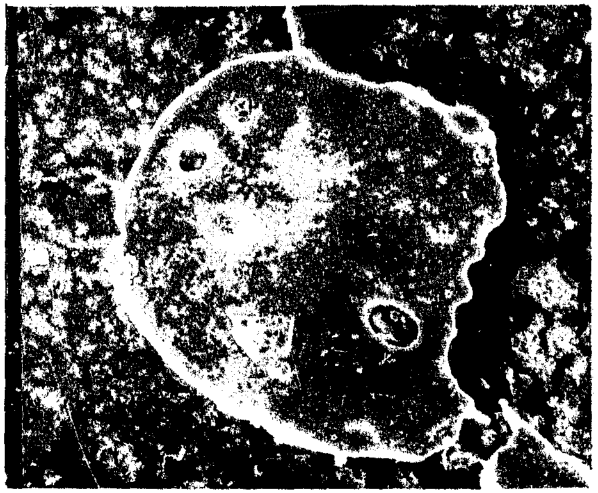
GUN .32 Semiautomatic Pistol
AMMUNITION Federal
MAGNIFICATION 2,000 X



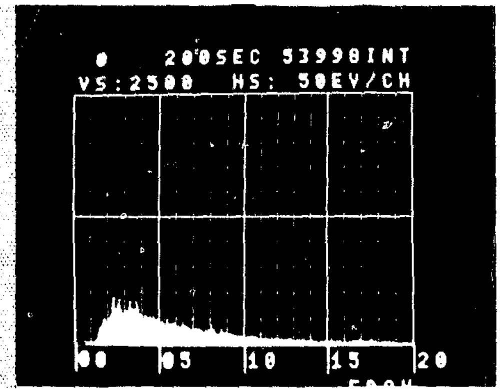
GUN .32 Semiautomatic Pistol
AMMUNITION Federal
MAGNIFICATION 200 X



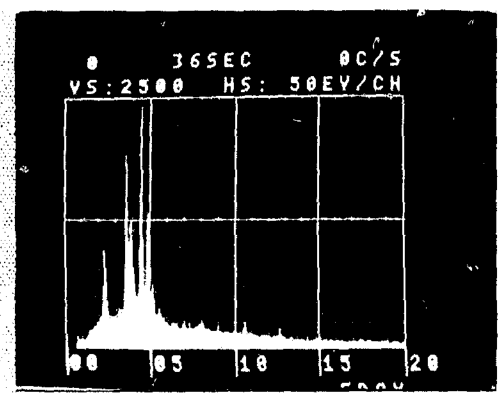
SEM Analysis of Gunshot Residue



GUN .380 Browning Semiautomatic Pistol
AMMUNITION Remington
MAGNIFICATION 100 X

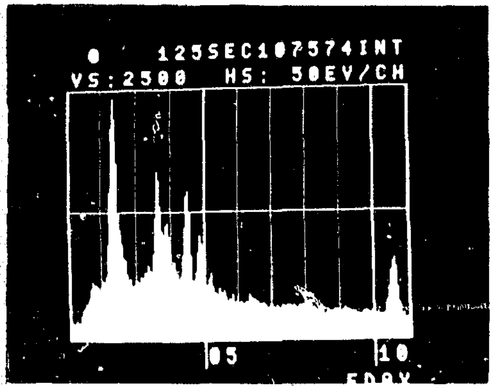


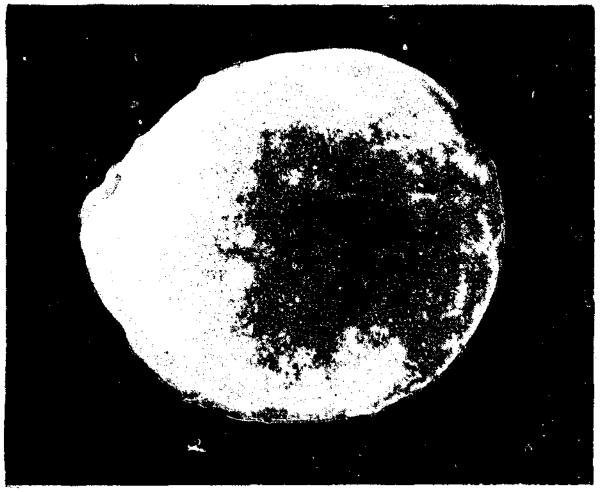
GUN .380 Browning Semiautomatic Pistol
AMMUNITION Remington
MAGNIFICATION 10,000 X



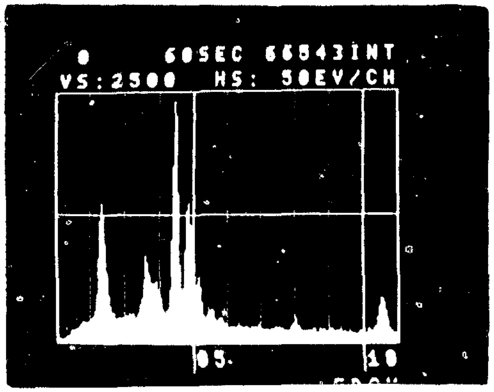
SEM Analysis of Gunshot Residue

GUN .380 Browning Semiautomatic Pistol
AMMUNITION Remington
MAGNIFICATION 2,400 X



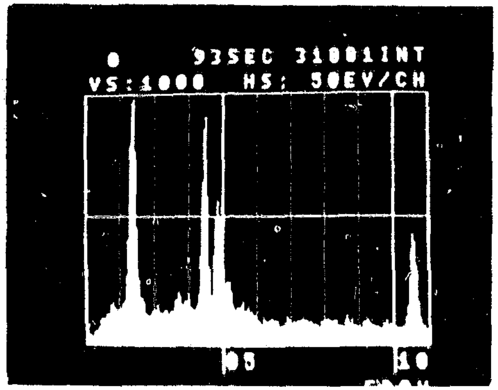


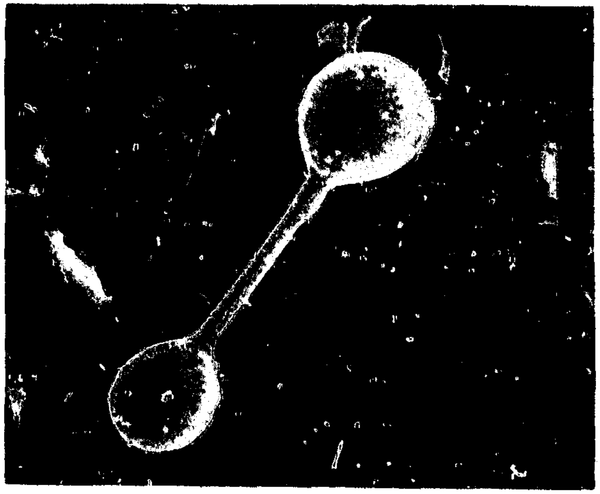
GUN .380 Browning Semiautomatic Pistol
AMMUNITION Remington
MAGNIFICATION 10,000 X



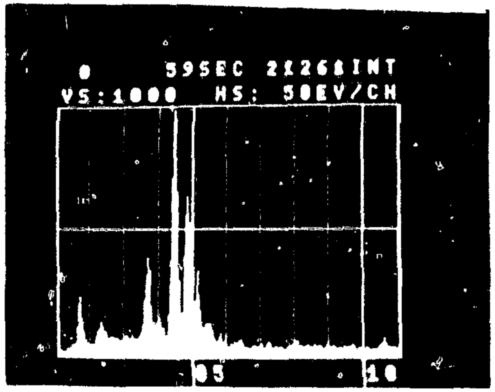
SEM Analysis of Gunshot Residue

GUN 9 mm Browning Semiautomatic Pistol
AMMUNITION Federal
MAGNIFICATION 6,000 X



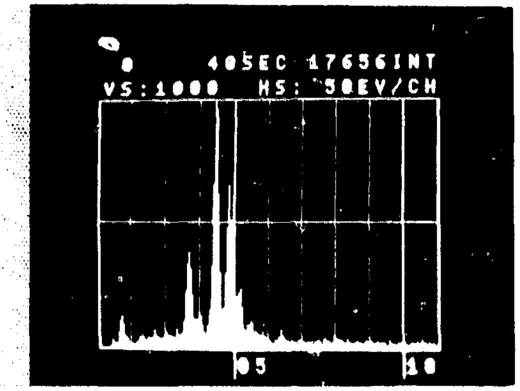


GUN 9 mm Browning Semiautomatic Pistol
AMMUNITION Federal
MAGNIFICATION 7,500 X

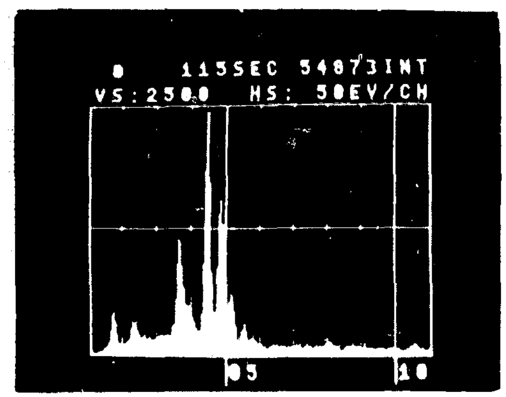


SEM Analysis of Gunshot Residue

GUN 9 mm Browning Semiautomatic Pistol
AMMUNITION Federal
MAGNIFICATION 3,000 X

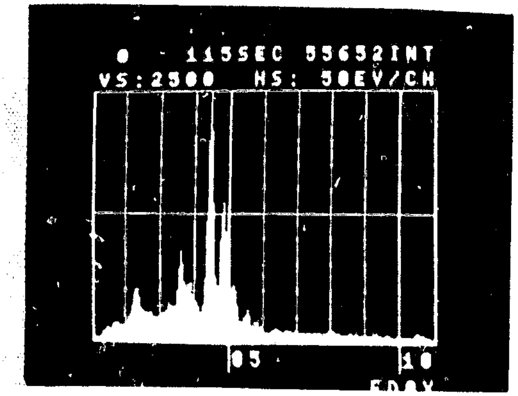


GUN 9 mm Browning Semiautomatic Pistol
AMMUNITION Federal
MAGNIFICATION 5,000 X

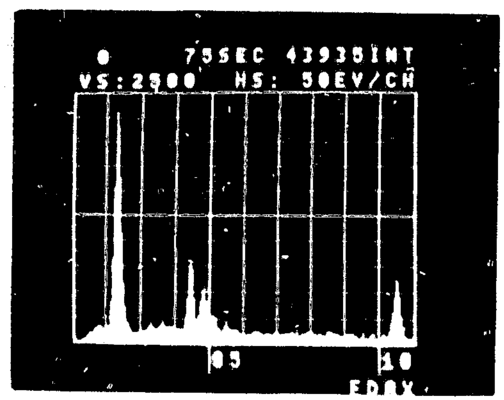


SEM Analysis of Gunshot Residue

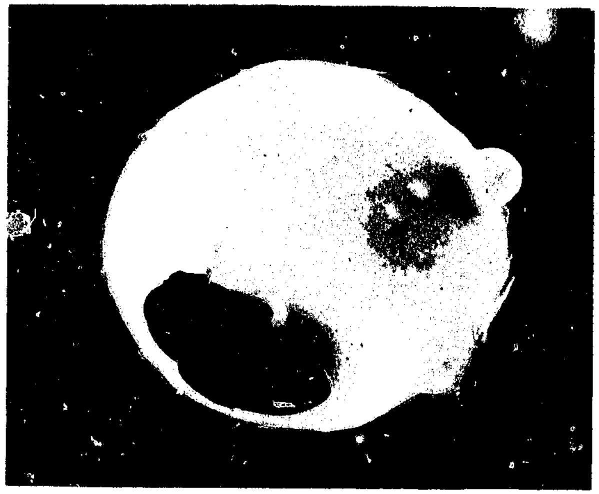
GUN .45 Colt Semiautomatic Pistol
AMMUNITION Western
MAGNIFICATION 9,000 X



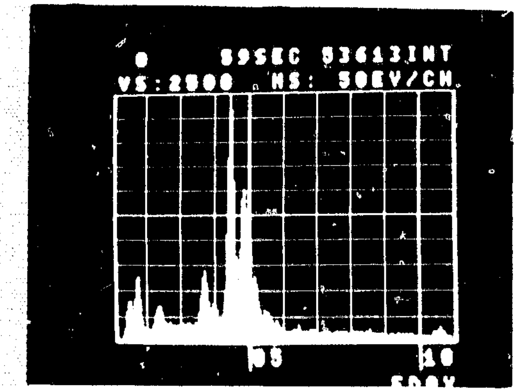
GUN .45 Colt Semiautomatic Pistol
AMMUNITION Super Vel
MAGNIFICATION 5,000 X

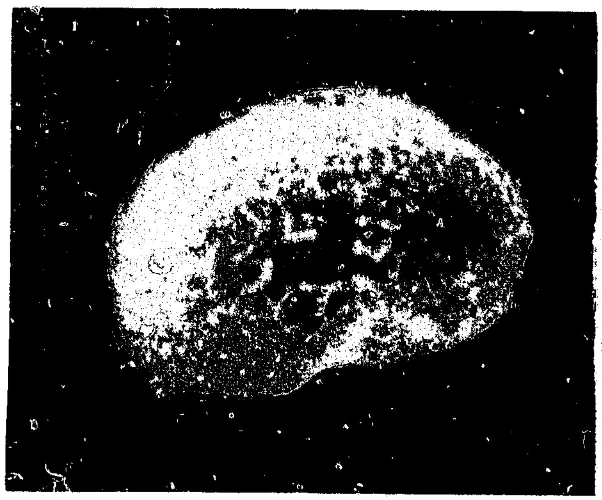


SEM Analysis of Gunshot Residue

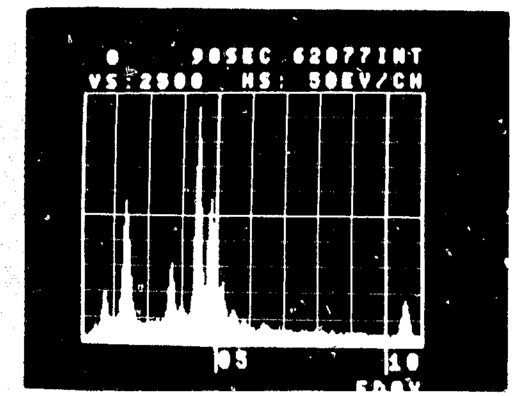


GUN .45 Colt Semiautomatic Pistol
AMMUNITION Norma
MAGNIFICATION 1,800 X



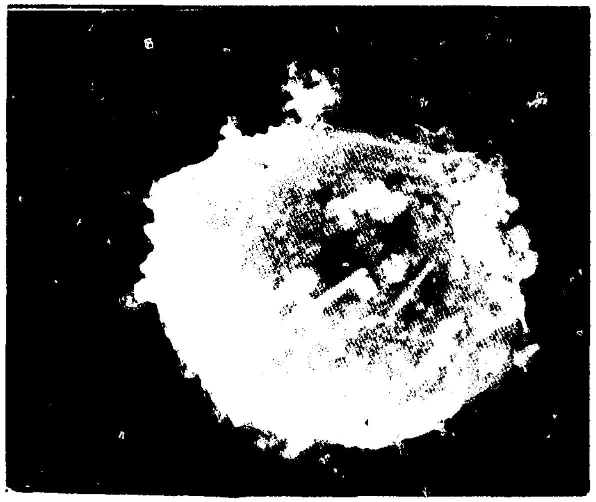


GUN .45 Colt Semiautomatic Pistol
AMMUNITION Norma
MAGNIFICATION 3,000 X



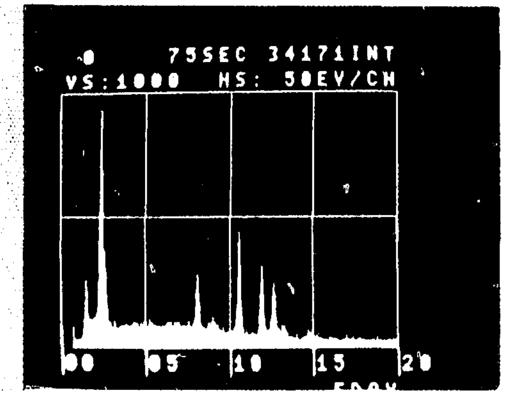
ENVIRONMENTAL PARTICLES

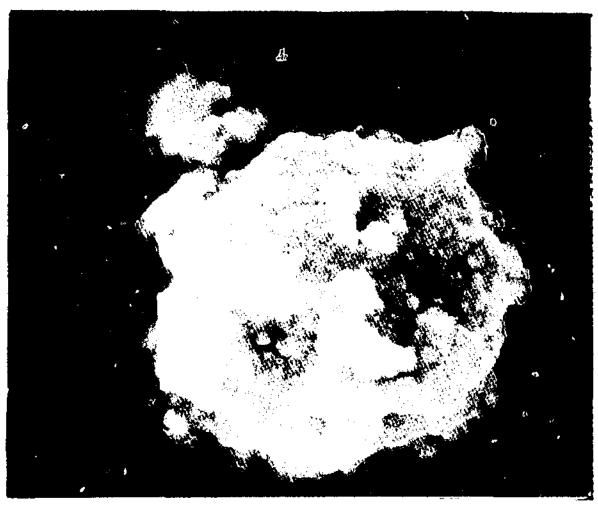
SEM Analysis of Gunshot Residue



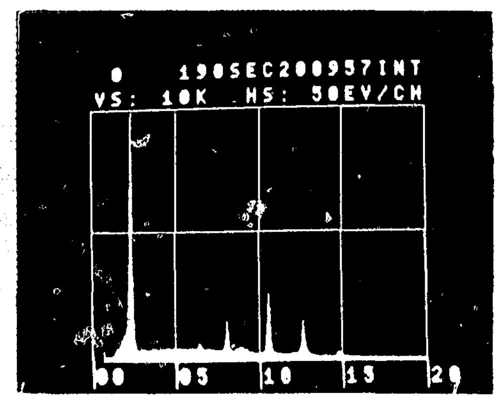
Automobile Exhaust

MAGNIFICATION 6,000 X

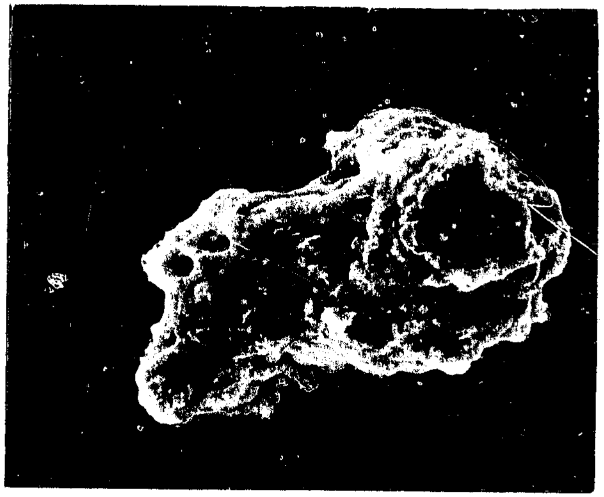




GUN Automobile Exhaust
AMMUNITION
MAGNIFICATION 6,000 X

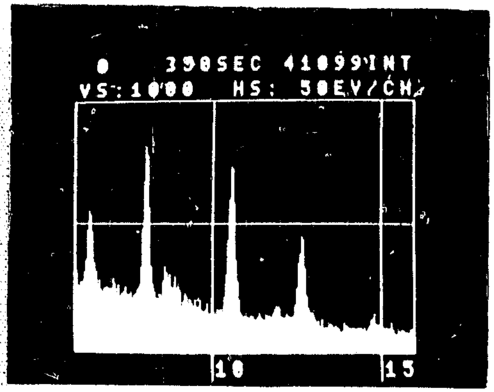


SEM Analysis of Gunshot Residue

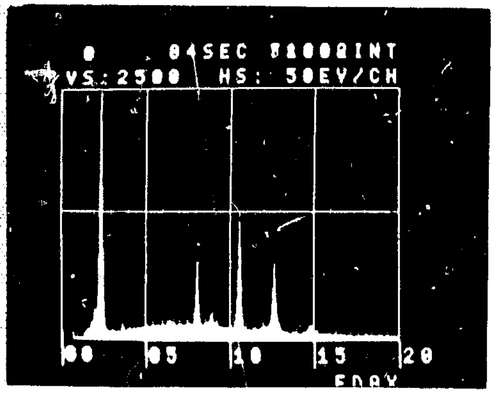


Automobile Exhaust

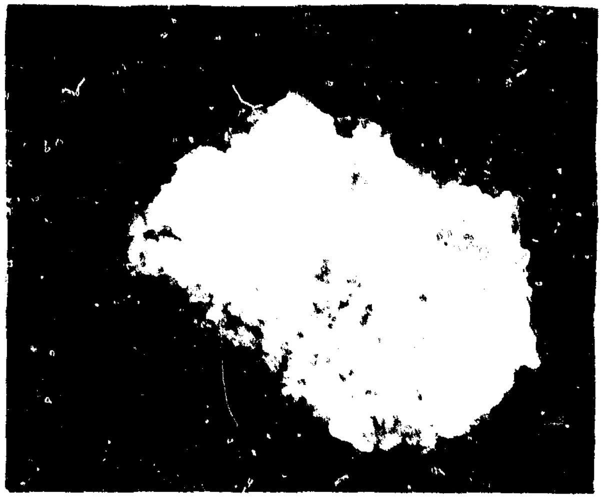
MAGNIFICATION 2,000 X



GUN Automobile Exhaust
AMMUNITION
MAGNIFICATION 3,500 X

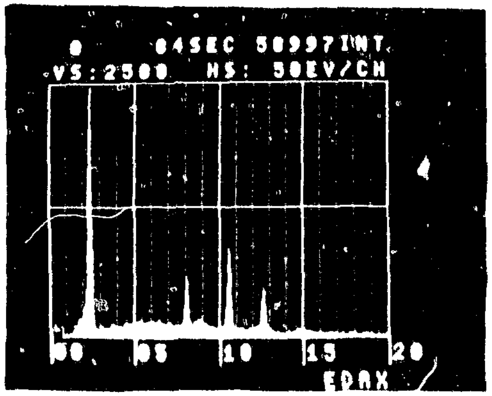


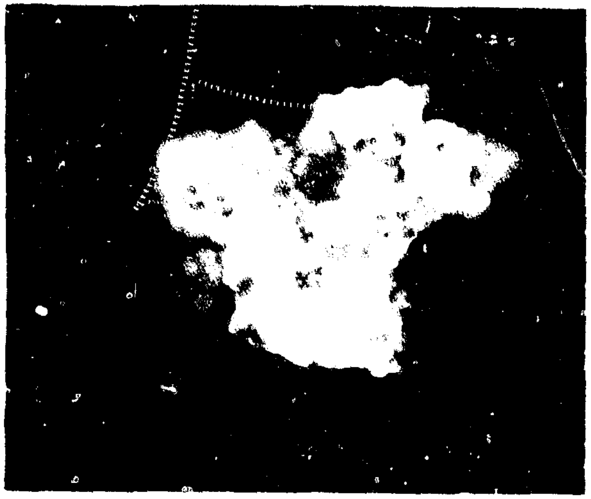
SEM Analysis of Gunshot Residue



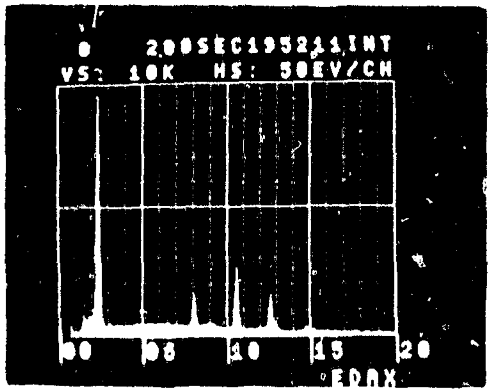
Automobile Exhaust

MAGNIFICATION 3,500 X

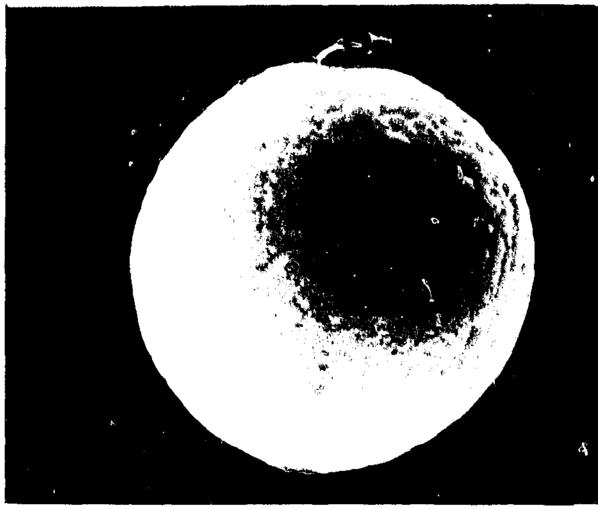




GUN Automobile Exhaust
AMMUNITION
MAGNIFICATION 5,000 X

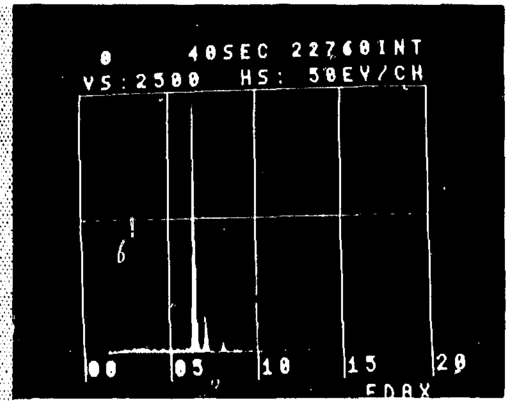


SEM Analysis of Gunshot Residue

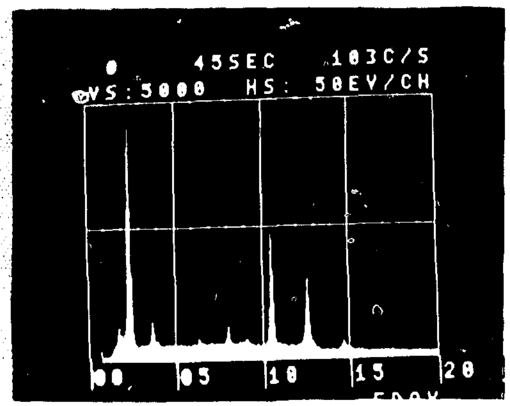


Handblank

MAGNIFICATION 6,000 X



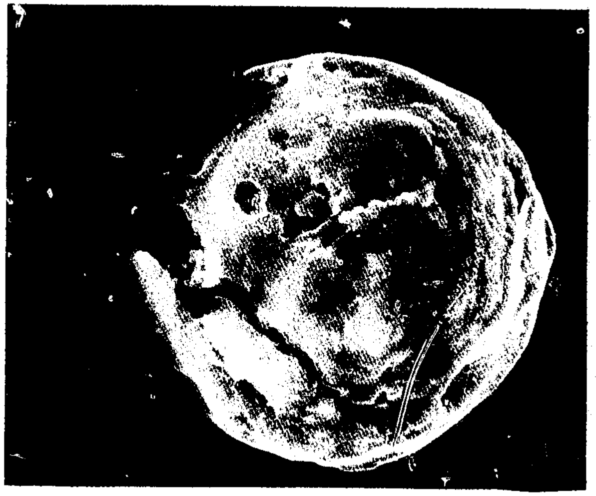
GUN Handblank
AMMUNITION
MAGNIFICATION 800 X



CONTINUED

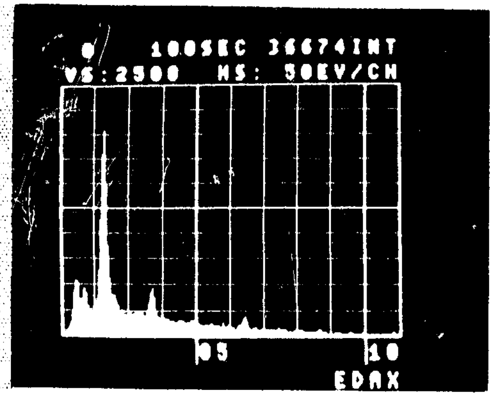
2 OF 3

SEM Analysis of Gunshot Residue

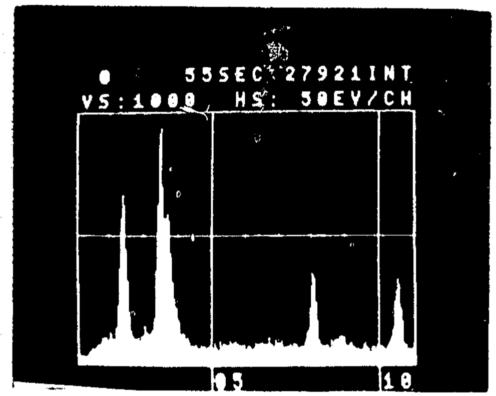


Handblank

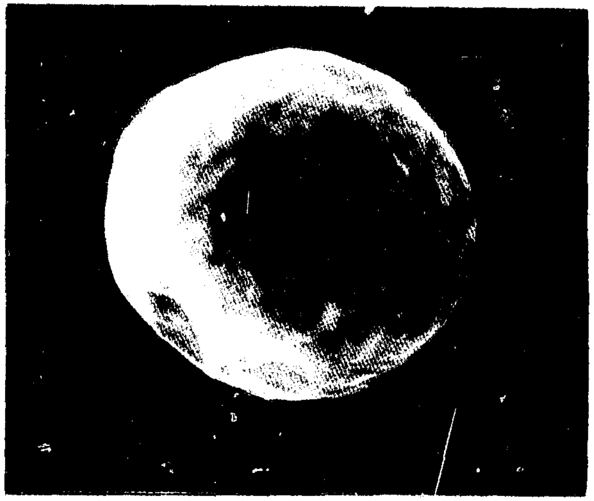
MAGNIFICATION 3,000 X



GUN Handblank
AMMUNITION
MAGNIFICATION 1,000 X

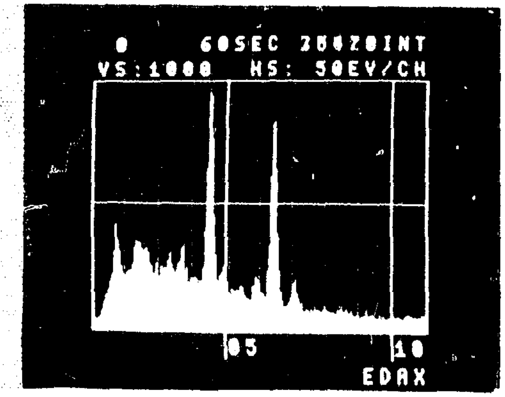


SEM Analysis of Gunshot Residue

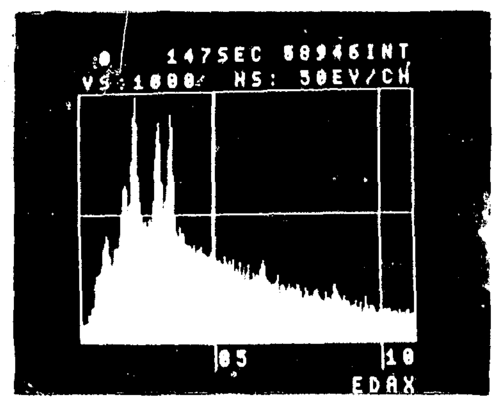


Handblank

MAGNIFICATION 2,000 X



GUN Handblank
AMMUNITION
MAGNIFICATION 1,000 X

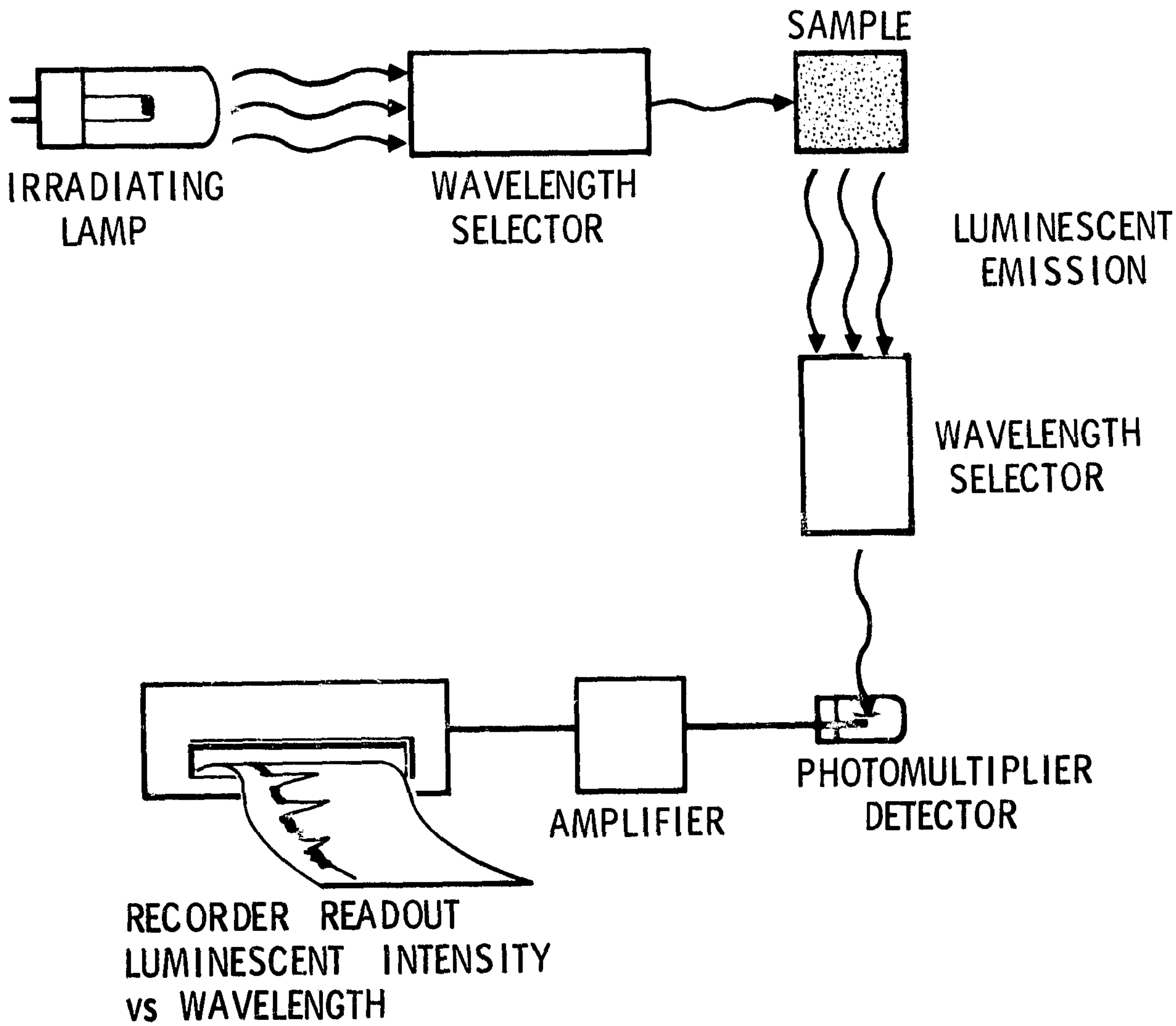


APPENDIX D

LUMINESCENCE METHOD FOR ELEMENTAL ANALYSIS

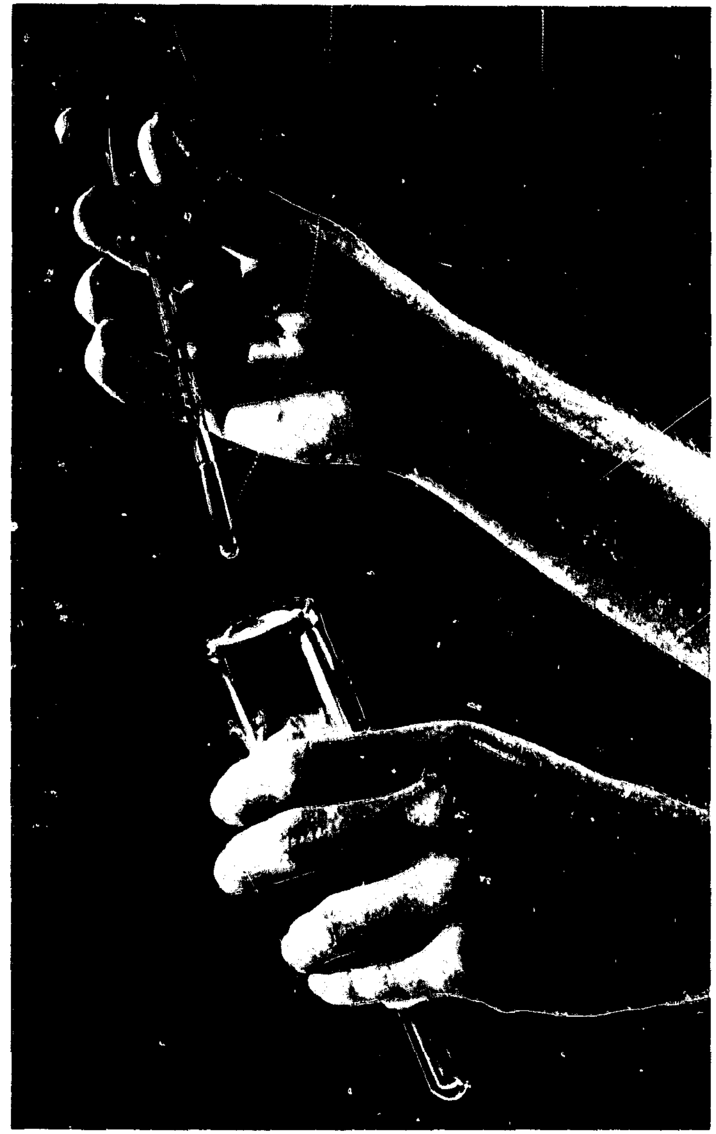
Detection of Gunshot Residue

INORGANIC LUMINESCENCE ANALYSIS



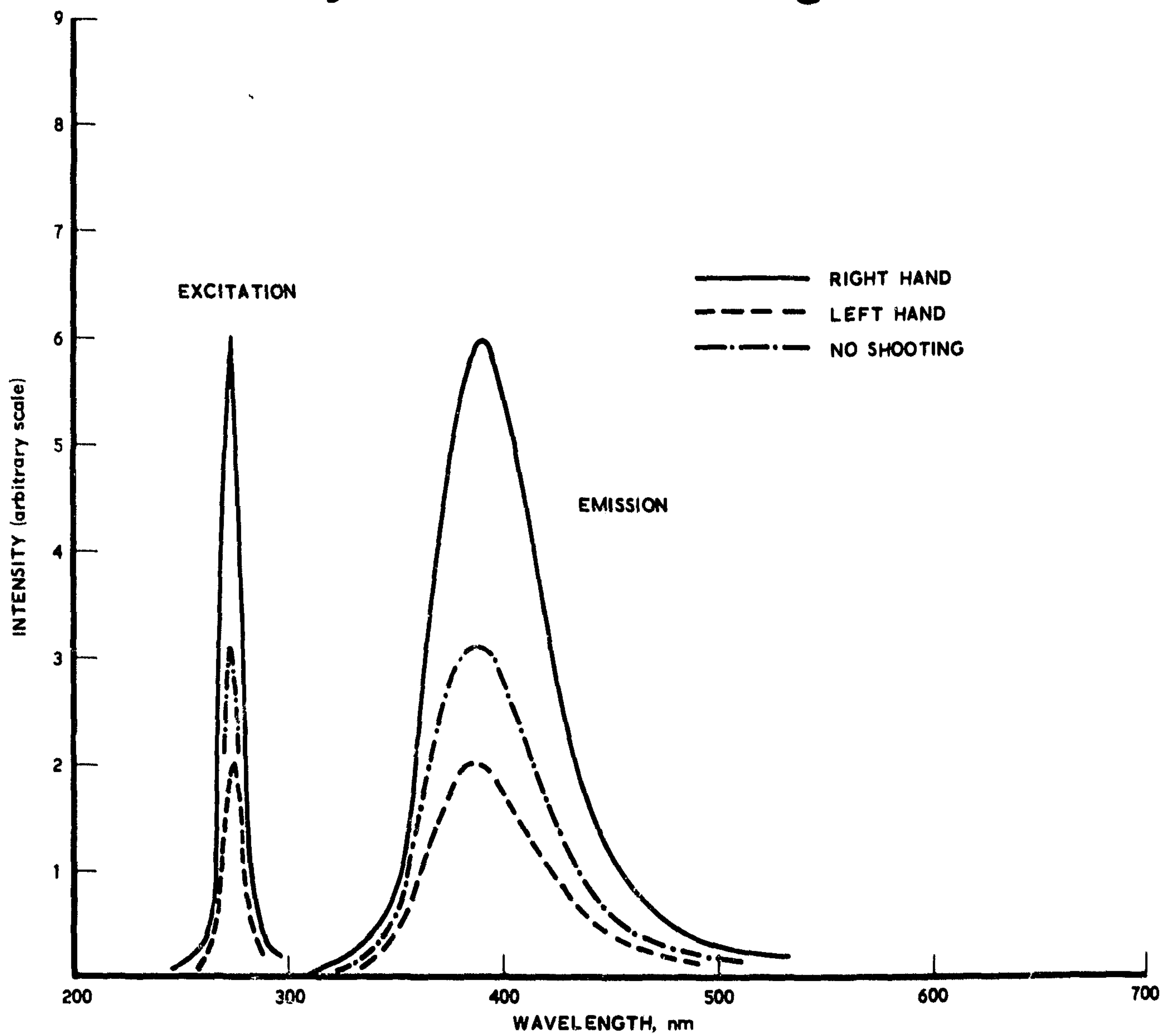
DISSOLVING RESIDUE

PIPETTING SAMPLE INTO DEWAR

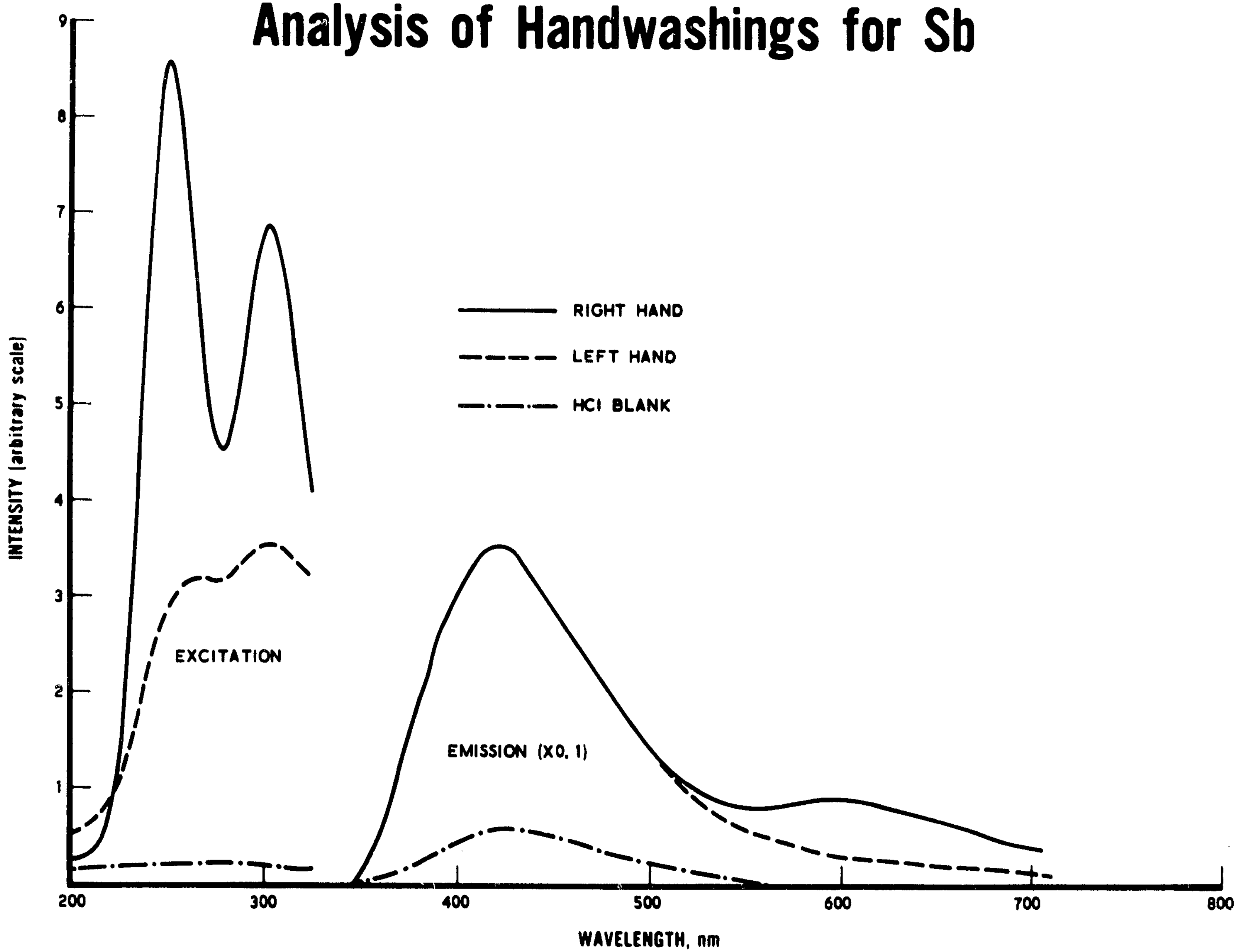


FLUORIMETER

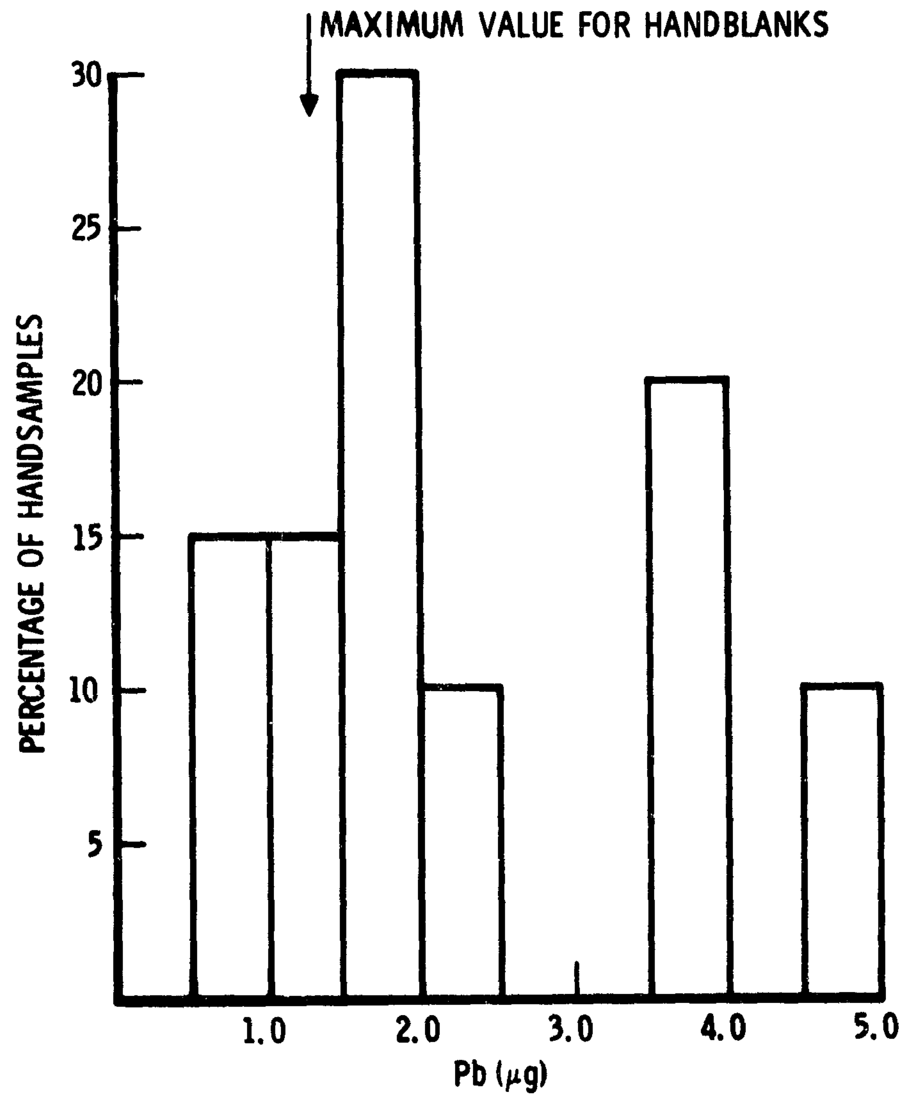
Analysis of Handwashings for Pb



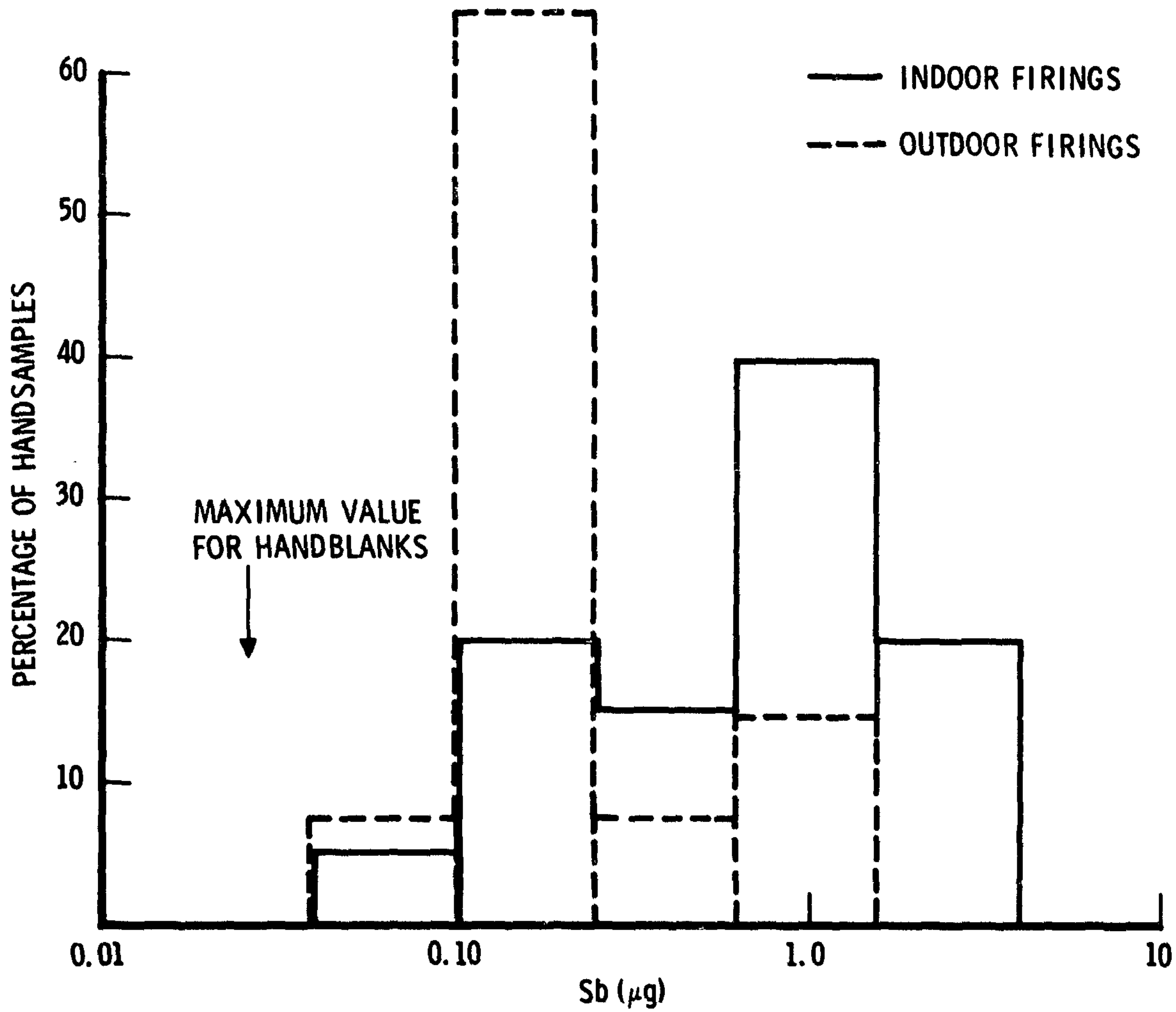
Analysis of Handwashings for Sb



Amounts of Lead Found on Hand After Firing .32 Semi-Automatic Pistol



Amounts of Antimony Found on Hand After Firing
.32 Semi-Automatic Pistol



PHOTOLUMINESCENCE DETECTION

INDOOR VERSUS OUTDOOR FIRINGS

	INDOOR		NUMBER	OUTDOOR		NUMBER
	Pb	Sb	SAMPLES	Pb	Sb	SAMPLES
REVOLVERS						
.38	4 μg	.13 μg	16	.6 μg	.03 μg	31
.32	3	.07	2	1.3	.05	3
.22	1.4	.05	6	1.0	.03	13
SEMIAUTOMATIC PISTOLS						
9 mm	2.2	.1	2	.5	.02	9
.380	5	.5	5	2.2	.7	6
.32	2.3	.8	20	1.7	.24	14
.22	1.9	.07	9	.5	.03	2

INORGANIC PHOTOLUMINESCENCE DETECTION

	Pb	Sb	NUMBER SAMPLES
HANDS IN POCKET 3 TIMES			
HANDSAMPLE	.9 μg	.1 μg	7
POCKET SAMPLE	.8	.1	7
POCKET BLANK	.3	$<.01$	7
HANDS WIPED ON CLOTHING			
HANDSAMPLE	.6	.04	7
HANDBLANKS	.4	$<.01$	45

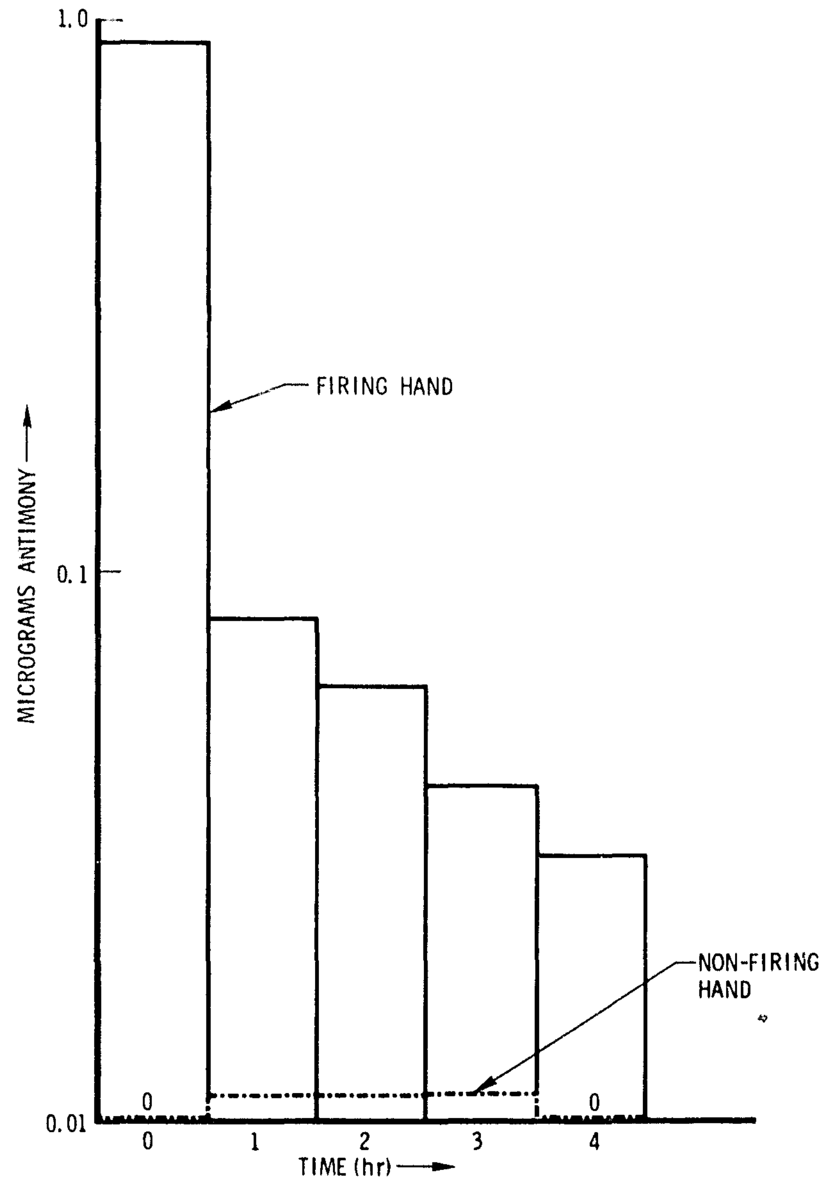
(1/2 SUBJECTS IN HIGH EXPOSURE GROUP: TV REPAIRMAN, ASSEMBLY WORKERS, CARPENTERS, PAINTERS, MACHINISTS, AUTOMECHANICS, MAINTENANCE MEN)

(ONLY 1 SAMPLE $> .01$μg Sb)

Inorganic Photoluminescence

PERSISTENCE

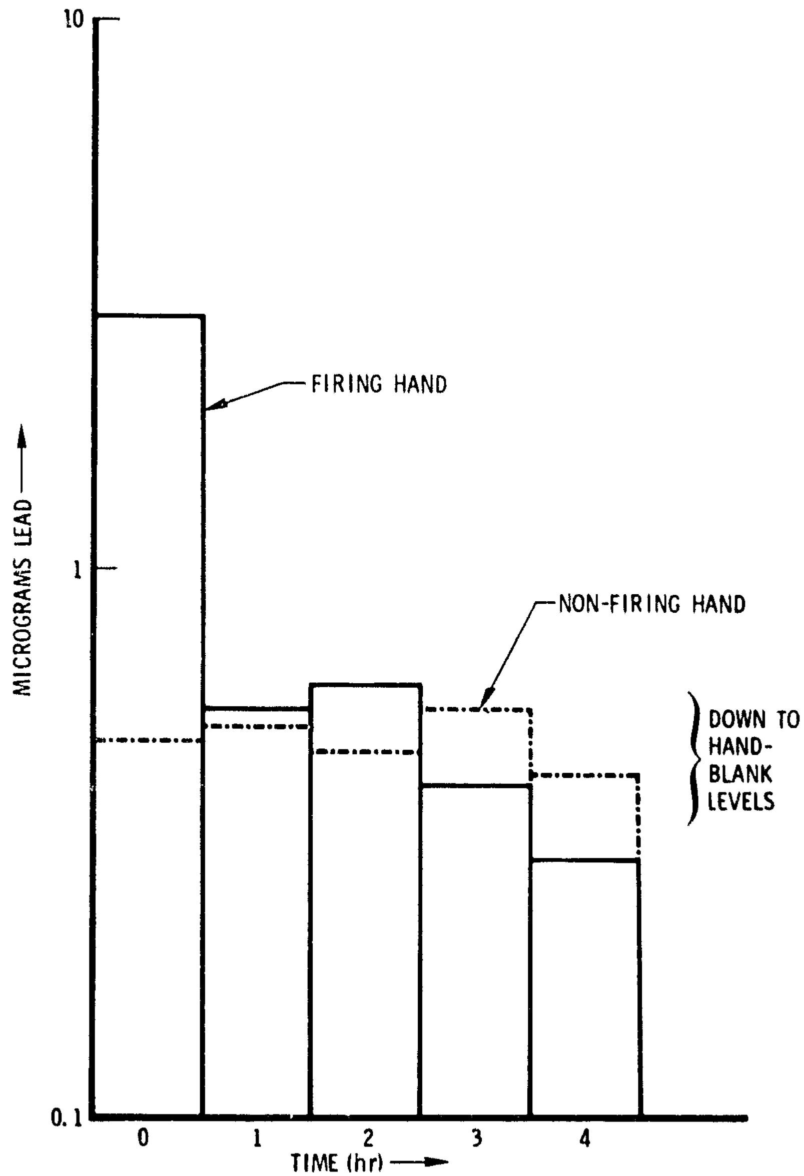
ANTIMONY,
.32 SEMI-AUTOMATIC PISTOL



Inorganic Photoluminescence

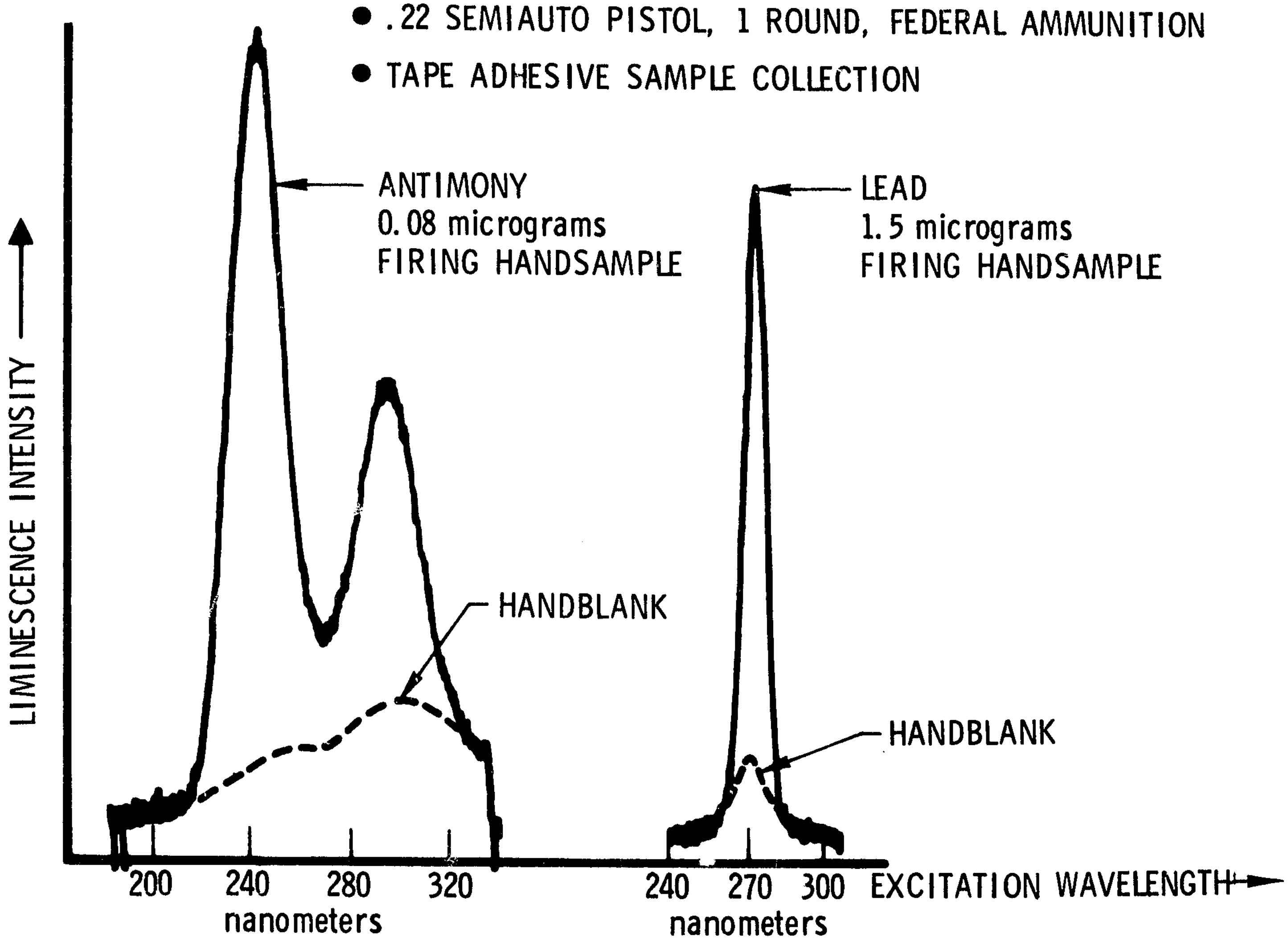
PERSISTENCE

LEAD,
.32 SEMI-AUTOMATIC PISTOL



Inorganic Photoluminescence Demonstration

ANALYSIS OF HANDSAMPLE FROM DR. HODGKIN, 23 OCT 1975



APPENDIX E

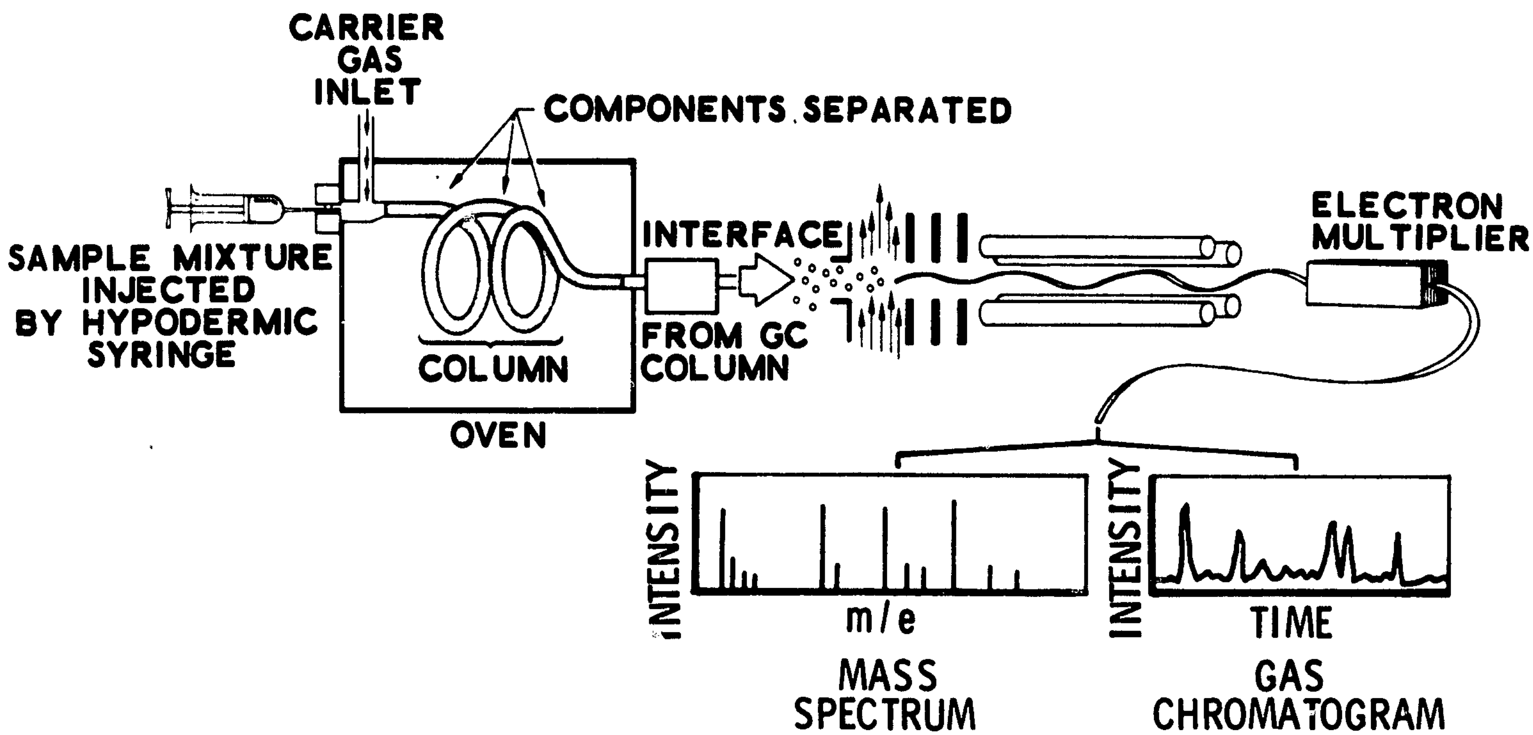
ORGANIC CONSTITUENTS OF GUNPOWDER AND OF RESIDUE

Detection of Gunshot Residue

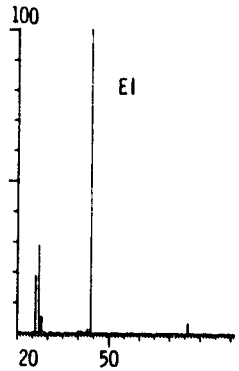
ANALYSIS METHODS

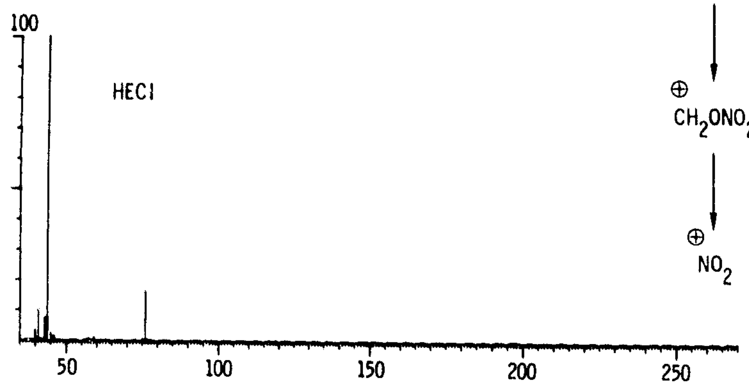
- GAS CHROMATOGRAPHY/MASS SPECTROMETRY

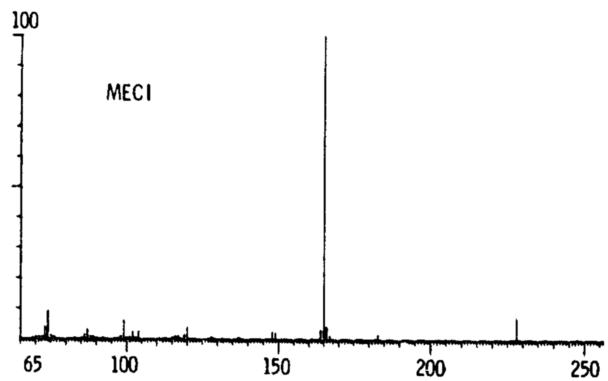
PRINCIPLE - SEPARATION OF COMPONENTS, IONIZATION, AND IDENTIFICATION IN MASS SPECTROMETER

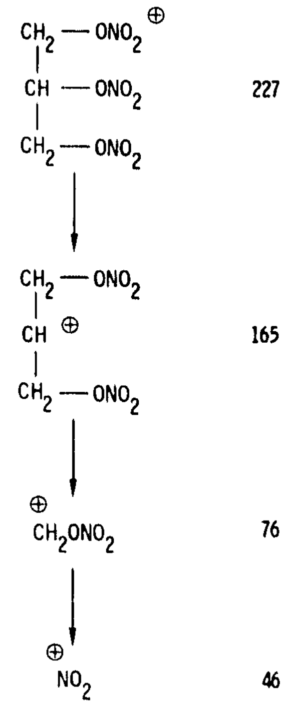


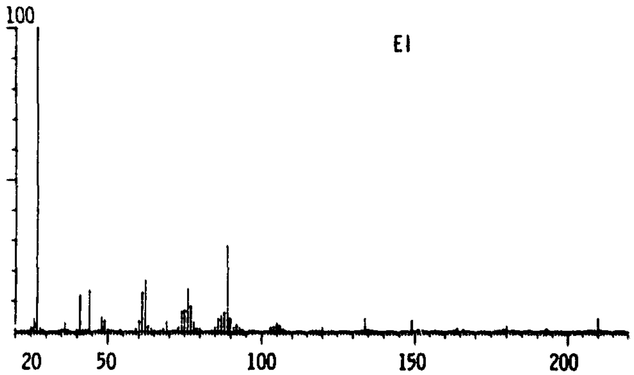
Mass Spectra of Nitroglycerin

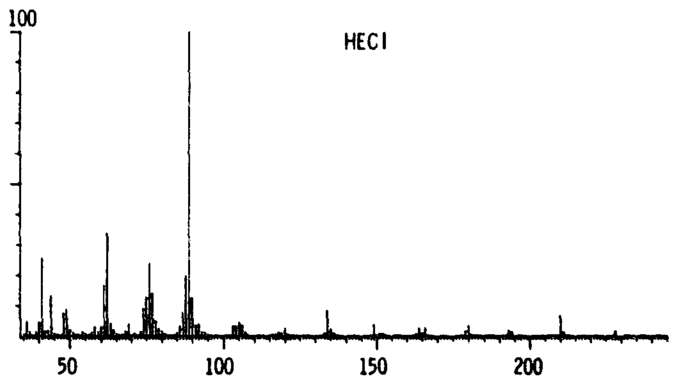


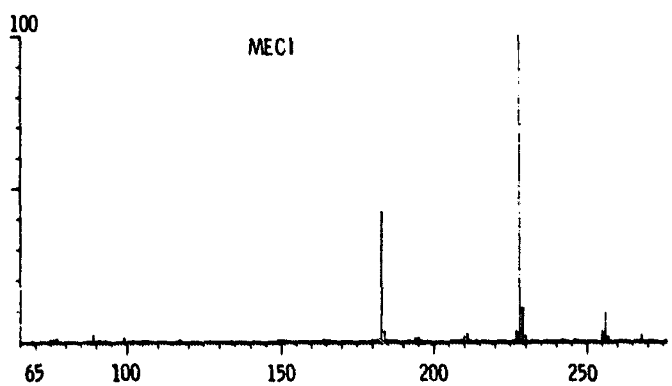


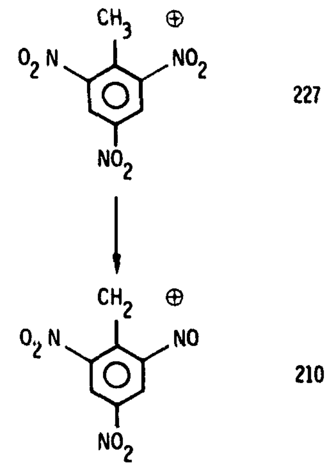






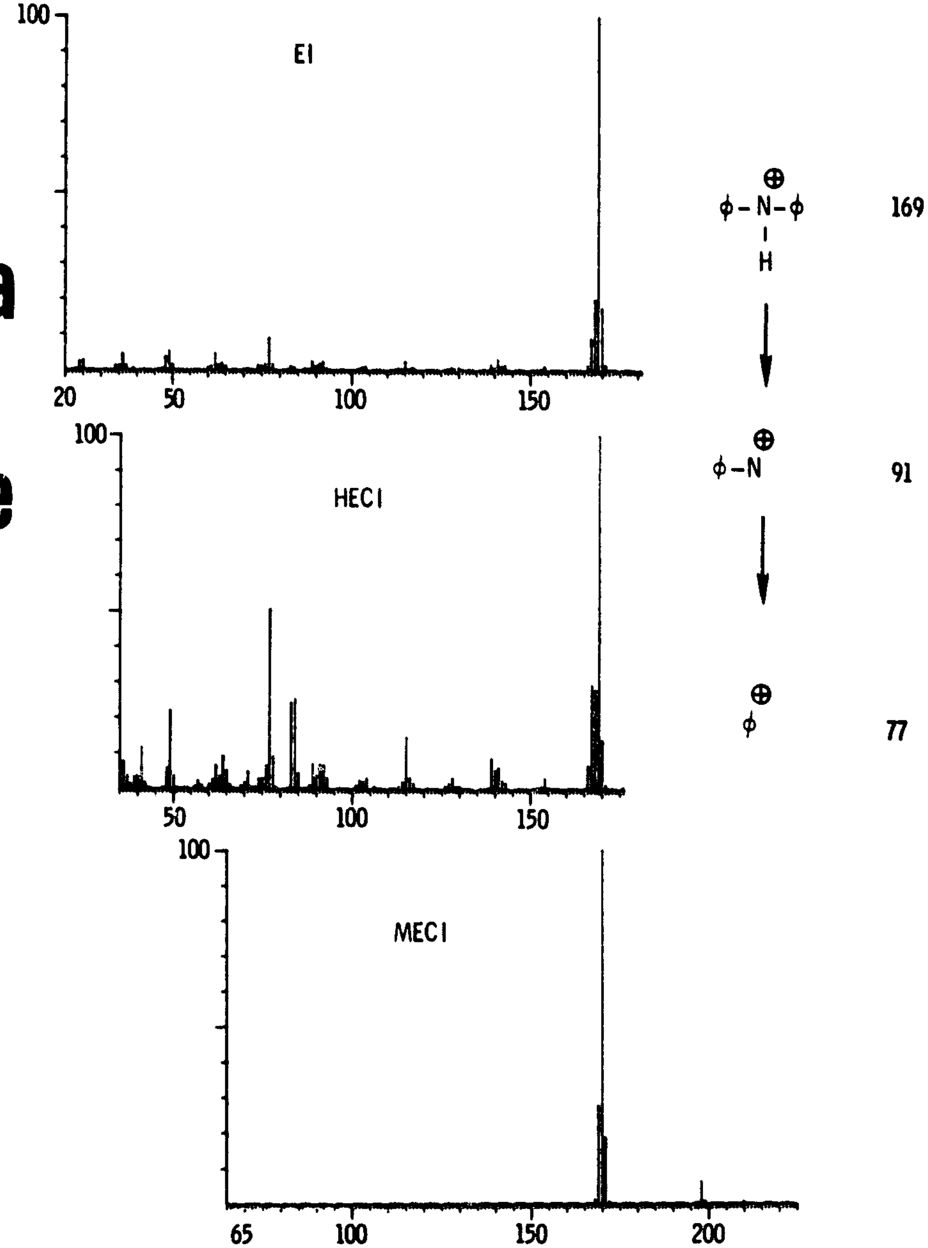


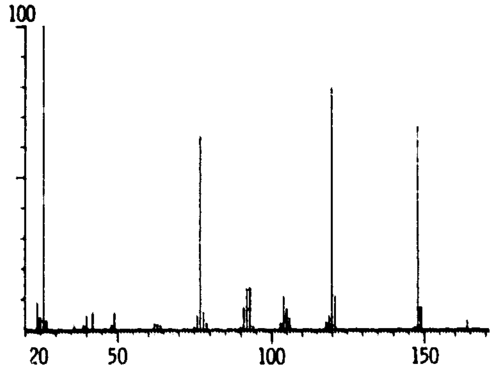


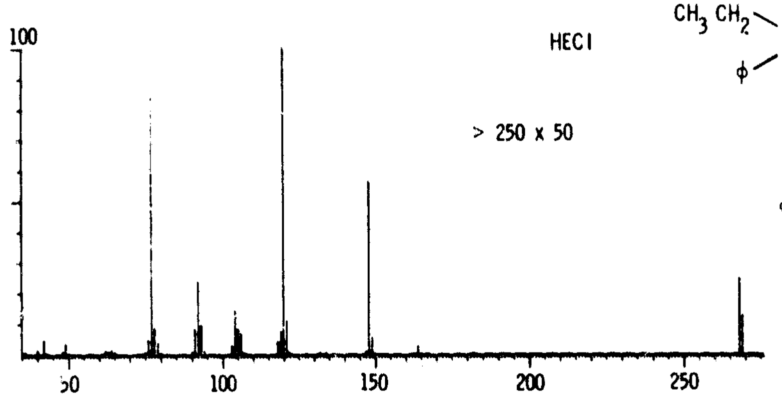


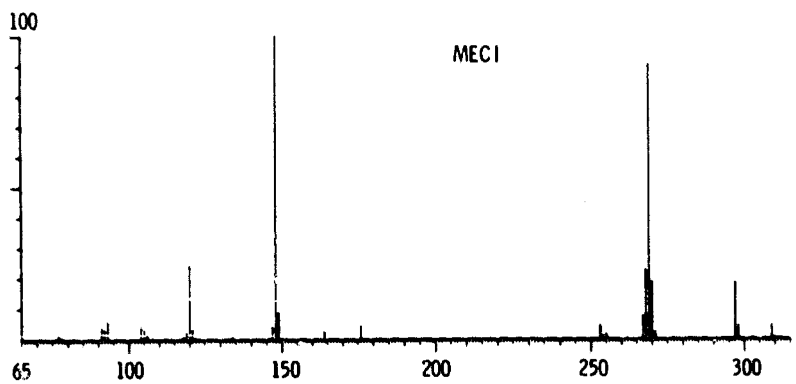
Mass Spectra of Sym-Trinitrotoluene

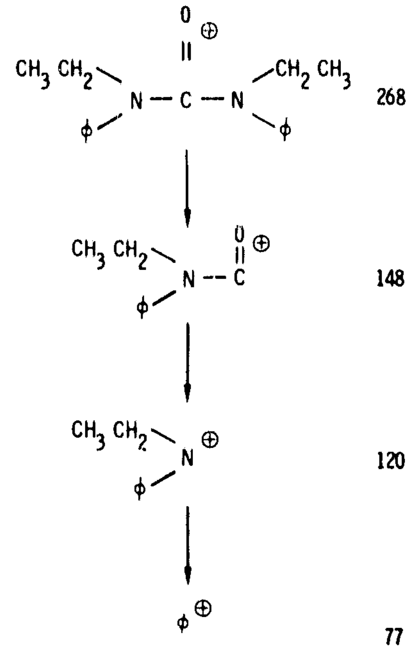
Mass Spectra of Diphenylamine





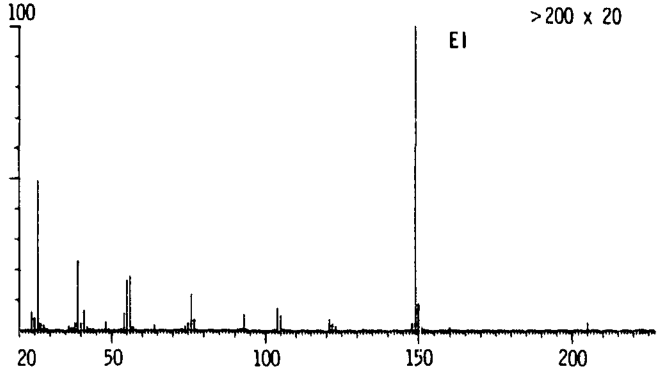


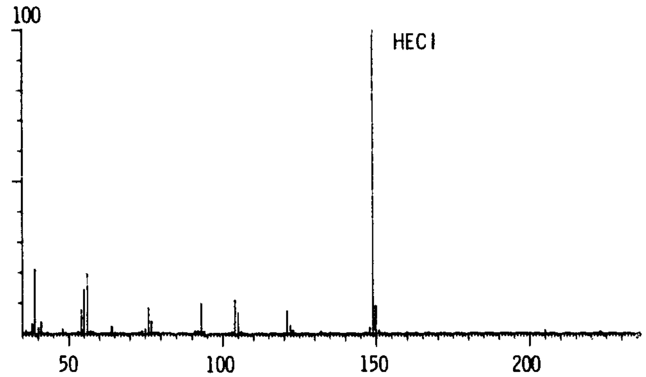


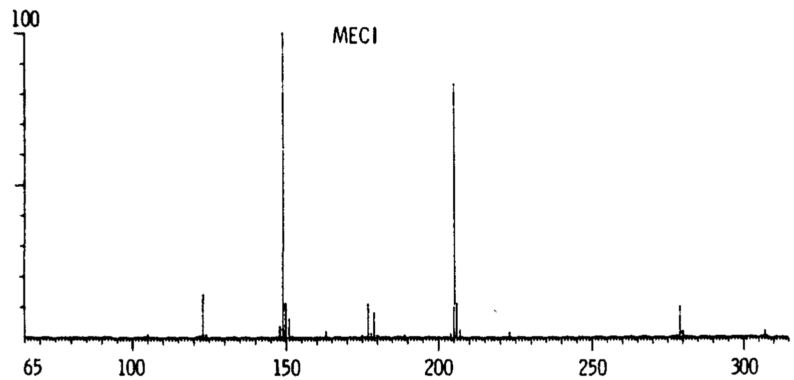


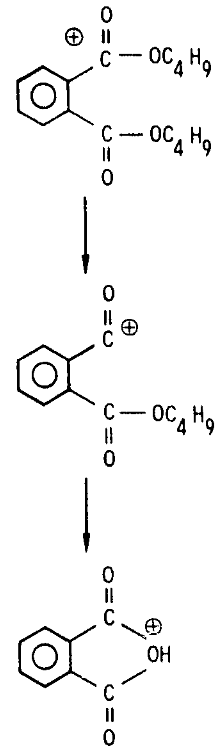
Mass Spectra of Ethyl Centralite

Mass Spectra of Dibutylphthalate





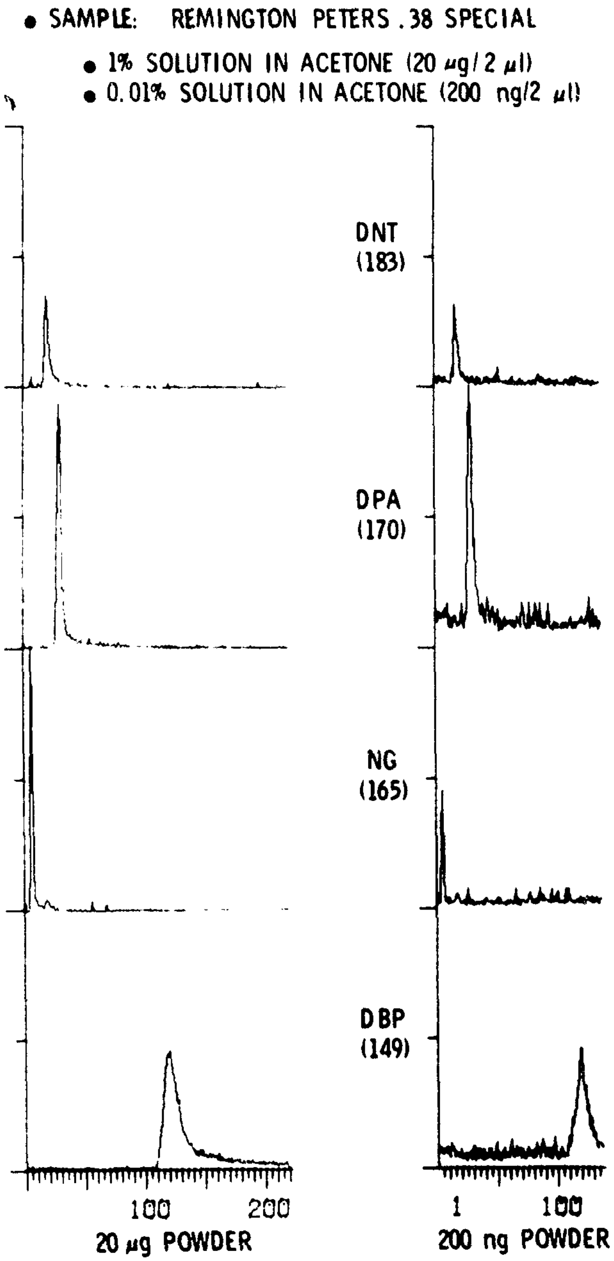




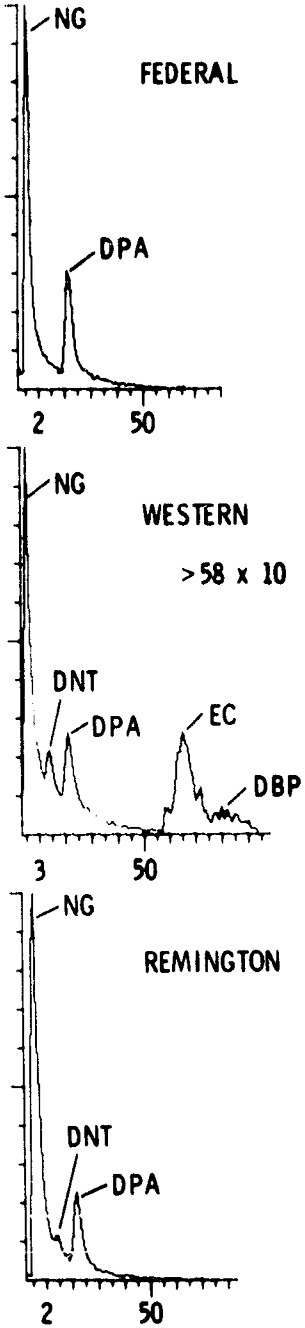
278

205

149



Identification of Smokeless Powder by Mass Fragmentography



.22 Long Rifle Cartridges Smokeless Powder Composition

NG: NITROGLYCERIN
DNT: DINITROTOLUENE
DPA: DIPHENYLAMINE
EC: ETHYL CENTRALITE
DBP: DIBUTYL PHTHALATE

Summary of Smokeless Powder Compositions

SOURCE	NG	DNT	DPA	EC	DBP
• .22 LR					
• WESTERN	●	●	●	●	●
• REMINGTON	●	●	●		
• FEDERAL	●		●		
• .32					
• W-W	●				●
• R-P	●		●		
• .357 MAGNUM					
• W-W	●	●	●		●
• R-P	●	●	●		●
• SUPERVEL	●		●		●
• NORMA			●		
• 9 mm					
• FEDERAL	●			●	
• LAPUA			●		
• SPEER	●		●		
• .38 SPECIAL					
• W-W	●	●	●		●
• R-P, LEAD NOSE	●		●	●	
• R-P, HOLLOW PT.	●	●	●		●
• SUPERVEL	●		●		
• NORMA			●		
• .45 AUTO					
• W-W	●	●	●		(●)
• R-P	●			●	
• SUPERVEL	●		●		
• NORMA			●		
• IMR 4875	●	●			

Occurrence of Smokeless Powder Constituents

- NITROGLYCERIN
  - EXPLOSIVES, PROPELLANTS
  - MEDICINAL

- DINITROTOLUENE
  - EXPLOSIVES, PROPELLANTS
  - TOLUENE DIISOCYANATE PRECURSOR
  - DIAMINOTOLUENE PRECURSOR
  - BINDER IN CARBON ELECTRODES
  - IN CROSSLINKED POLYOLEFINS

- DIPHENYLAMINE
  - PROPELLANTS
  - GROWTH INHIBITORS
  - LUBRICATING OILS, GREASES, HYDRAULIC FLUID, GASOLINE
  - ANTIOXIDANT, CORROSION INHIBITORS

- ETHYL CENTRALITE
  - PROPELLANTS
  - ADHESIVES
  - ETCHING

- METHYL CENTRALITE
  - PROPELLANTS
  - ETCHING
  - EPOXY CURING

END