

NBSIR 73-223

Penetration Tests on J-SIIDS Barriers

R. T. Moore

Measurements Automation Section
Information Processing Technology Division
Institute for Computer Sciences and
Technology
Washington, D. C. 20234

June 4, 1973

Interim Report for Period March 13 – 16, 1973

Prepared for
Defense Nuclear Agency
Washington, D. C. 20305

NBSIR 73-223

PENETRATION TESTS ON J-SIIDS BARRIERS

R. T. Moore

Measurements Automation Section
Information Processing Technology Division
Institute for Computer Sciences and
Technology
Washington, D. C. 20234

June 4, 1973

Interim Report for Period March 13 - 16, 1973

Prepared for
Defense Nuclear Agency
Washington, D. C. 20305



U. S. DEPARTMENT OF COMMERCE, Frederick B. Dent, Secretary
NATIONAL BUREAU OF STANDARDS, Richard W. Roberts, Director

ILLUSTRATIONS

	<u>Page</u>
PREFACE	2
INTRODUCTION	7
TEST SITE DESCRIPTION	8
DEFINITION OF PENETRATION.....	8
TEST IDENTIFICATION	10
INSTRUMENTATION	12
ATTACK 20S	16
ATTACK 20M	19
ATTACK 21N	22
ATTACK 26P	25
ATTACK 22A	29
ATTACK 22B	32
ATTACK 27T	37
ATTACK 23B	41
ATTACK 29A	50
ATTACK 25D	52
ATTACK 24B	59
ATTACK 28D	64
ATTACK 30D	71
CONCLUSIONS	75
APPENDIX	76
ATTACK 20S	77
ATTACK 20M	78
ATTACK 21N	79
OTHER ATTACKS.....	80
ATTACK 22A	81
ATTACK 22B	82
ATTACK 27T	83
ATTACK 23B	84

PREFACE

The cooperation and active support of many individuals in several organizations made the collection of these barrier penetration test data possible. In particular, we wish to thank the U. S. Army, Mobility Equipment Research and Development Center for providing the opportunity to conduct the tests, and for providing overall test support including photographic coverage. James W. Owen and Robert L. Barnard and the many other MERDC participants were key contributors. Attack tooling and much of the instrumentation was provided by the U. S. Army, Intelligence Materiel Development Office, Fort Holabird, Maryland, ably represented by Frank C. Veirs. Penetrations were accomplished by personnel from the Naval Security Group under the direction of Richard F. Blackmon. R. S. Koyanagi of the Vibration Section of the National Bureau of Standards provided support in the collection of the vibrational disturbance data and T. L. Quindry of the Applied Acoustics Section provided the acoustical data shown in the appendix. The guidance and active participation of Marvin C. Beasley, Defense Nuclear Agency Task Officer for this project is gratefully acknowledged.

ILLUSTRATIONS

Figure	Title
1	Layout for Simulated Arms Rooms
2	Locations of Attack Areas on Simulated Arms Room Test Facility
3	Data Collection Instruments
4	Attack 20S
5	Acoustical Disturbances Made by Hand-operated Brace and Bit
6	Acoustical Disturbances from Electric Saber Saw
7	Vibrational Disturbances from Electric Saber Saw
8	Attack 20M
9	Acoustical Disturbances from Rotary Electric Saw
10	Vibrational Disturbances from Rotary Electric Saw
11	Acoustical Disturbances from 3/4" Wood Bit Used with 3/8" Variable Speed Electric Drill
12	Vibrational Disturbances from 3/4" Wood Bit and Electric Drill
13	Attack 21N
14	Rotary Electric Saw, Acoustical
15	Rotary Electric Saw, Vibration Through Eight-foot Transmission Path
16	Vibration produced by Handsaw Cutting Rafter
17	Interior View of Opening Produced by Attack 21N
18	Attack 26P
19	Acoustical Disturbances from Oxyacetylene Cutting Torch
20	Vibration from Cutting Torch

<u>Figure</u>	<u>Title</u>
21	Multiple Sweep of Acoustical Disturbances from Breaking Glass Window
22	Breaking Glass Window with Bolt Cutters
23	Attack 22A
24	Acoustical Disturbance from Sledgehammer Prior to Breakthrough
25	Vibrational Disturbances from Attack 22A
26	Acoustical Disturbance from Attack on Brick Veneer
27	Vibration from Attack on Brick Veneer
28	Attack 22B
29	Acoustical Disturbance from Rotohammer Attack on Cinder Block
30	Vibration from Attack on Cinder Block
31	Acoustical Disturbances from Cutting Torch
32	Vibrational Disturbances from Cutting Torch
33	Attack 27T
34	Vibration During Bolt-cutter Attack
35	Ambient Vibrational Background at Location 27T
36	Multiple Sweep of Acoustical Disturbances Produced by Bolt Cutters
37	Vibration from Sledgehammer Attack on Draw Bolt
38	Attack 23B
39	Acoustical Disturbance from Drilling
40	Vibrational Disturbance from Drilling
41	Acoustical Disturbance from Spalling
42	Vibration from Spalling

<u>Figure</u>	<u>Title</u>
43	Abrasive Wheel Cutoff Saw Used in Attack 23B
44	Acoustical Disturbances from Abrasive Wheel Cutoff Saw
45	Vibration from Abrasive Wheel Cutoff Saw
46	Opening Made by Attack 23B
47	Acoustical Disturbances from Sledgehammer
48	Vibration from Sledgehammer
49	Acoustical Disturbances from the Cutting Torch
50	Attack 29A
51	Vibration from Sledgehammer on Cinder-block Wall
52	Attack 25D
53	Acoustical Disturbances from Drilling Reinforced Concrete
54	Vibration from Drilling Reinforced Concrete
55	Interior of the Wall with Spalling Nearly Complete
56	Multiple Sweep of Acoustical Disturbances Produced by Spalling
57	Vibration from Spalling with Transducer Mounted 10' from Attack Point
58	Vibration from Spalling with Transducer Mounted 20' from Attack Point
59	Vibration from 20-pound Sledgehammer
60	Vibration from 10-pound Sledgehammer
61	Vibration from Rotohammer
62	Acoustical Disturbances from Spalling
63	Vibration from Spalling

<u>Figure</u>	<u>Title</u>
64	Use of Tapered Punch in Attack 24B
65	Vibration from File
66	Acoustic Disturbances from Drilling on Vault Door
67	Vibration from Drilling on Vault Door
68	Acoustical Disturbances from Rocket Torch
69	Vibration from Rocket Torch
70	Comparison of Cuts Made by Rocket Torch (Wide) and Oxygen-fed Electric Arc (Narrow)
71	Acoustical Disturbances from the Electric Arc Torch
72	Vibration from the Electric Arc
73	Burning Bar Melting a Hole Through Concrete
74	Acoustical Disturbance from Burning Bar Attack on Concrete
75	Vibration from Burning Bar Attack on Concrete
76	Burning Bar Cutting Reinforcing Rod at Location 24B
77	Acoustical Disturbance from Burning Bar Attack on Expanded Metal
78	Vibration from Burning Bar Attack on Expanded Metal

PENETRATION TESTS
ON
J-SIIDS BARRIERS

by
R. T. Moore

INTRODUCTION

The degree of protection that is afforded to computers, money or negotiable securities, weapons, classified materials, or other valuable items, is dependent upon the effectiveness of the physical security measures which are employed to safeguard them. Current physical security measures are usually based on the concept of employing one or more barriers, such as fencing, a strong room or a vault to enclose a protected area coupled with one or more electronic sensors which are intended to detect penetration of the barrier(s) or any intrusion into the protected area. Detection of barrier penetration or area intrusion causes an alarm and initiates some form of reaction on the part of guards, police or other forces. To be effective in safeguarding the protected area, the time that is required for a potential intruder to penetrate the barriers must be greater than the total time required for detection of the penetration and the response of the reactionary force. Thus, an evaluation of the effectiveness of a physical security system requires, among other things, some basis for developing estimates of the time which might be required to penetrate a given barrier.

This report describes the results of a series of penetration tests which were made on three simulated arms rooms located at the U. S. Army Mobility Equipment Research and Development Center (MERDC) test facility, Woodbridge, Virginia, during a one week period beginning March 13, 1973. The objectives of these tests were to develop estimates of

- (a) the times required to make man-passable penetration openings;
- (b) the times required for the electronic intrusion systems with which the simulated arms rooms were equipped to respond to the penetration attacks;
- (c) the acoustic, ultrasonic and vibrational disturbances produced by the various attacks; and finally,
- (d) (not reported herein) to evaluate the performance of the Joint-Service Interior Intrusion Detection System (J-SIIDS) in detecting these penetration attacks and to assess the vulnerability of this system to countermeasures.^{1/}

^{1/} Intrusion Detection Test Report, J-SIIDS Equipment, Robert Barnard, U. S. Army, MERDC.

TEST SITE DESCRIPTION

The simulated arms room facility consisted of a three-room structure located inside of the 45' X 90' west wing of one of the Harry Diamond Laboratories buildings at Woodbridge, Virginia. The general arrangement of the structure is shown in figure 1. Room 1 was fabricated of wood with a double planking of nominal one-inch thick wood siding over 2" X 4" studs and no interior finish. The flat roof was similarly planked over 2" X 6" rafters. The roof height was approximately 9' and was level with that of the other two rooms.

Room 2 had exterior walls of 8" cinder block with 5/8" reinforcing bars inserted vertically in the cores of the blocks with a spacing of about 14". The cores of the blocks were filled with mortar and three 1/8" steel wires were used as horizontal reinforcement in every second course. One of the exterior walls had a single layer of block veneer laid up with a one-inch air space between the veneer and the block and tied to every second course of block with sheet metal ties.

Room 3 had walls of 8" concrete reinforced with 3/4" rod on 12" centers vertically and horizontally. The room was equipped with a GSA Class 6 vault door. The roof of this room and of Room 2 was of 5-1/2" thick reinforced concrete with 1/2" reinforcing bars on 8" X 12" centers.

These rooms had been constructed by MERDC in support of the J-SIIDS development effort and were instrumented with appropriate components of this intrusion detection system during the penetration tests. The rooms were intended to be representative of the broad range of structural barriers which might be found in existing arms rooms.

DEFINITION OF PENETRATION

A barrier is considered to have been penetrated when an opening has been made which is large enough for a small man to wriggle through. It is generally accepted that an opening having an area of 96 square inches with one dimension of at least 6" will meet this criterion. In these tests, attack areas were marked out on the barriers in the form of either an 8" X 12" rectangle or an 11.1" diameter circle as appropriate to the attack tooling which was employed. In those instances where the attack produced an opening larger than, or significantly different from these sizes, its dimensions are reported.

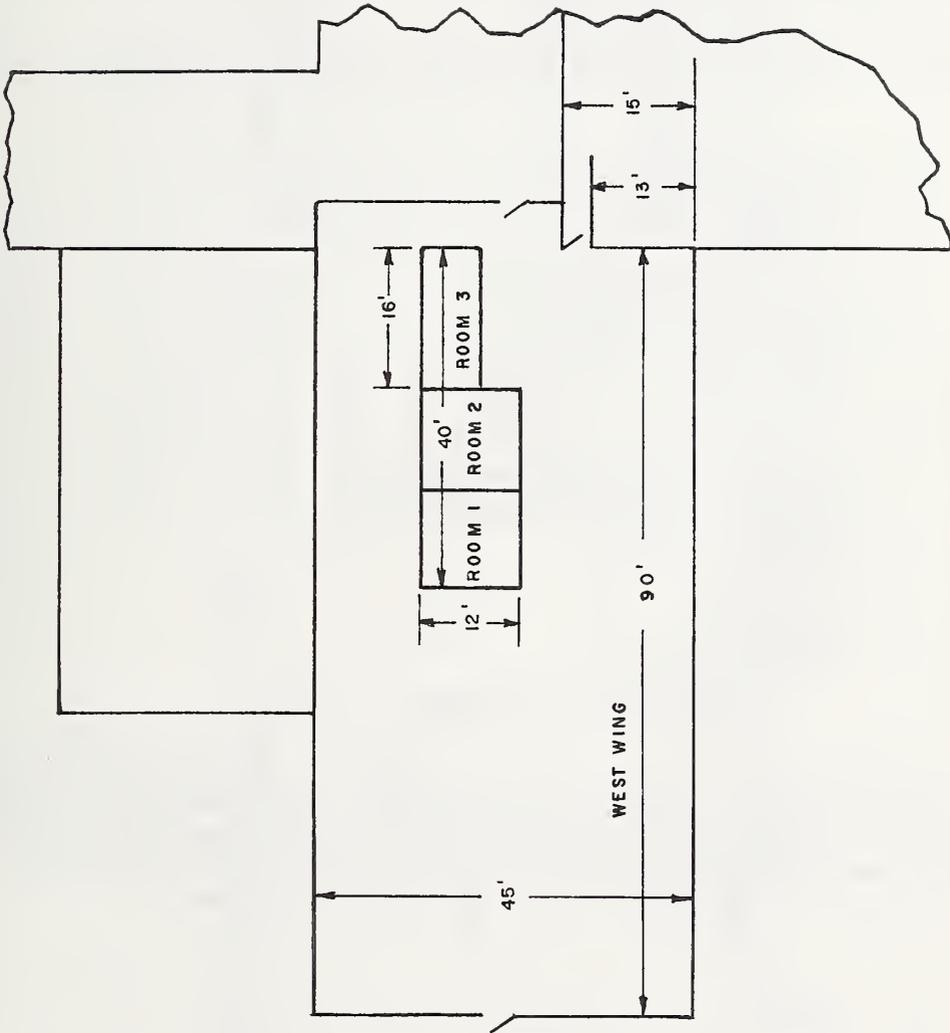


Figure 1. Layout for Simulated Arms Rooms

TEST IDENTIFICATION

Each proposed target area for a penetration attack was assigned an alphanumeric identifier which was painted on the external surface of the selected barrier adjacent to the perimeter of the planned opening. It is used to label test data from each attack and is especially helpful in identifying photographic records. The identifier consists of a number-letter-number sequence in which the first number indicates the barrier to be attacked. The following letter indicates the area of the attack and the general nature of the initial tooling used on that area. The final number is a sequence number associated with changes in tooling or to identify individual measurements. The sequence number is used in connection with data from the instrumentation and does not appear in the photographic records.

Letters designating initial tooling were selected from the following list:

- A. Sledgehammer
- B. Rotohammer
- C. Diamond Drill
- D. Burning Bar
- E. Linear-Shaped Charge
- F. Demolition Saw
- G. Pneumatic Jackhammer
- H. Rock Melter
- J. Water Jet
- K. Battering Ram
- M. Gasoline-Powered Rotary Saw
- N. Electric-Powered Rotary Saw
- P. Cutting Torch
- Q. Electric Drill
- R. Saber Saw
- S. Brace and Bit
- T. Bolt Cutters

Some deviation from this list of designators occurred when changes in the test plan were occasionally made after the identifiers had been painted on the barrier. Rather than delay the test series to repaint the identifier, the testing proceeded using the original markings. Figure 2 shows the locations of all of the attack areas.

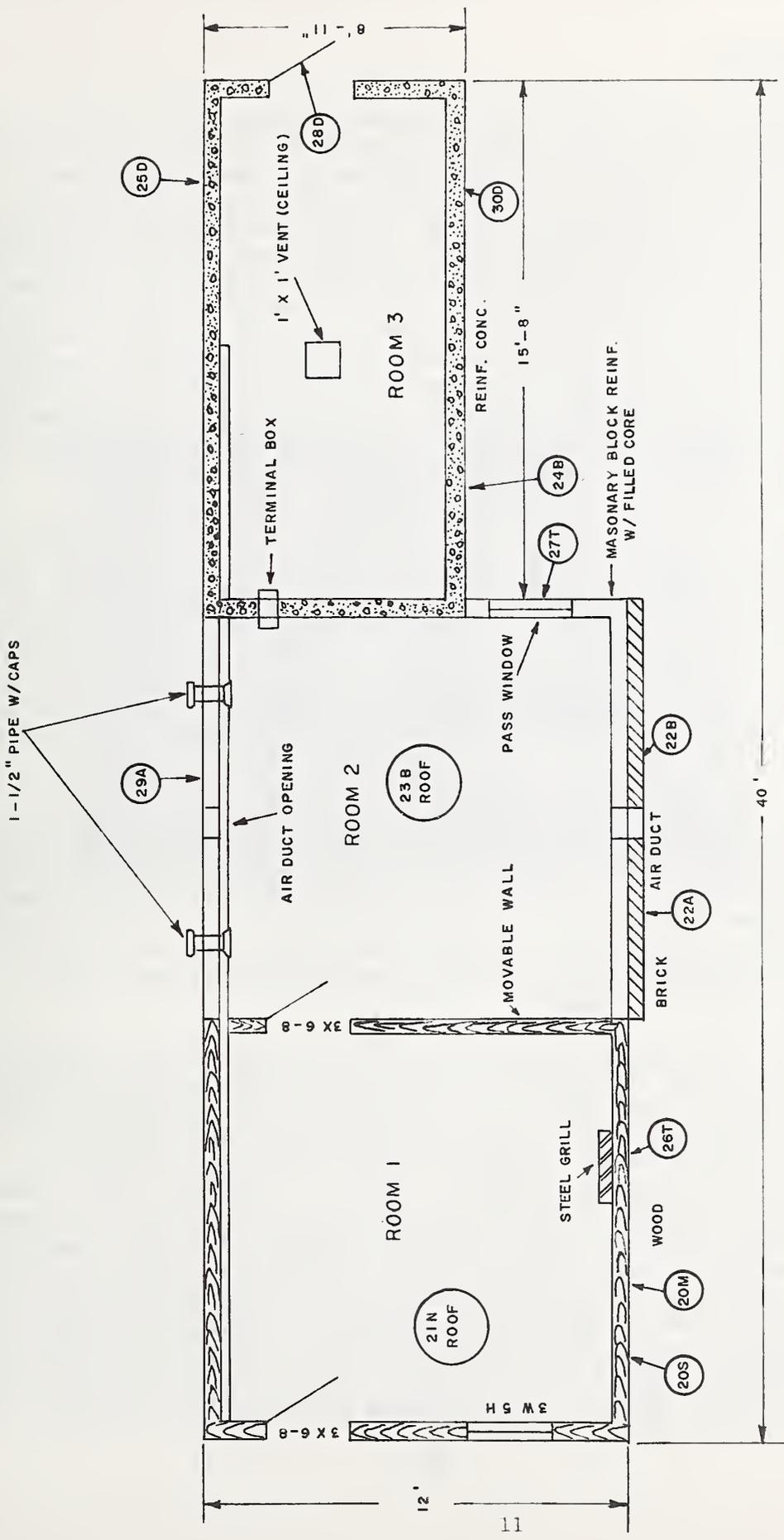


Figure 2. Locations of Attack Areas on Simulated Arms Room Test Facility

INSTRUMENTATION

Acoustic and ultrasonic disturbances produced by the various attacks were observed using a 1/4" microphone having a nominally flat frequency response to above 50 kHz. This was mounted on a small tripod and together with its preamplifier and power supply was positioned inside the room involved during each attack. The distance from the microphone to the inner surface of the area under attack ranged from a minimum of about 6' to a maximum of about 12'. Since the variation in attenuation over this distance range is less than the variation in sound pressure levels which may result from reinforcement or cancellation caused by reflections from the walls and corners of the room itself, no attempt has been made to normalize the observed data or to compensate for minor deviations in the frequency response of the microphone. All sound pressure levels (SPL) are expressed as dB reference a zero level of .0002 dynes per square centimeter and, for the reasons noted above, should be considered only as representative values.

Vibrational disturbances were picked up by piezoelectric transducers mounted on the interior surface of the room under attack. These had a frequency response extending to over 100 kHz. Their associated charge amplifiers were located nearby in a protective enclosure and were coupled by a 50-ohm transmission line to the data recording position which was external to the simulated arms rooms. The nominal separation between attack point and vibration transducer is reported with the data presented for each attack. Vibrational spectra are expressed in terms of peak g values.

The transmission lines from the charge amplifiers and microphone preamplifier were each 50' long and terminated at a selector switch box arranged so that either one could be selected as the input to a real-time spectrum analyzer. The output of the spectrum analyzer was displayed on a storage tube oscilloscope and photographs were taken of samples of the spectra of the disturbances. The data recording instrumentation was typically clustered outside the arms rooms adjacent to the attack location as shown in figure 3.

The spectrum analyzer was operated with a sweep width of 50 kHz, a sweep rate of 5 kHz per cm (on the display), a sweep speed of 30 ms per cm and a bandwidth of 500 Hz. The vertical axis of the display showed the spectral amplitude in a logarithmic mode with sensitivity of 10 dB per cm and covered a dynamic range of 60 dB. The type of spectrum analyzer used does not have memory; that is, it displays those spectral components of the signal which are within its passband at the "instantaneous" center frequency of the sweeping passband. A single sweep provides a reasonably good representation of continuous signals such as from a motor-driven tool or a cutting torch, but on intermittent signals, such as hammer blows, many sweeps may be required to develop an estimate of their spectrum over the full 50 kHz sweep width. This is because on one hammer blow the passband of the analyzer may be sweeping past the 5 kHz region and on the next it may be sweeping past the 35 kHz region. Under



Figure 3. Data Collection Instruments

circumstances such as these, multiple sweeps were collected on the storage tube oscilloscope prior to photographing them whenever the attack duration was long enough for this to be feasible.

On some of the tests, peak sound pressure levels were also recorded from a position outside of the arms rooms using a hand-held sound pressure level meter equipped with a 1/2" microphone. These observations are reported as external SPL values (dB) together with the distance from the attack point to the observer.

During a portion of the tests, audio frequency disturbances were picked up using a one-inch microphone within the room under attack. These data were recorded on magnetic tape and subsequently analyzed and reduced to 1/3 octave bandwidth sound pressure levels in the 20 to 20,000 Hz frequency bands. The resulting tabulations are presented in the appendix.

Throughout the test sequence, each penetration that was made into one of the rooms was covered over by an aluminum panel before the next penetration was begun. The aluminum panels were held in place with 4" wide pressure sensitive tape and were intended to reduce the level of acoustical disturbance within the room resulting from normal test crew activities outside the room.

Timing information on the penetration tests was derived from a variety of sources including a hand-held stopwatch, a strip chart event recorder and by manual control of the application of power to a self-starting electric clock with a sweep-second hand. A test plan objective was to try to accumulate three time values associated with each attack: (a) working time, (b) elapsed time, and (c) time from start of attack until the first J-SIIDS alarm. Working time is considered that amount of time during which the attack tooling is being actively employed. It does not include intervals required for changing tools, selecting the next place to drill a hole, changing to a fresh operator when the first attacker becomes fatigued, or similar interruptions to an attack which would be necessary with even a skilled team of determined attackers. Elapsed time was planned to take into account these additional factors. For a number of reasons it was not always possible to obtain a value for elapsed time which could be considered representative of what could be accomplished by a determined team of attackers. Where values were obtained which were considered nonrepresentative, they are omitted from this report.

The accuracy of all of the timing information was also slightly degraded by the fact that nearly all of the attacks were purposely stopped on from one to several occasions so that changes could be made in the sensitivity settings of the J-SIIDS equipment to permit the development of information on the gain control settings required for response to the various attacks. Thus, in most instances, attack time and elapsed time values represent the sum of a number of discrete time increments. There is a probable uncertainty on the order of at least ± 1 second in the

determination of each such increment. The uncertainty in the length of time between the start of the attack and the initiation of the first alarm is also believed to be about one second.

ATTACK 20S

The first attack was on the wooden wall of Room 1. A hand brace with 1" wood bit was used to make two holes in diagonally opposite corners of the rectangular perimeter outline. Then an electric saber saw with a 6" course-toothed blade was used. The blade was inserted in each hole and two cuts were then made outward to each of the remaining corners of the rectangle freeing the central plug (see fig. 4). A vibration transducer was mounted on the interior of the wall at a distance of 3' from the center of the opening.

The first hole required 19 seconds working time. The second hole was aborted after 28 seconds when the lead screw of the bit entered a crack between planks of the inner layer and the bit would not feed. A new hole was then started and was completed 16 seconds later. A sample of the acoustical disturbances is shown in figure 5. The vibrational disturbances were not noticeable above the ambient vibrational background. Sawing required 45 seconds with acoustical and vibrational spectra as shown in figures 6 and 7, respectively.

In this attack, the total working time was 1.33 minutes, the elapsed time was 1.55 minutes, and the first J-SIIDS alarm occurred 27 seconds after the attack was started.



Figure 4. Attack 20S

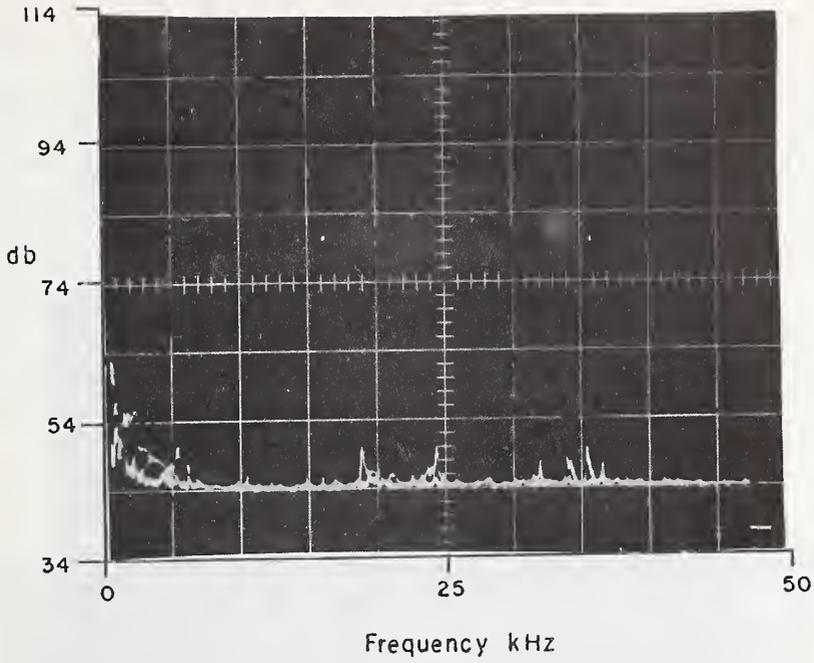


Figure 5. Acoustical Disturbances Made by Hand-operated Brace and Bit

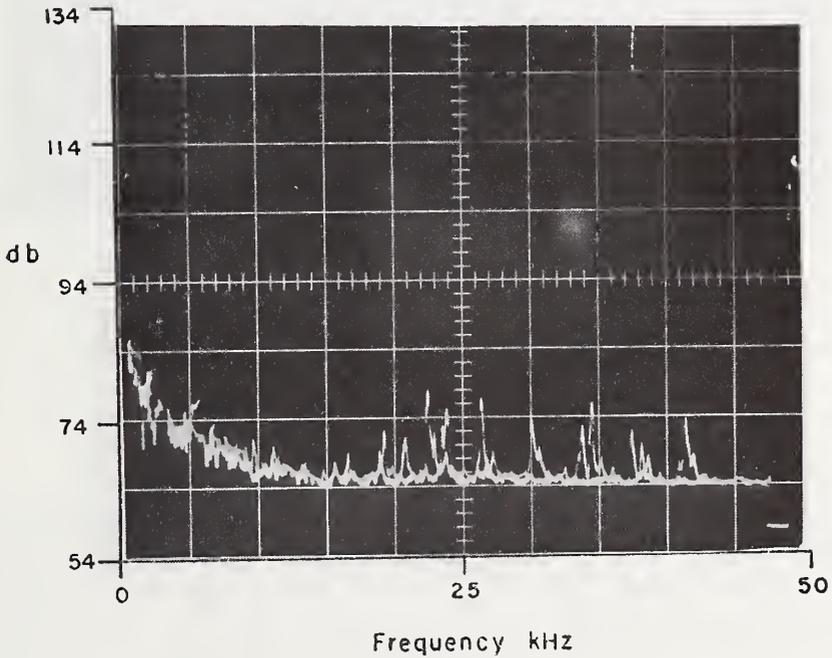


Figure 6. Acoustical Disturbances from Electric Saber Saw

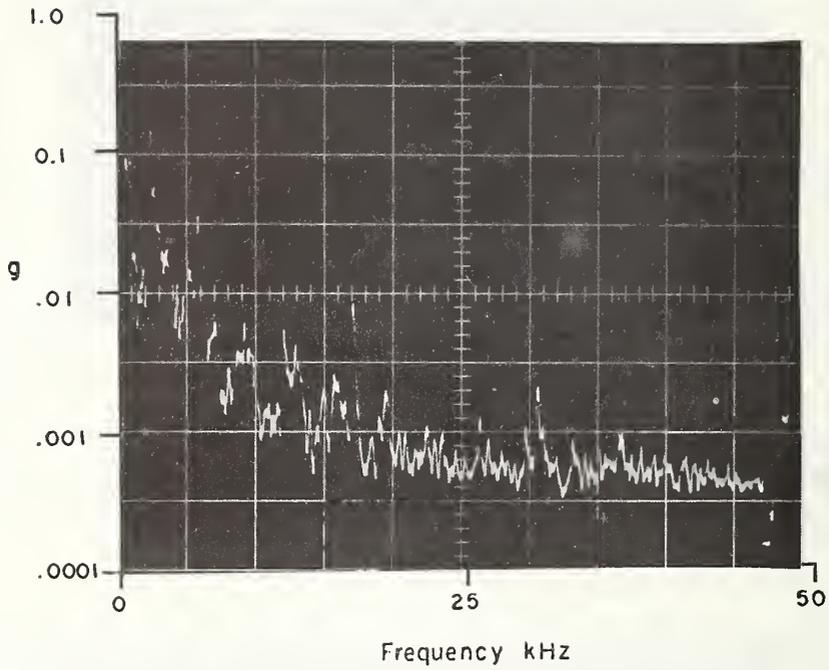


Figure 7. Vibrational Disturbances
from Electric Saber Saw

ATTACK 20M

Location 20M was adjacent to 20S and centered 3' from the unchanged vibration transducer position. A gasoline-powered rotary saw had been scheduled for use in this attack. Because of mechanical problems, an electric-powered rotary handsaw with a 7-1/4" carbide-tipped blade was substituted and was used to make 4 cuts along the sides of the rectangular opening as shown in figure 8. Then the plug was knocked out with one blow from a sledgehammer. The working time was 1.30 minutes, the elapsed time 1.62 minutes, and the first J-SIIDS alarm occurred 5 seconds after the attack started. Acoustical and vibrational disturbances are shown in figures 9 and 10.



Figure 8. Attack 20 M

Following attack 20M, a brief test was made to estimate the disturbances likely to be produced by a power-driven wood bit. This was accomplished by drilling sample holes in the area between the previous two attacks. A 3/4" wood bit was used in a 3/8" variable speed electric drill. Acoustical disturbances are shown in figure 11 and vibrational disturbances in figure 12.

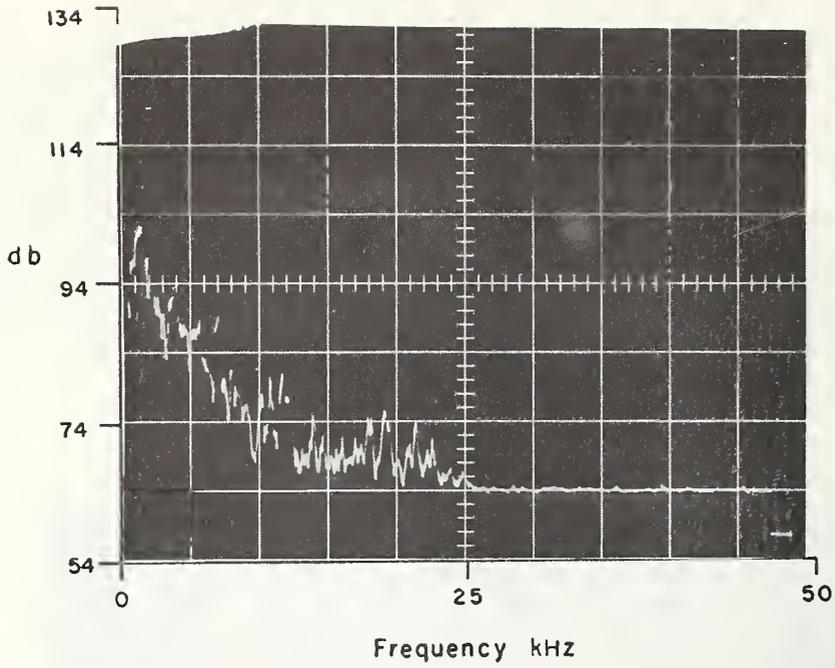


Figure 9. Acoustical Disturbances from Rotary Electric Saw.

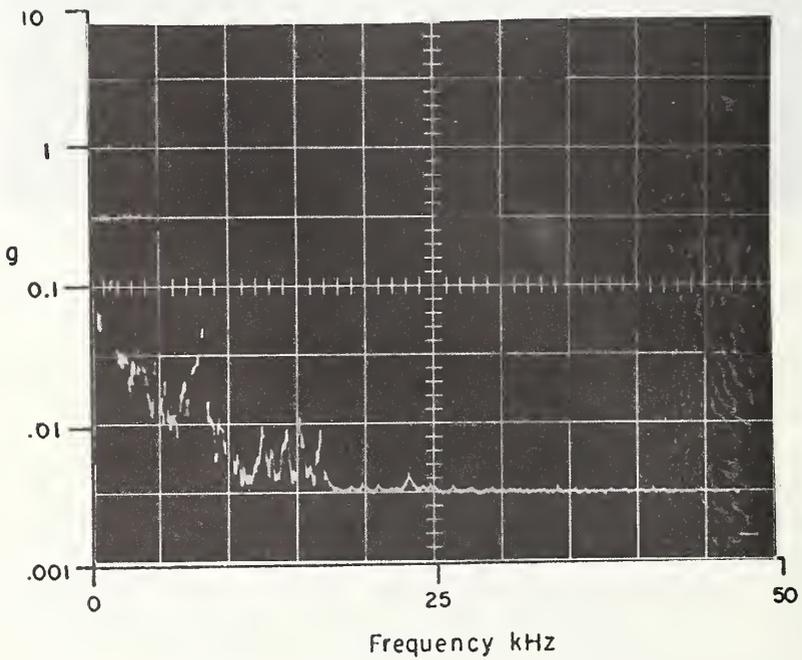


Figure 10. Vibrational Disturbances from Rotary Electric Saw

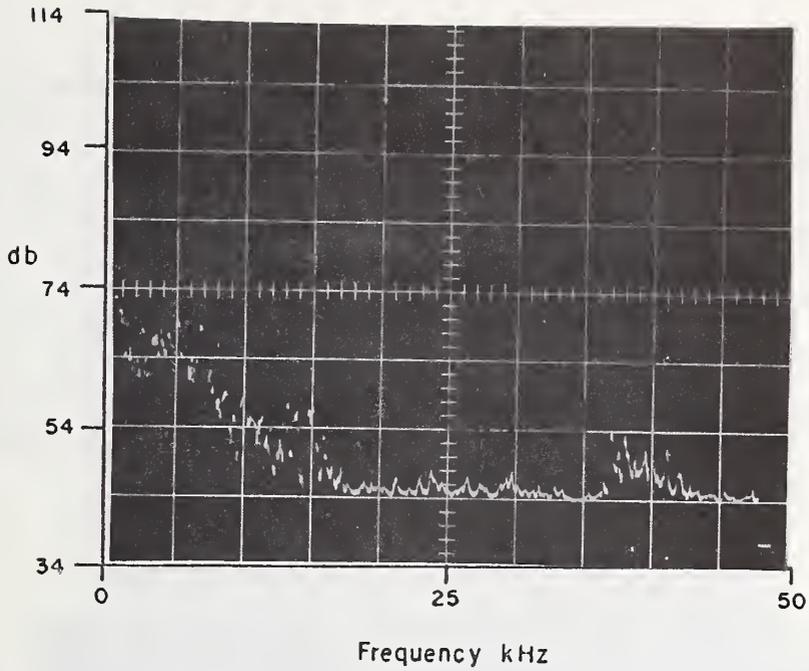


Figure 11. Acoustical Disturbances from
 3/4" Wood Bit Used with 3/8"
 Variable Speed Electric Drill

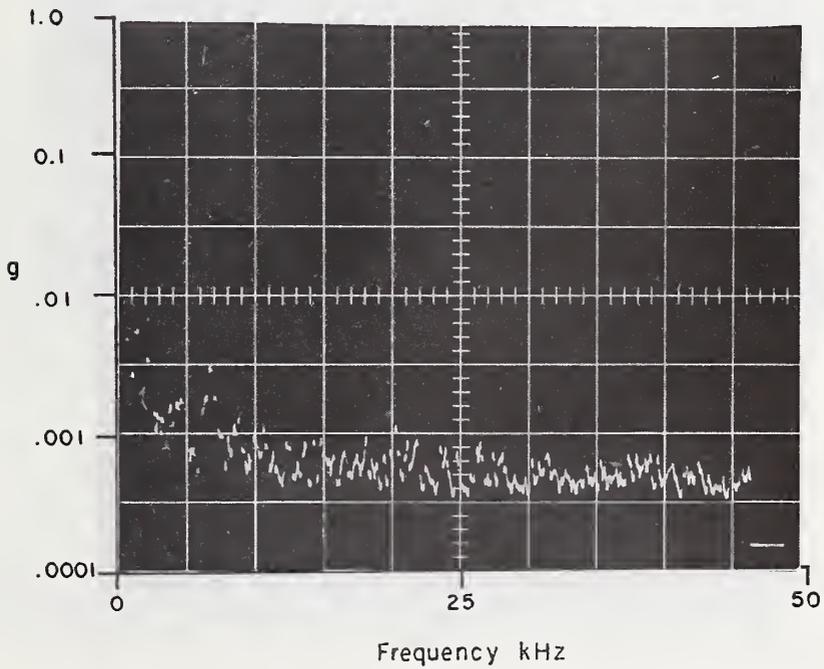


Figure 12. Vibrational Disturbances from 3/4"
 Wood Bit and Electric Drill

ATTACK 21N

Location 21N was centered on the roof of Room 1 at a distance of 8' from the vibration transducer. The vibration transducer was mounted on an interior wall of the room at a point 2' below the roof. Thus, the transmission path included 2' of wall and 6' of roof of the structure. The attack location was chosen so that the opening would straddle one of the 2" X 6" wooden rafters so that this would have to be cut in two places to complete the penetration. A 1-1/2 horsepower electric saw with a 7-1/4" combination blade was used to cut through the planking along the rectangular perimeter of the opening in 0.5 minute. The rafters were then cut with a carpenter's handsaw in 0.96 minute, as shown in figure 13. The total working time was 1.47 minutes with elapsed time of 1.73 minutes. The initial J-SIIDS alarm occurred 5 seconds after the attack began.



Figure 13. Attack 21N

Samples of the acoustical, figure 14 , and vibrational, figure 15 , disturbances from the electric saw were quite similar to those observed from the different electric saw and blade used in Attack 20M.

The vibrational disturbances produced by the handsaw are shown in figure 16. The handsaw produced a peak SPL of 98 dB observed at a distance of approximately 5'.

The opening produced by the attack is shown in figure 17.

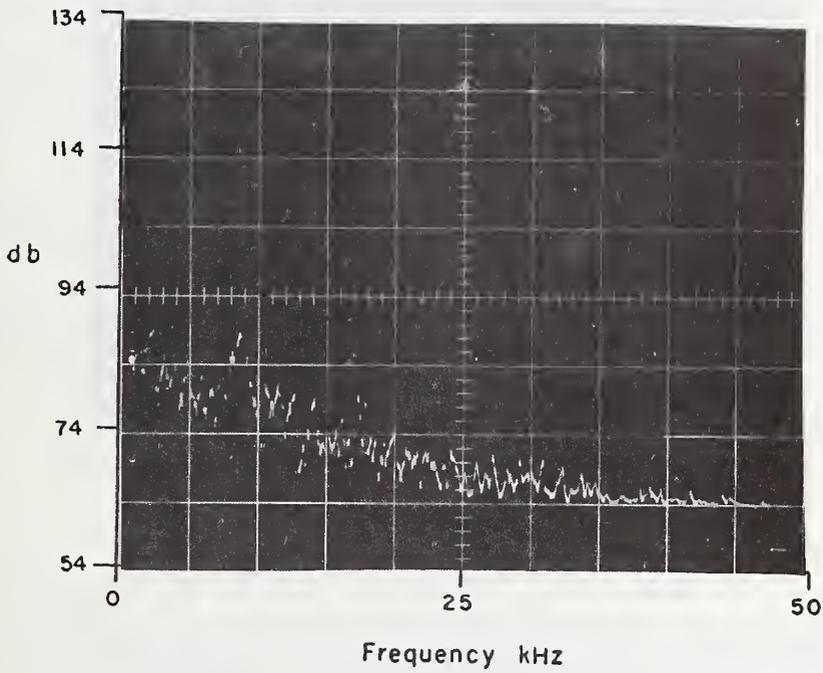


Figure 14. Rotary Electric Saw, Acoustical

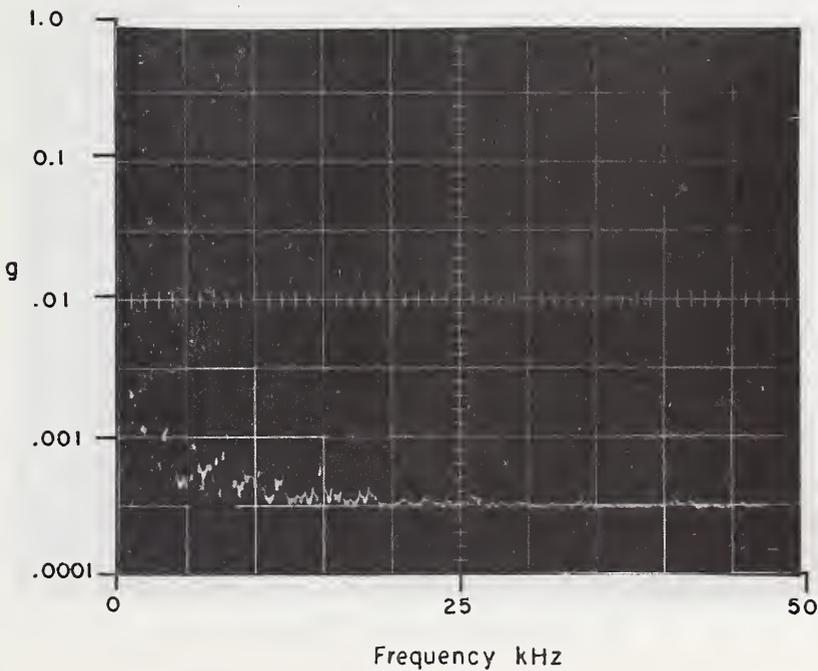


Figure 15. Rotary Electric Saw, Vibration through Eight-foot Transmission Path

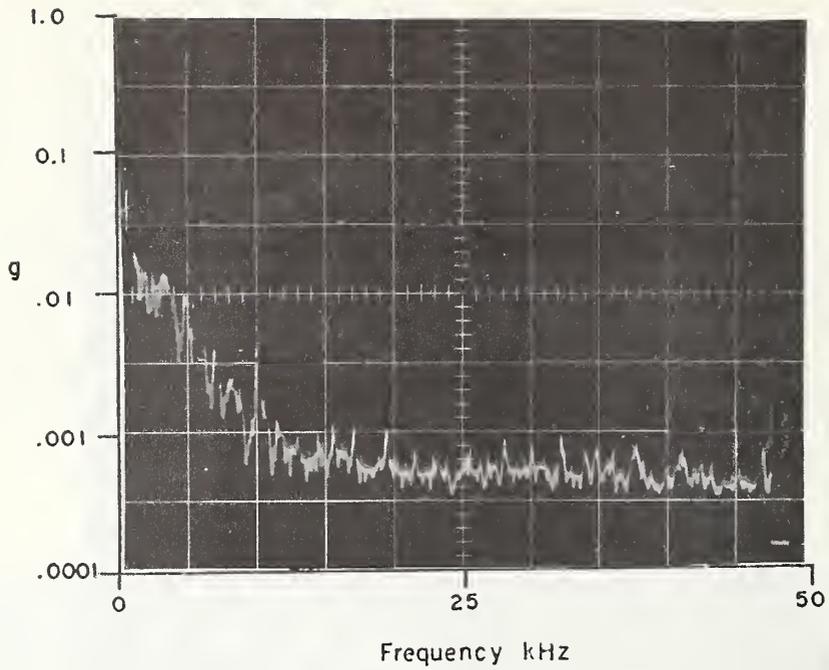


Figure 16. Vibration Produced by Handsaw Cutting Rafter



Figure 17. Interior View of Opening Produced by Attack 21N

ATTACK 26P

Location 26P was centered on a 3/16" thick expanded steel grill which was fastened to a window-like opening in Room 1, as shown in figure 18. The attack involved the use of an oxygen-acetylene cutting torch to cut out along the targeted rectangular perimeter. The torch was used with a No. 5 cutting tip and oxygen pressure of 30 p.s.i. and acetylene pressure of 12 p.s.i. The cutting required 3.05 minutes working time and 3.14 minutes elapsed time. A J-SIIDS alarm was initiated within 5 seconds after the torch was ignited and before the first cut was started.

The vibration pickup was located on the wall of Room 1 approximately 6' from the grill and in the same position that it occupied during the earlier attacks.

Samples of the acoustical disturbances are shown in figure 19 and of the vibration disturbances in figure 20.



Figure 18. Attack 26P

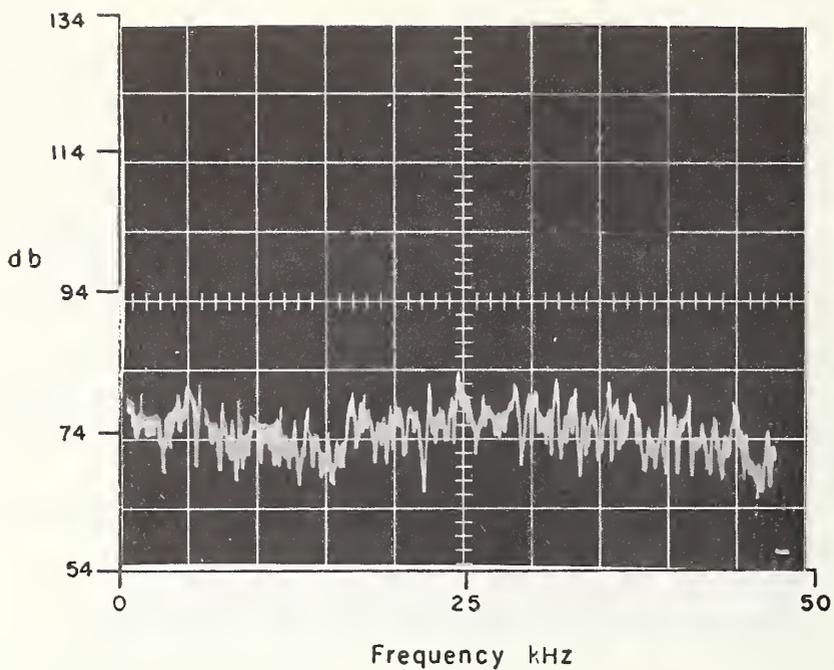


Figure 19. Acoustical Disturbances from Oxyacetylene Cutting Torch

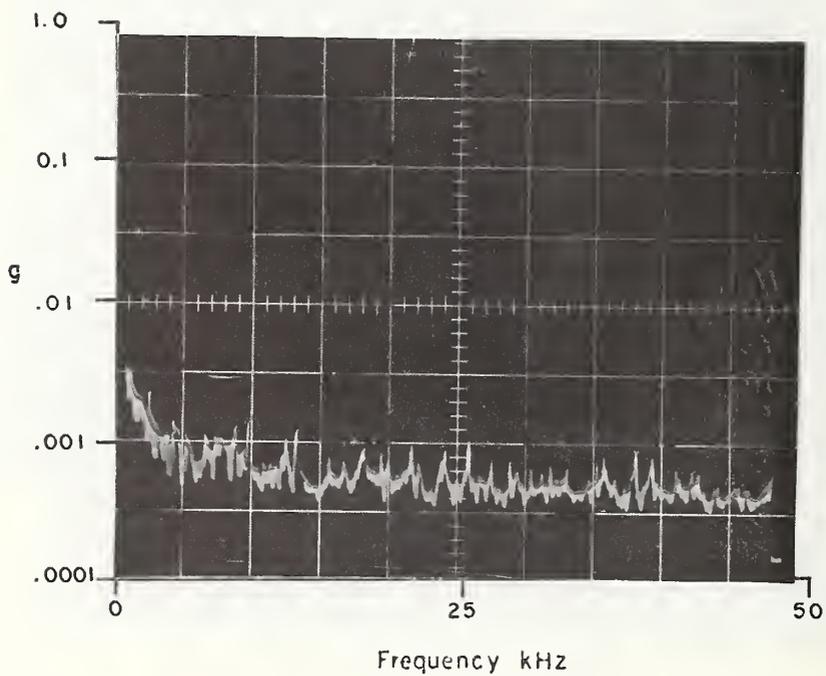


Figure 20. Vibration from Cutting Torch

To conclude the activities in Room 1, another unscheduled test was performed. This involved breaking the glass in a window located at the west end of the room and cutting a coarse wire mesh attached rather flimsily to the inside of the window frame. The glass was quickly broken with a hammer and samples of the acoustic disturbances are shown in the multiple trace photograph of the spectrum analyzer output in figure 21. When a bolt cutter was used to cut the wire mesh, see figure 22, it fell off of the window frame on the second or third cut so no actual total times are available. It is estimated that this penetration could have been completed in less than 30 seconds if the mesh had remained in place.

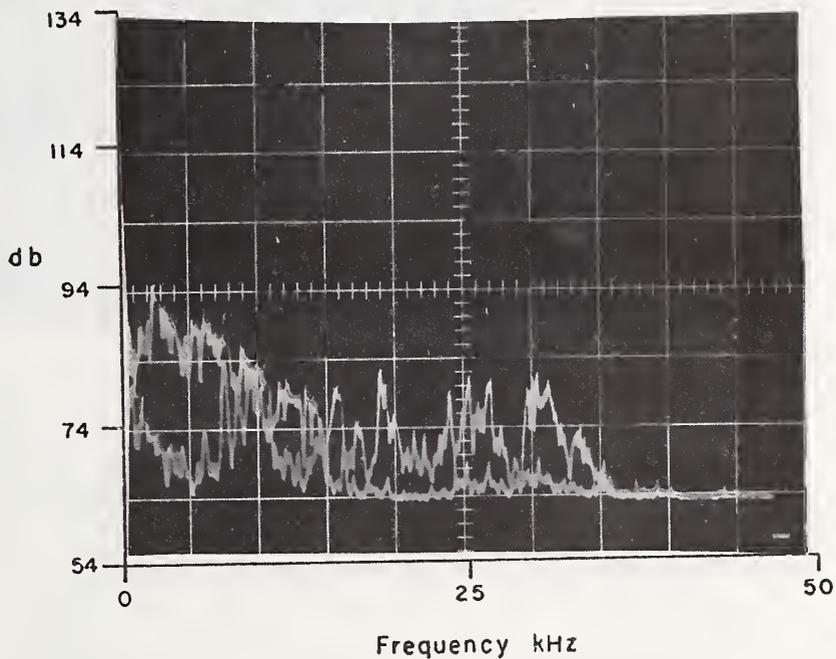


Figure 21. Multiple Sweep of Acoustical Disturbances from Breaking Glass Window

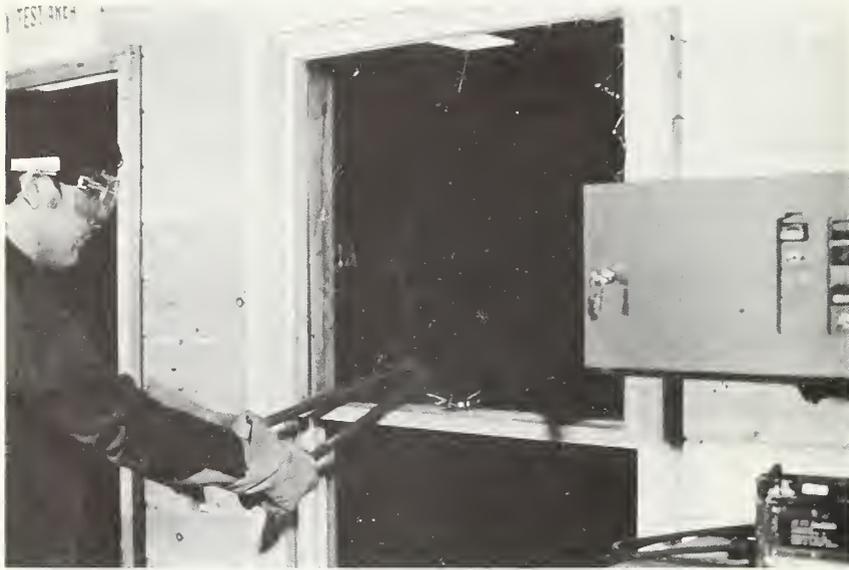


Figure 22. Breaking Glass Window
with Bolt Cutters

ATTACK 22A

Attack 22A was conducted on Room 2 on a wall made up of a layer of brick veneer over 8"-thick cinder block. The brick was spaced out from the cinder block 1" and tied to every second course of block by metal ties. The block was reinforced with 5/8" diameter rod inserted vertically in the cores on approximately 14" centers. The cores of the block were presumably to have been filled with mortar. After the attack, examination showed the mortar filling to be rather loose and crumbly with a large number of voids.

The vibration transducer was mounted on the interior surface of the wall at a distance of 5' from the center of the target area.

The attack was begun with a 10-pound sledgehammer and 28 blows produced an oversize opening through the brick veneer. These produced a peak SPL of 94 dB as observed at a distance of 10' outside of the room. This was followed by 16 blows with a 12-pound sledgehammer, see figure 23, and 28 blows with a 10-pound sledgehammer which produced a break measuring approximately 2" X 4" through the cinder block. Twelve more blows, with the end of the 10-pound sledgehammer being used as a ram, enlarged the opening to 10-1/2" X 11-1/4". This required a total of only 64 blows with a working time of only 2.12 minutes. By chance, the opening did not intercept one of the infrequent reinforcing bars so a cutting torch was not required. Samples of the acoustical disturbances prior to breakthrough are shown in figure 24 and of the vibrational disturbances in figure 25. Both of these figures show multiple sweeps of the spectrum analyzer.

The first J-SIIDS alarm occurred 5 seconds after the attack was started.



Figure 23. Attack 22A

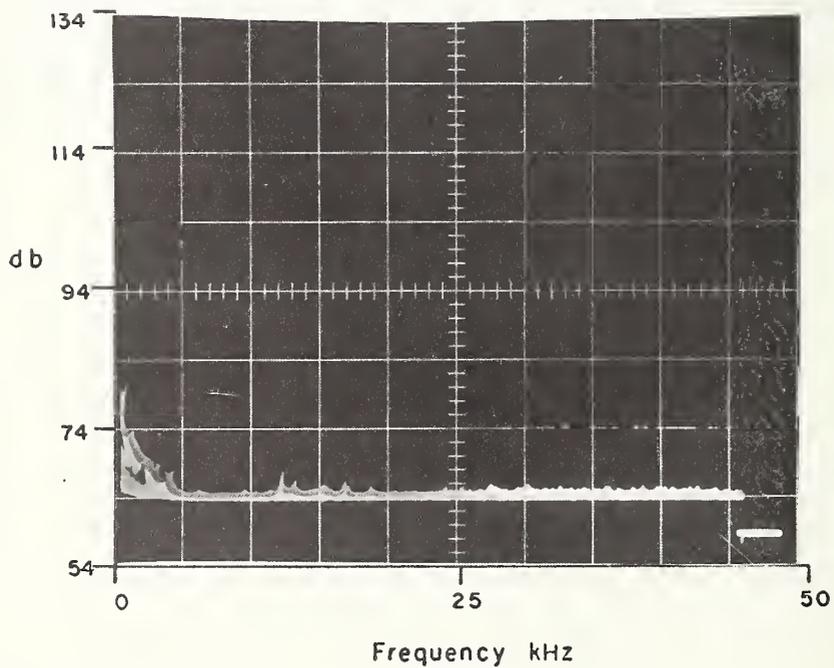


Figure 24. Acoustical Disturbance from Sledgehammer Prior to Breakthrough

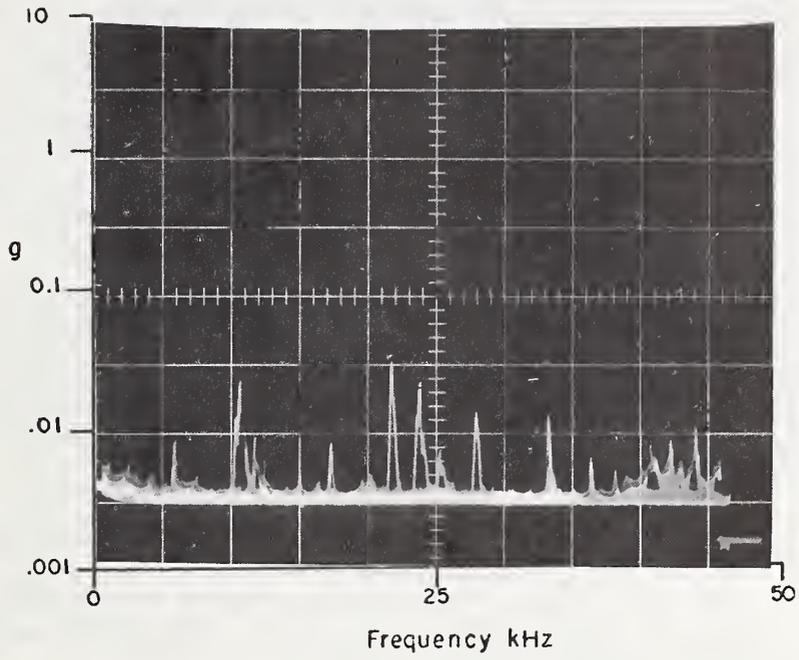


Figure 25. Vibrational disturbances
from Attack 22A

ATTACK 22B

Attack 22B occurred on the same wall as 22A and at a location centered 18" from the vibration transducers. This attack employed a rotohammer and 1-1/2" toothed-chisel to cut along the perimeter of the targeted opening. Mortar joints were prime targets to the extent that they reasonably corresponded with the perimeter. It required 4.87 minutes to clear a somewhat oversize opening through the brick veneer. This activity produced a SPL of 95 to 100 dB as observed at a distance of 12' and produced acoustical disturbances inside the room as shown in figure 26 . Vibrational disturbances are shown in figure 27 .

Then the cinder block was attacked through the opening in the brick veneer as shown in figure 28. It took 3.5 minutes with the rotohammer and approximately 0.25 minute with a sledgehammer to clear the block away making a suitably-sized hole containing a single reinforcing rod. Acoustical disturbance produced by the rotohammer are shown in figure 29 and vibrational disturbances in figure 30 .

Finally, the reinforcing rod was cut in 1.1 minutes with an oxygen acetylene torch using a No. 5 tip, oxygen pressure of 30 p.s.i. and acetylene pressure of 12 p.s.i.. The torch produced a peak SPL of 82 dB at 10'. Acoustic disturbances are shown in figure 31 and vibrational disturbances in figure 32 .

The total working time for this attack was 9.71 minutes and the first J-SIIDS alarm occurred 5 seconds after the attack started.

The opening produced was 13-1/4" high, 6-1/2" wide at the bottom, and 8-1/2" wide at the top.

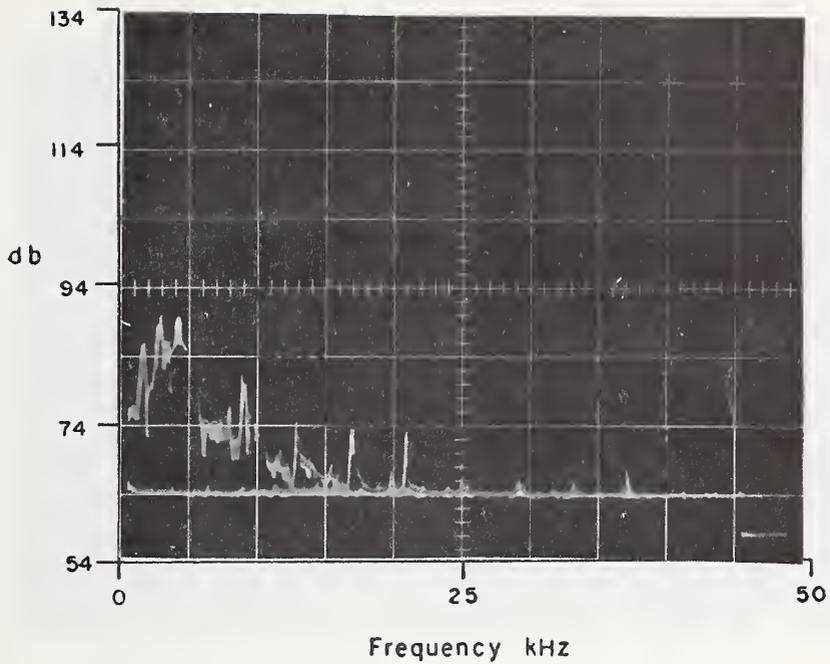


Figure 26. Acoustical Disturbance from Attack on Brick Veneer

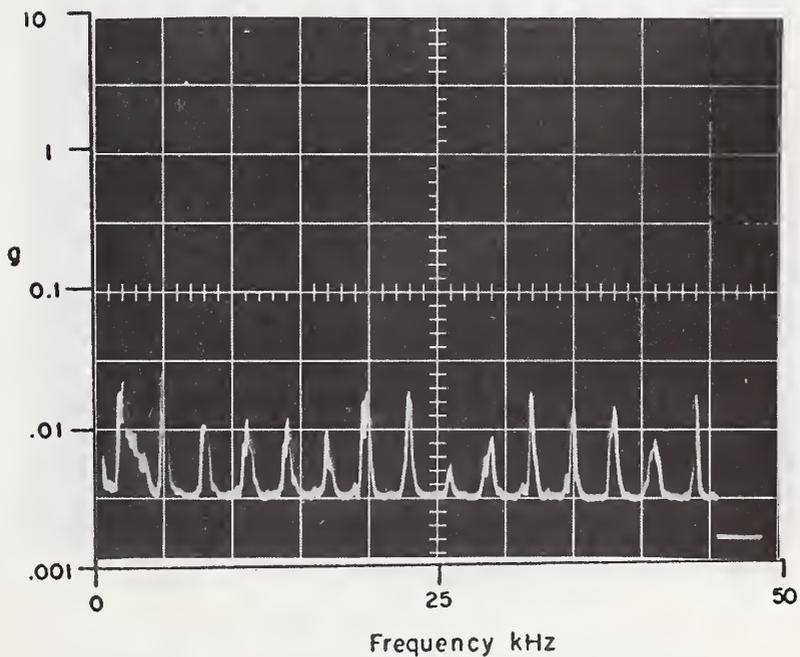


Figure 27. Vibration from Attack on Brick Veneer



Figure 28. Attack 22B

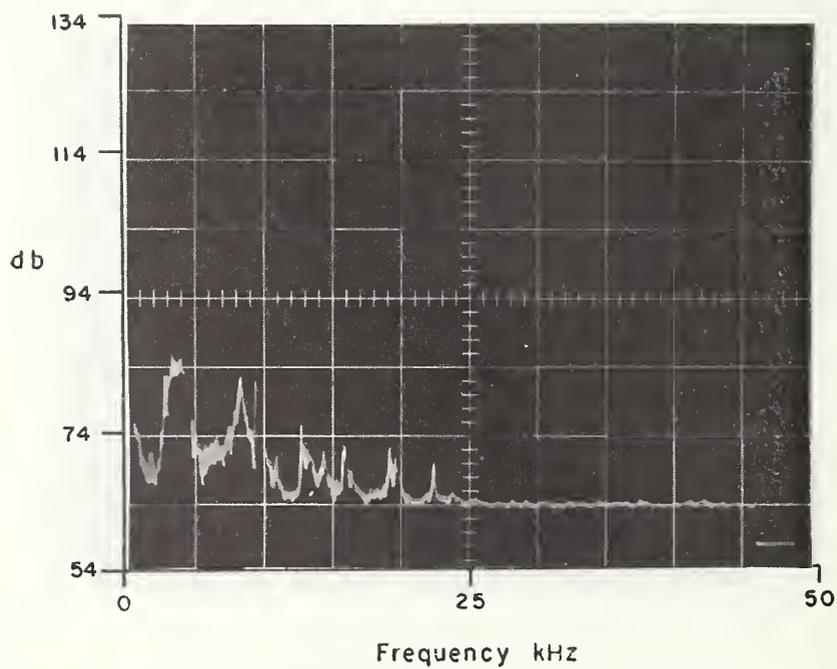


Figure 29. Acoustical Disturbance from Rotohammer Attack on Cinder Block

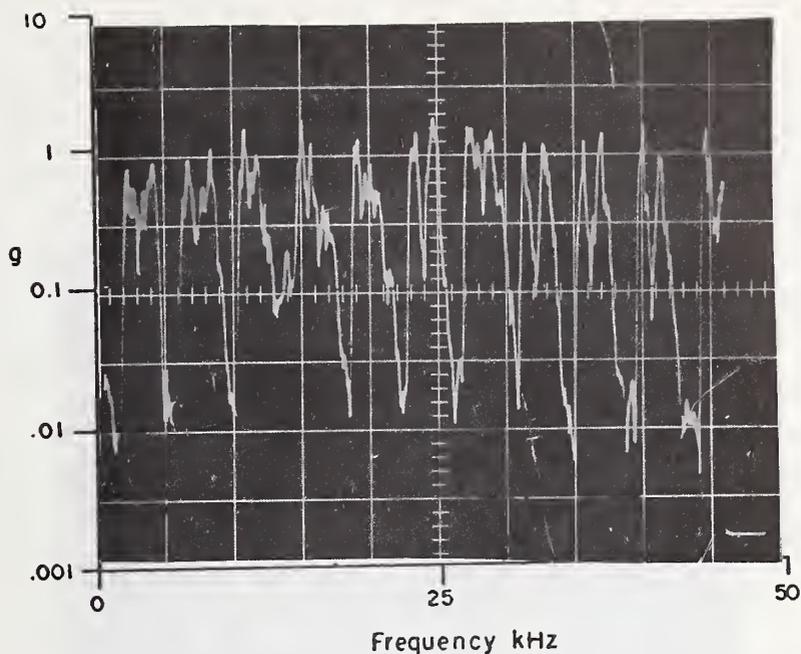


Figure 30. Vibration from Attack on Cinder Block

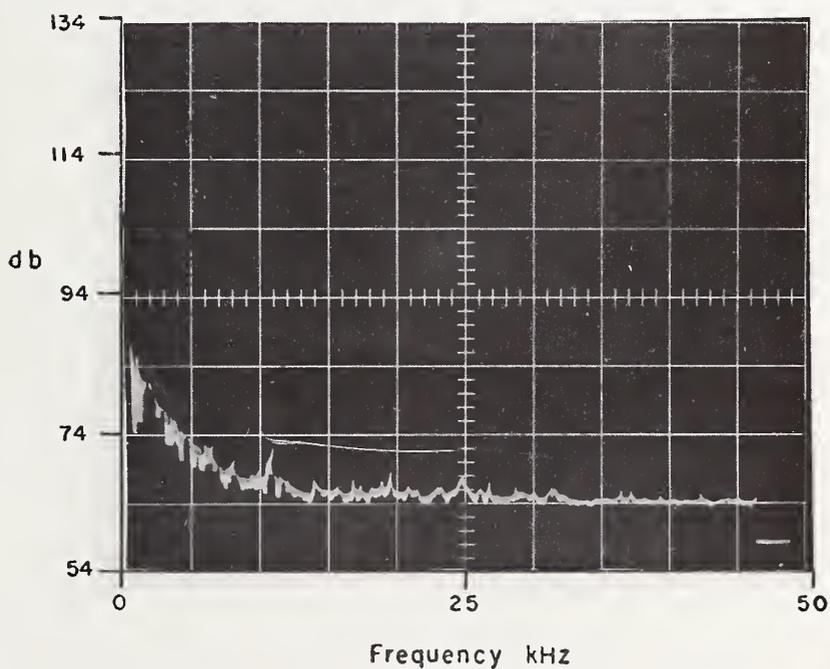


Figure 31. Acoustical Disturbances from Cutting Torch

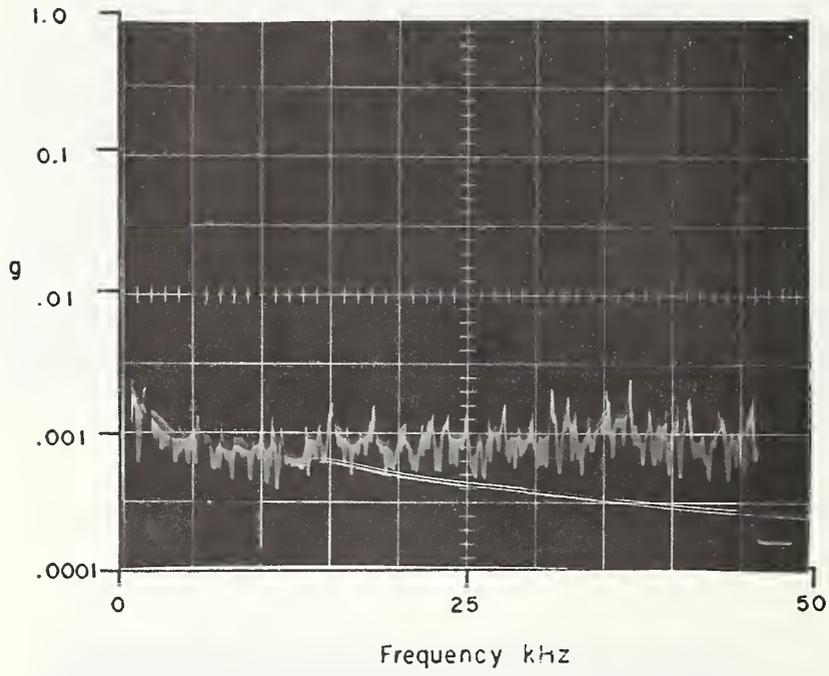


Figure 32. Vibrational Disturbances
from Cutting Torch

ATTACK 27T

Location 27T was a pass window screened with 1/8"-thick expanded metal and backed by a metal-clad wooden half door which was hinged on one side and secured to the frame by a draw bolt on the other. The targeted opening was located on one edge of the grill centered over the draw-bolt position. As shown in figure 33, 3/8" capacity bolt cutters were used to cut 3 sides of the perimeter of the opening leaving a flap of expanded metal which could be bent back out of the way. Two blows with the sledgehammer were then sufficient to break off the draw bolt permitting the half door to swing open. The working time for this attack was 3.25 minutes and the elapsed time 3.58 minutes. The first J-SIIDS alarm occurred 7 seconds after the attack began.

During this attack, the vibration transducer was located in the same position as in Attacks 22A and 22B and at a distance approximately 8' away. Vibrational disturbances observed during the bolt cutter attack are shown in figure 34 which does not materially differ from the background disturbance level prior to the attack as shown in figure 35. A multiple sweep of acoustical disturbances produced by the bolt cutters is shown in figure 36. The vibrational disturbance from the sledgehammer breaking the draw bolt is shown in figure 37.



Figure 33. Attack 27T

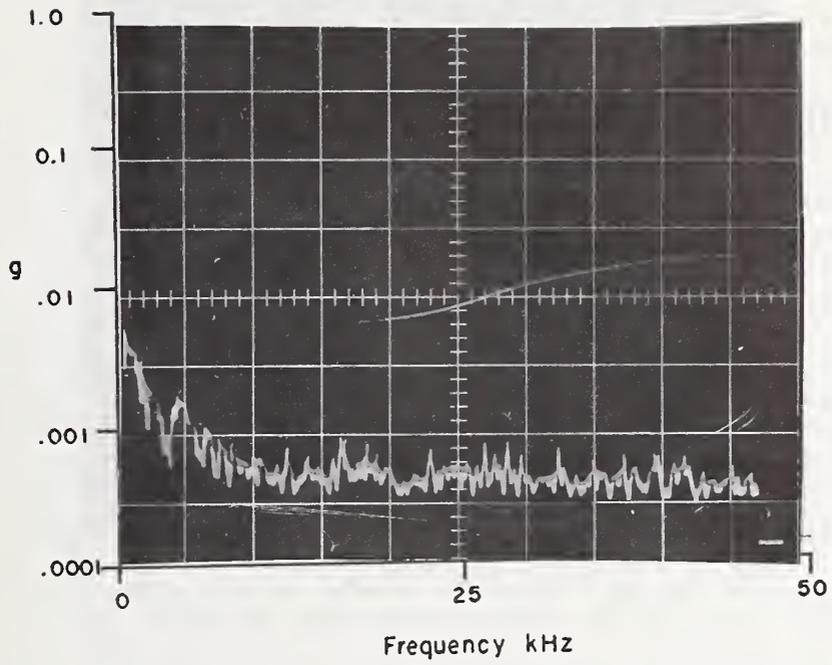


Figure 34. Vibration During Bolt Cutter Attack

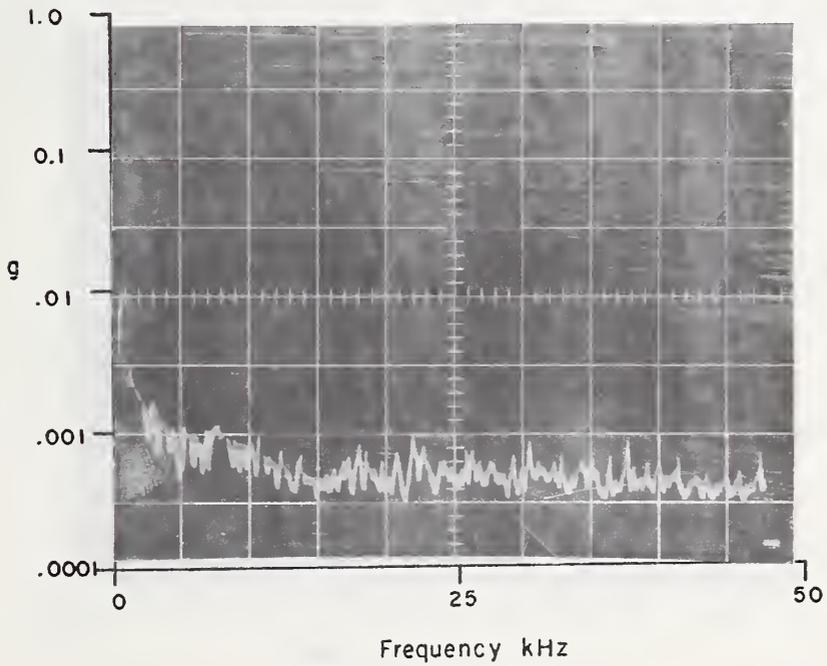


Figure 35. Ambient Vibrational Background at Location 27T

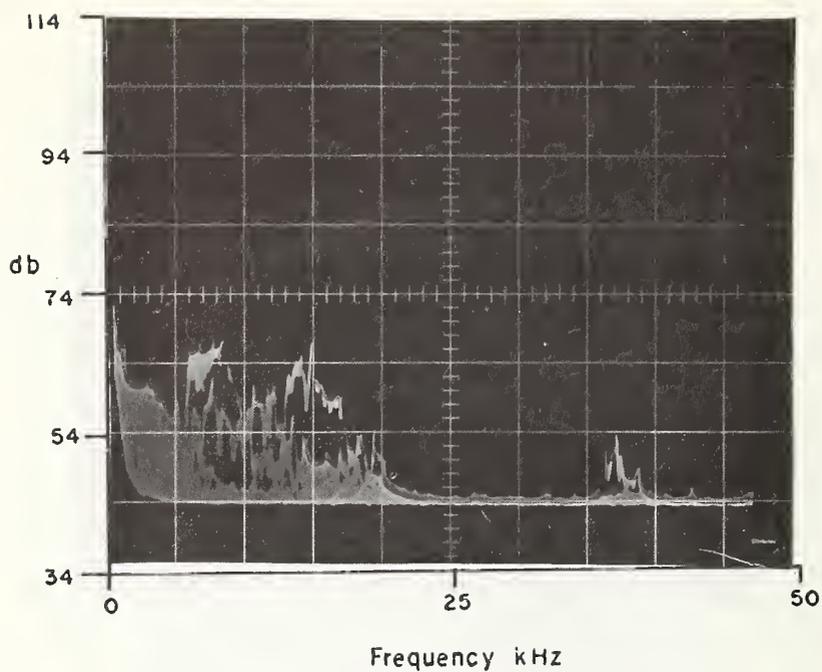


Figure 36. Multiple Sweep of Acoustical Disturbances Produced by Bolt Cutters

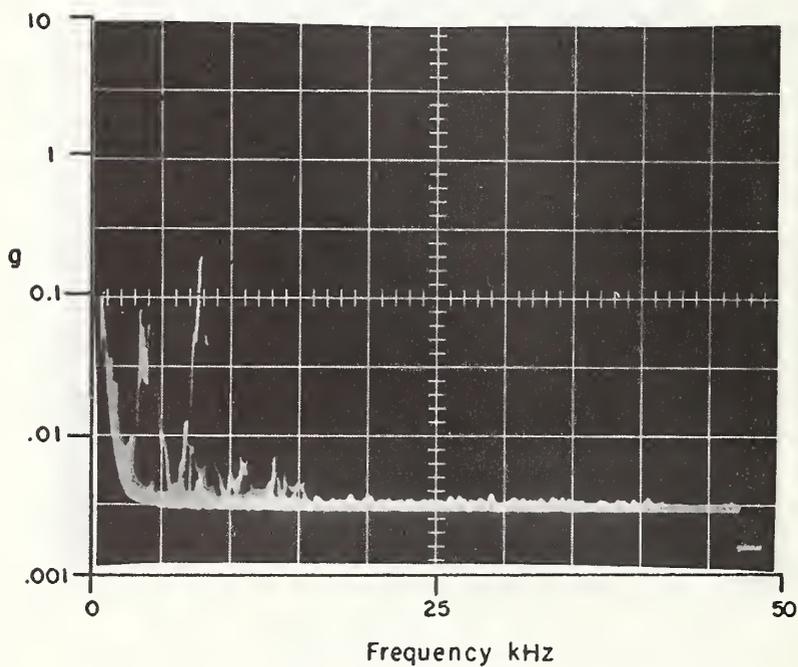


Figure 37. Vibration from Sledgehammer Attack on Draw Bolt

ATTACK 23B

Location 23B was on the roof of Room 2. The roof was 5-1/2" thick concrete reinforced with 1/2" bars located in the approximate center of thickness and spaced 8" apart in one direction and 12" apart in the other direction. An 8" X 12" opening perimeter was laid out and hole locations were spotted at each corner, in the center of the rectangle and midway on each 12" side. Using the rotohammer, 1" diameter holes were drilled to a depth of 3-1/2" at each of these 7 locations as shown in figure 38. A 1" bull-point punch was then used in each hole and with a 12-pound sledgehammer the interior 2" of concrete was spalled away. At this point, inspection inside the room revealed the fact that the targeted opening straddled an electrical conduit, previously concealed in the concrete, which supplied power to Room 3. Since this power would be needed in connection with later tests, the targeted opening was relocated by moving it 8" along its short dimension. This required drilling and spalling out 4 new holes and the time for this was not included in the measurements reported for this attack. It took 151 seconds or 2.52 minutes to drill the 7 original holes. Since 24.5 linear inches of material was drilled in these 7 holes, the average drilling rate for the 1" diameter bit was 6.16 seconds per inch. Samples of the acoustical disturbances are shown in figure 39 and the vibrational disturbances in figure 40. The latter were obtained with the transducer mounted on the inside of the concrete roof at a distance of 8' from the center of the opening.

Spalling out the concrete below the bottoms of the holes required 2.92 minutes and produced a peak SPL of 91 dB observed 25' away from the attack location. Multiple sweep photographs of the acoustical spectra are shown in figure 41 and the vibrational spectra in figure 42.



Figure 38. Attack 23B

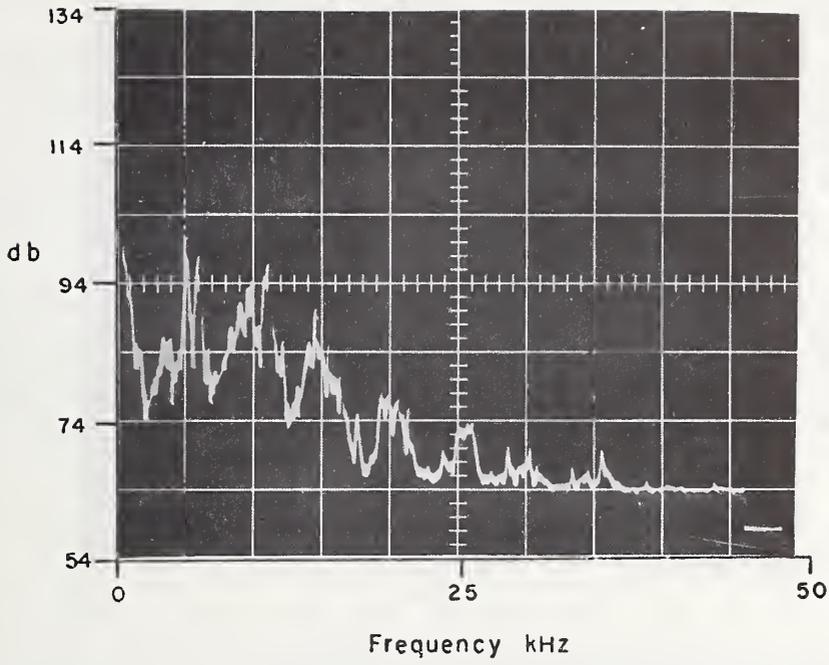


Figure 39. Acoustical Disturbance from Drilling

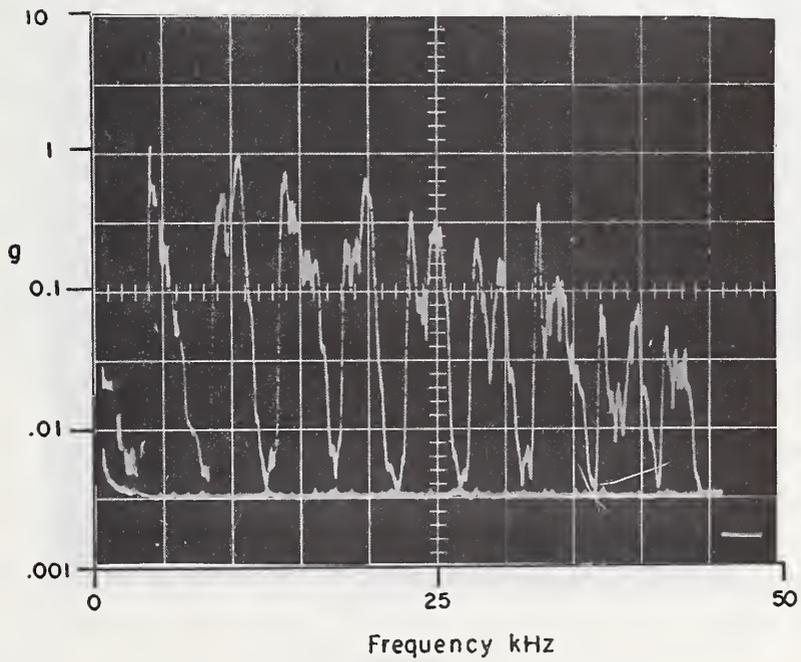


Figure 40. Vibrational Disturbance from Drilling

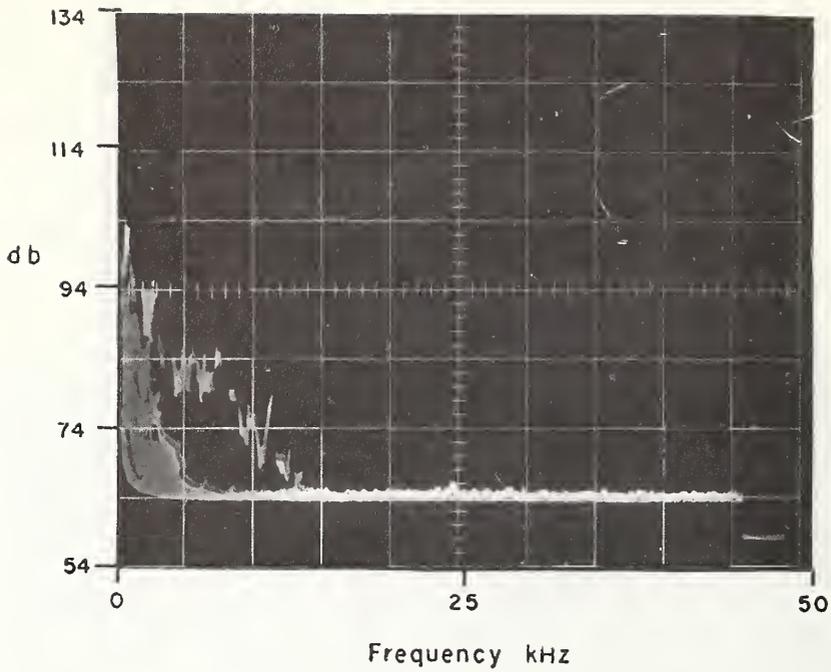


Figure 41. Acoustical Disturbance from Spalling

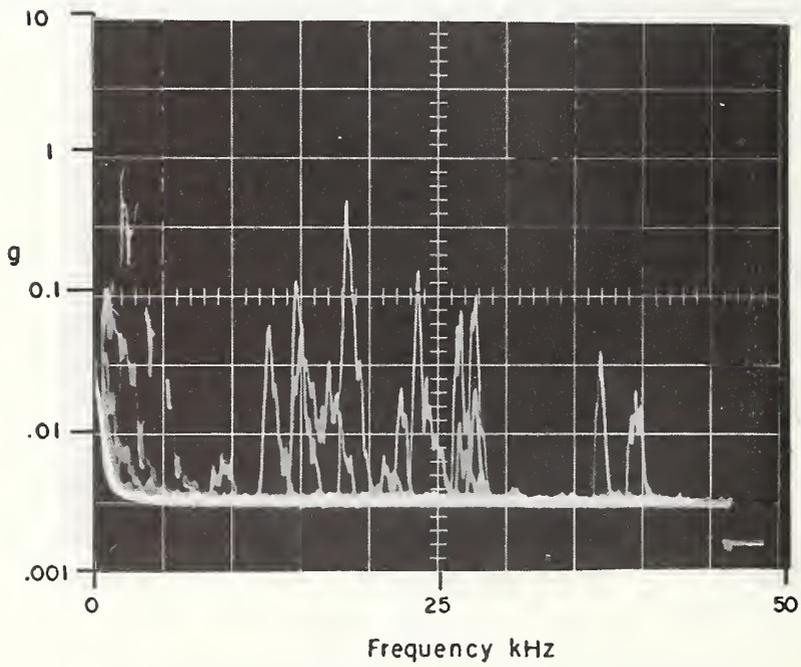


Figure 42. Vibration from Spalling

Next, as shown in figure 43, a 5-horsepower gasoline-powered saw equipped with a 12" diameter abrasive cutoff wheel was used to cut a groove around the perimeter of the relocated opening. This took 5.06 minutes working time and it was necessary to replace the cutoff wheel about midway through this activity because of wheel wear. In addition, it was necessary to vacate the wing of the building housing the arms rooms after each of the 4 perimeter cuts while the dust and exhaust fumes were cleared away by fans. These latter time intervals were not included in the calculation of elapsed time.

Outside of the room the abrasive wheel cutoff saw produced 105 dB SPL at a distance of 25'. Samples of the acoustical spectrum within the room were lower and are shown in figure 44 and the vibrational spectrum are shown in figure 45 . Note how the latter peaks in the 15 to 35 kHz frequency range.



Figure 43. Abrasive Wheel Cutoff Saw
Used in Attack 23B

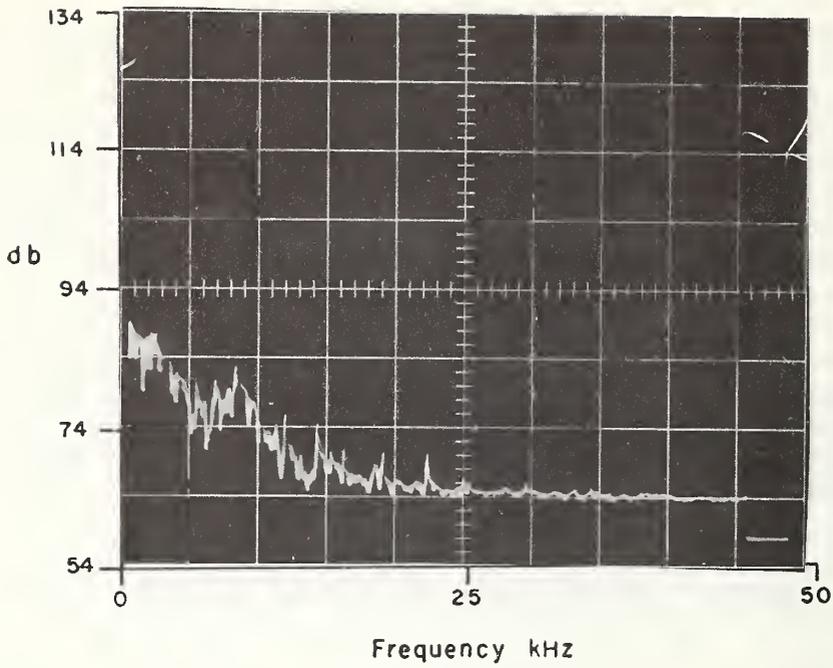


Figure 44. Acoustical Disturbances from Abrasive Wheel Cutoff Saw

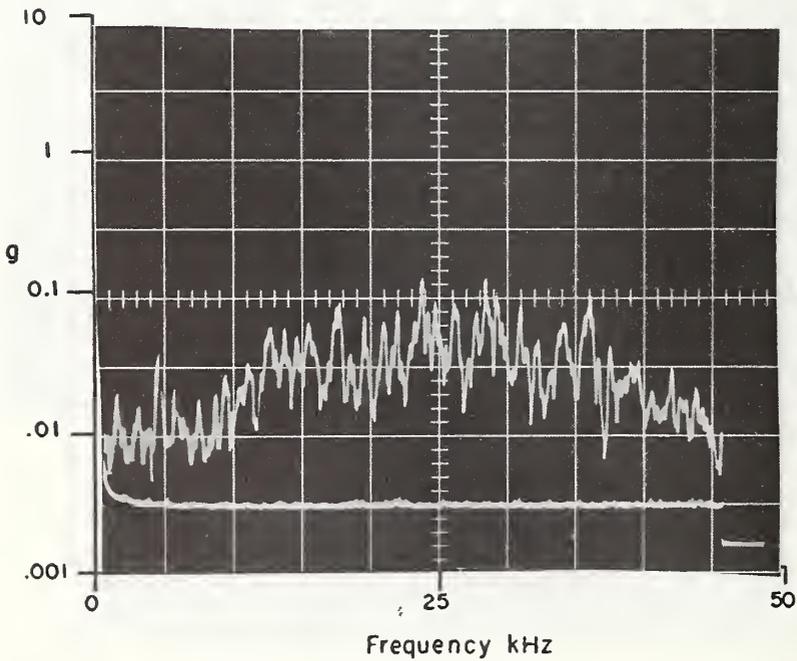


Figure 45. Vibration from Abrasive Wheel Cutoff Saw

The cut made by the abrasive wheel saw around the perimeter of the opening penetrated to a depth of between 2" and 3". This left about an inch of concrete between the bottom of the cut and the top of the previously spalled interior area. It was hoped that the remaining plug could be broken out by a direct sledgehammer assault, but, when 50 seconds of effort with this tool produced only moderate spalling on the surface, it was decided to drill two more holes with the rotohammer. These were made in 18 seconds and then the sledgehammer attack was resumed. This time it was quite successful and only 23 more seconds were required to clear the concrete from the opening exposing the reinforcing rods for cutting as shown in figure 46. Acoustic disturbances produced by the sledgehammer are shown in figure 47 and vibrational disturbances in figure 48. Both of these are photographs of multiple sweeps of the output of the spectrum analyzer.

The reinforcing rod was cut in 1.42 minutes using a No. 5 tip, 25 p.s.i. oxygen pressure and 5 p.s.i. acetylene pressure. Acoustical disturbances are shown in figure 49 which exhibits the typical flat spectrum of a cutting torch.

The total working time to produce the final 9" X 12-1/2" opening was 13.58 minutes and the calculated elapsed time was 17.0 minutes. The first J-SIIDS alarm occurred 5 seconds after the attack was started.

The relatively long working time required in this attack was undoubtedly due, in part, to the rather awkward working conditions associated with this location. The roof of Room 3 was only about 3-1/2' below the ceiling of the building housing the simulated arms rooms. This low clearance forced the attackers to work from a sitting or kneeling position and severely limited their freedom of movement and the effective application of their tools. Later attacks on the 8" thick reinforced concrete walls of Room 3 provide some indication of the magnitude of the influence of this constrained working space.



Figure 46. Opening Made by Attack 23B

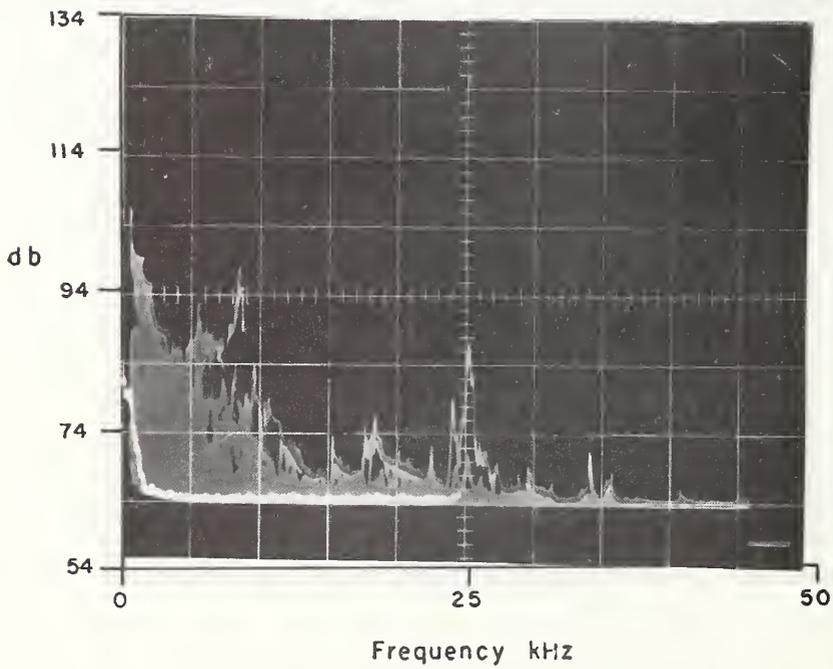


Figure 47. Acoustical Disturbances from Sledgehammer

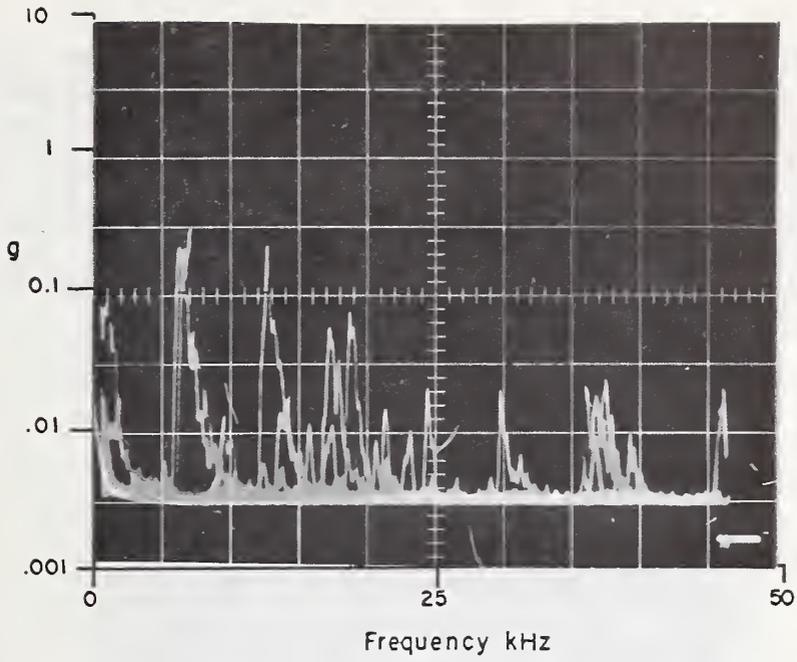


Figure 48. Vibration from Sledgehammer

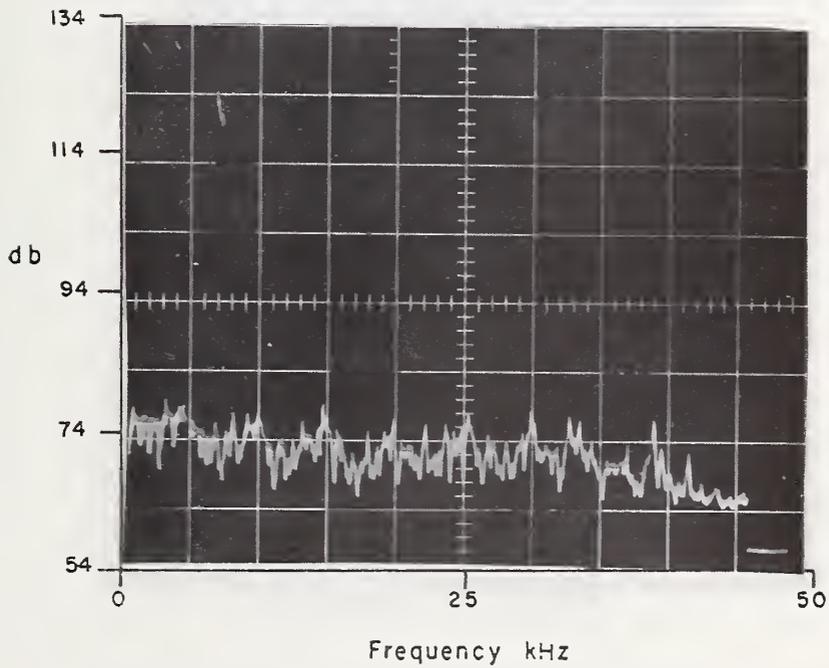


Figure 49. Acoustical Disturbances from the Cutting Torch

ATTACK 29A

The last attack on Room 2 was made on the un-veneered cinder-block wall. The attack was with a 12-pound sledgehammer, as shown in figure 50 , and required 47 blows and 1.26 minutes. No reinforcing bars were encountered, however, two horizontal reinforcing wires were exposed and these were cut with a No. 0 bolt cutter in 4 seconds. The total working time was 1.32 minutes and the elapsed time was 1.52 minutes. The first J-SIIDS alarm occurred 8 seconds after the attack began. Vibration disturbances picked up by a transducer mounted on the wall 4-1/2' from the center of the attack area are shown in figure 51 .



Figure 50. Attack 29A

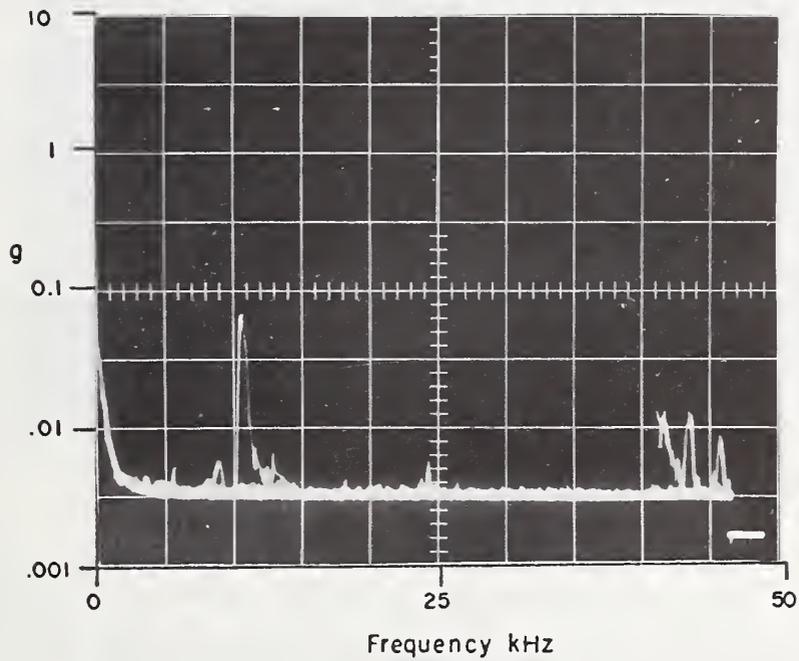


Figure 51. Vibration from
Sledgehammer on
Cinder-block Wall

ATTACK 25D

This test was identified as 25B on the test plan but the physical location was stenciled as 25D and it will hereinafter be referenced by that identifier to be consistent with the photographic coverage. The attack was made on one of the 8" thick reinforced concrete walls of Room 3. It involved drilling a pattern of 1" diameter holes partially through the concrete to predetermined depths, then spalling out concrete on the interior using a 1" bull-point punch and sledgehammer. Initial spalling was from the deepest holes and after the material was cleared out behind them the attack shifted to the shallower holes and finally to the surface of the remaining plug. Finally, reinforcing would be cut if necessary. As developed, the opening exposed but did not straddle a reinforcing bar and cutting was not necessary in this attack.

The hole pattern that was laid out was in the form of two concentric circles; the outer circle approximately 11-1/2" in diameter and the inner circle approximately 5-3/4" in diameter. Locations for the six holes were laid out at 60° increments on the outer circle and for three holes at 120° increments on the inner circle. These nine holes were to be drilled 5" deep. Nine more locations were then laid out midway between those of the original group and marked for drilling to a depth of 2-1/2". Figure 52 shows the hole pattern as laid out.

Using the rotohammer and 1" drill, it took 7.88 minutes to drill the nine holes 5" deep. This represents 45 linear inches and an average rate of 10.5 seconds per inch. There was a range of from 38 to 70 seconds of time required for individual holes but several were drilled in 42 to 47 seconds. The nine 2-1/2" deep holes required 3.27 minutes for an average rate of 8.7 seconds per inch. The overall average drilling rate was 9.91 seconds per inch.

Typical SPL values of 108 to 110 dB were observed at a distance of 7'. Acoustical disturbances inside Room 3 are shown in figure 53. Vibrational disturbances recorded from a transducer mounted on the wall 10' from the attack point are shown in figure 54 .



Figure 52. Attack 25D

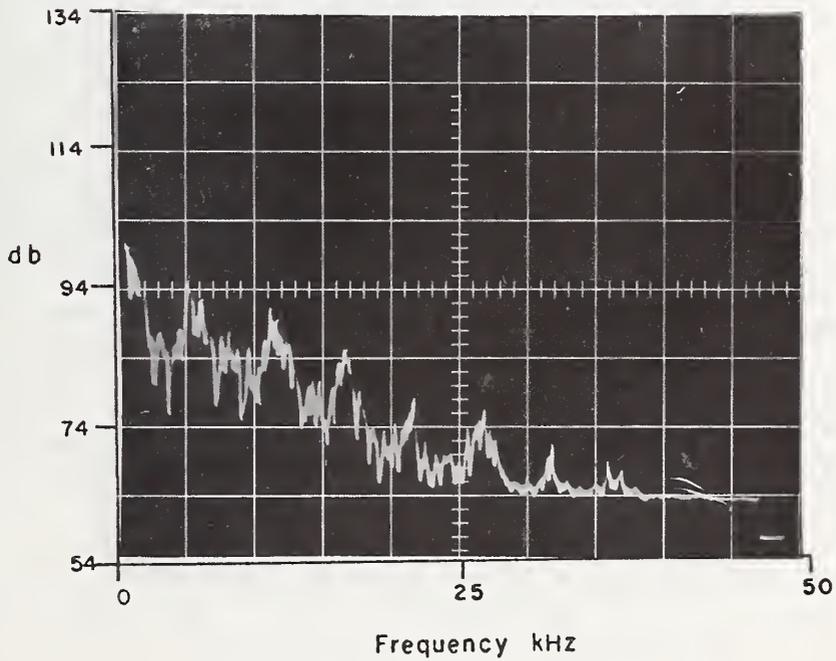


Figure 53. Acoustical Disturbances from Drilling Reinforced Concrete

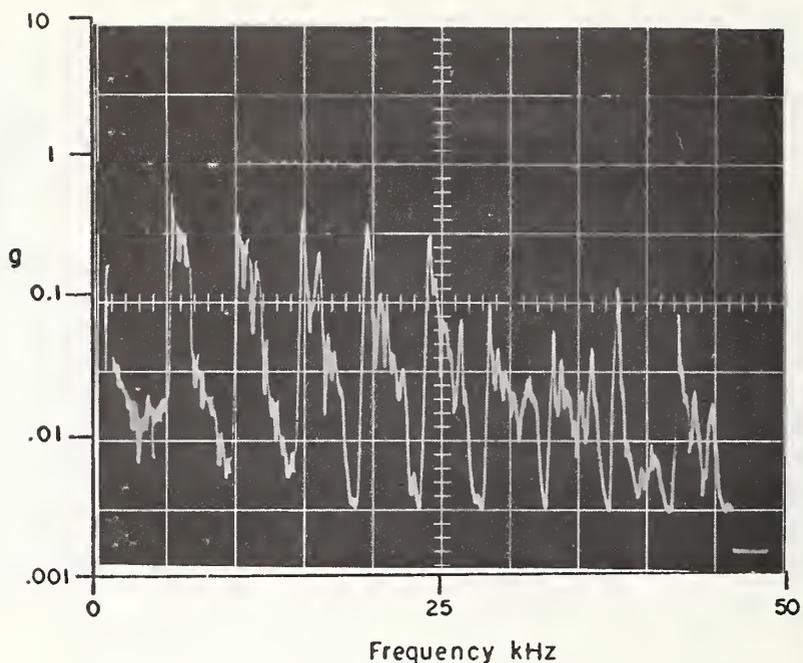


Figure 54. Vibration from Drilling Reinforced Concrete

Spalling the concrete from the interior beneath the holes was accomplished using a 10-pound sledgehammer and 1" diameter bull-point punch and required 6.98 minutes. Figure 55 shows the interior of the wall with spalling nearly complete. Figure 56 is a multiple sweep photograph of the acoustical disturbances which were produced within Room 3. Outside SPL readings 99 to 102 dB were observed at a distance of 8'. Typical vibrational disturbances observed with a transducer located on the same wall as the attack and at a distance of 10' are shown in figure 57. A second transducer mounted on the opposite wall of Room 3 with a transmission path length of approximately 20' yielded the spectrum shown in figure 58.

After the spalling was completed, the remaining plug was broken out using a 20-pound sledgehammer for 23 seconds and a 10-pound sledgehammer for 13 seconds. Multisweep vibrational data from the 20-pound hammer is shown in figure 59 and from the 10-pound hammer in figure 60. In both instances the transducer was 10' from the attack point. Note the higher g values developed by the 10-pound hammer. This is attributed to the higher velocity which could be developed in swinging this lighter hammer.

The total working time required to complete penetration 25D was 18.73 minutes. The first J-SIIDS alarm occurred 5 seconds after the attack began.



Figure 55. Interior of the Wall with Spalling Nearly Complete

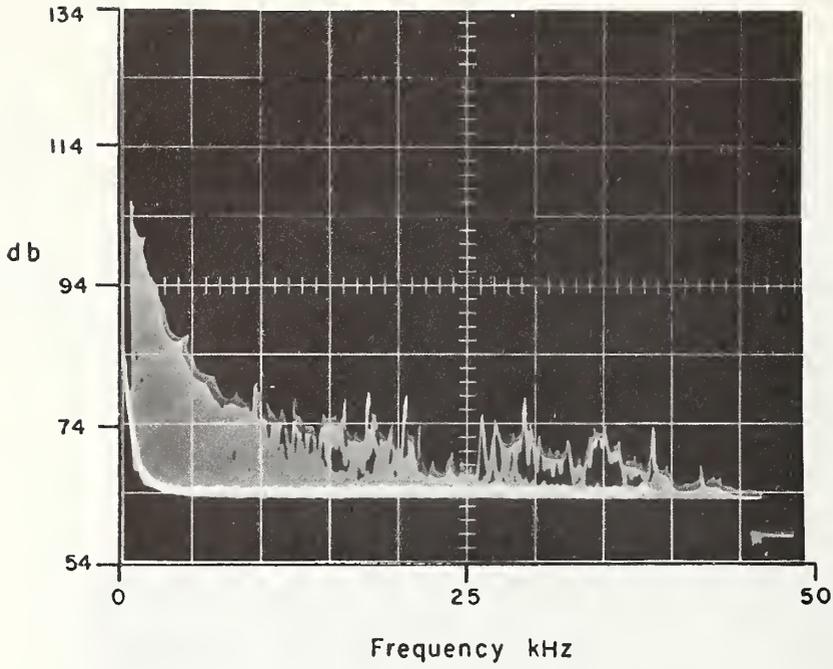


Figure 56. Multiple Sweep of Acoustical Disturbances Produced by Spalling

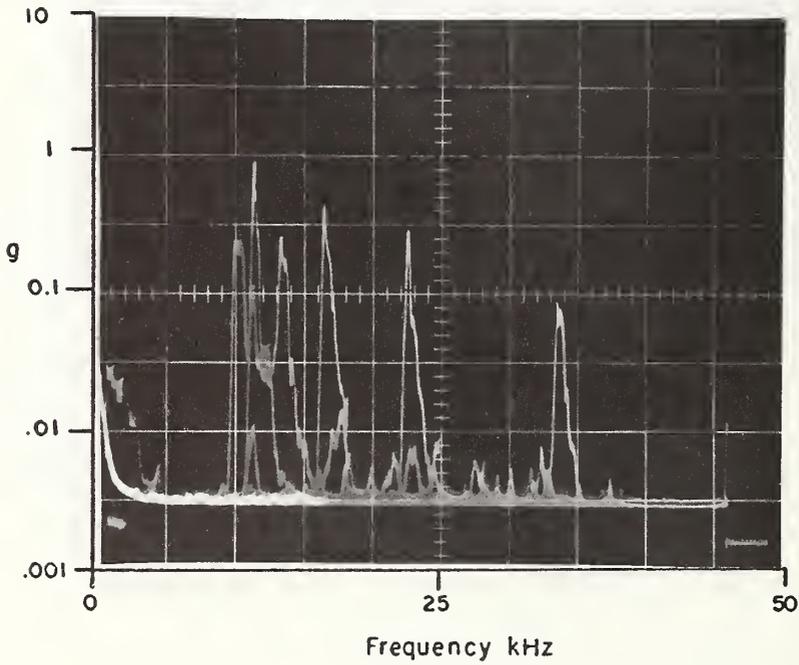


Figure 57. Vibration from Spalling with Transducer mounted 10' from Attack Point

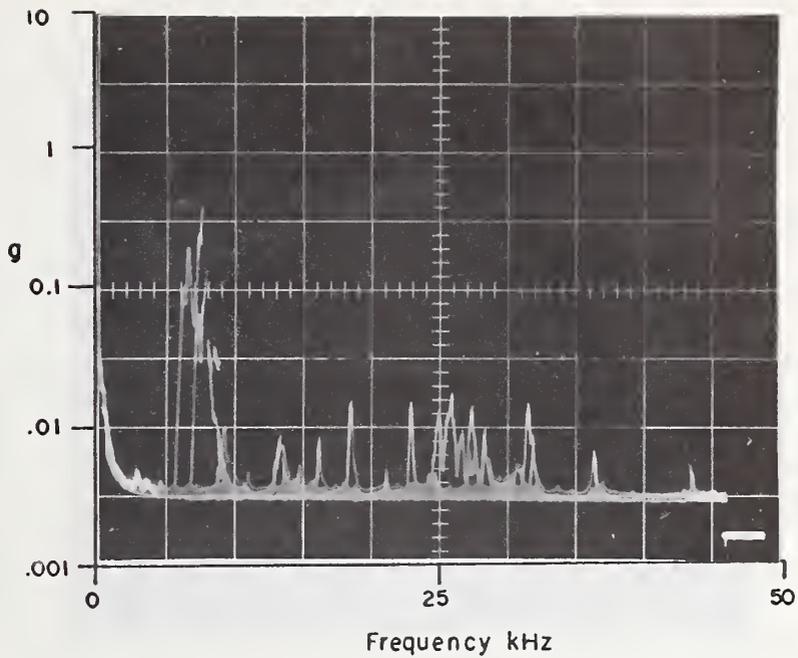


Figure 58. Vibration from Spalling with Transducer Mounted 20' from Attack Point

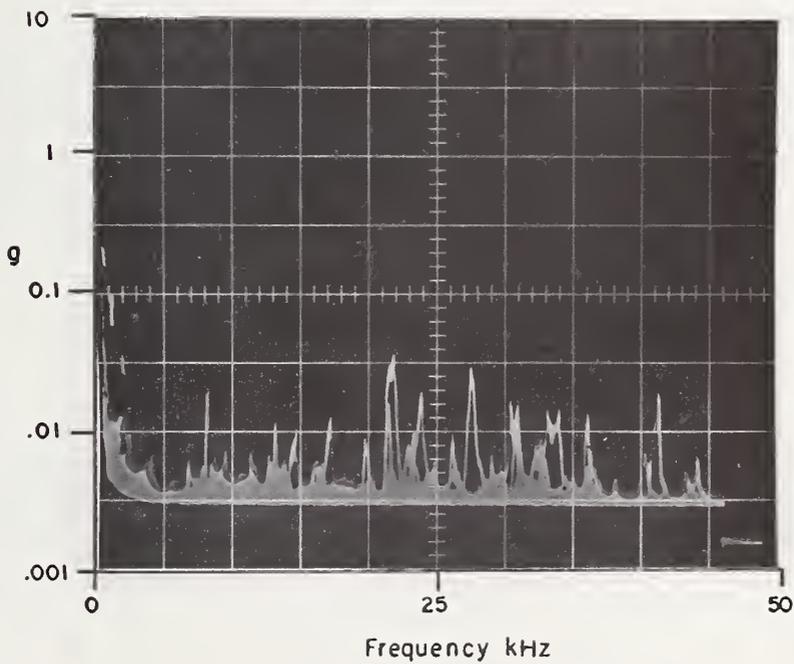


Figure 59. Vibration from 20-pound Sledgehammer

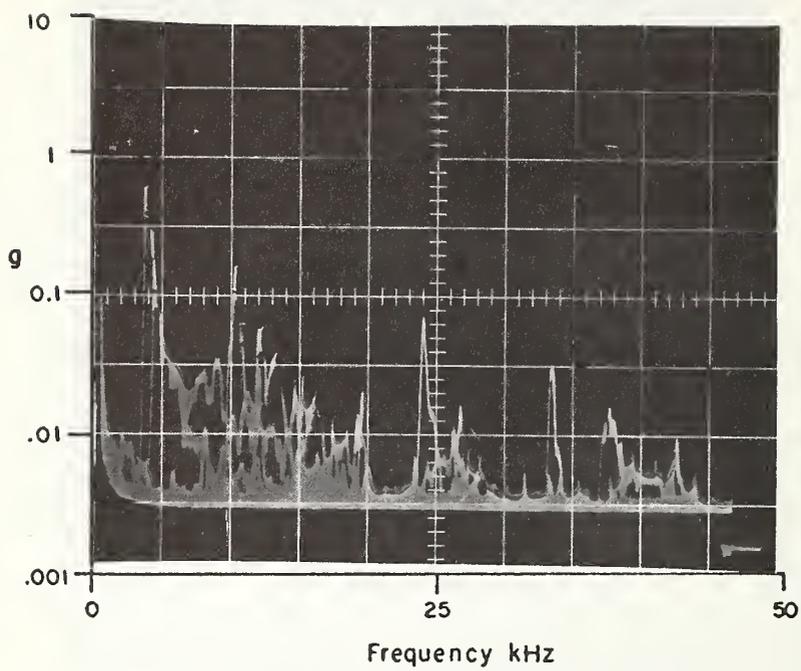


Figure 60. Vibration from 10-pound Sledgehammer

ATTACK 24B

Attack 24B was similar in concept to 25D but employed a fewer number of smaller diameter holes to prepare for spalling. The size of the chunks of concrete initially spalled out in Attack 25D led to the conviction that more holes had been drilled than were necessary. Also, since earlier tests² had shown that drilling rate with the rotohammer is dependent upon the volume of material removed in the case of hole diameters of 1" or less, drilling 3/4" holes would be appreciably faster than the 1" holes in Attack 25D. Whether or not a 3/4" diameter bull-point punch would hold up under the sledgehammer was not known.

The hole pattern selected consisted of eight holes equispaced around the perimeter of a circle 11-1/2" in diameter. Alternate holes were drilled 5" and 3-1/2" deep. A single 4" deep hole was drilled at the center of the circle. The rotohammer with 3/4" bit completed this 38 linear inches of drilling in 2.62 minutes at an average rate of 4.13 seconds per inch. SPL values of 104 dB were observed at 8' and 112 dB at 2' distance. Vibrational disturbances as observed with the transducer mounted on the interior of the wall at a distance of 5' from the center of the opening are shown in figure 61 .

Spalling out the bottoms of the drilled holes was accomplished with the 3/4" diameter bull-point punch and 12-pound sledgehammer. It took 1.42 minutes and 63 hammer blows on the 5" deep holes followed by 1.26 minutes and 58 blows for the 3-1/2" deep holes and 0.2 minutes and 9 blows for the 4" deep center hole. Samples of acoustic disturbances are shown in figure 62 and vibrational disturbances in figure 63 .

The 3/4" diameter bull-point punch performed satisfactorily in spalling out the first few holes. Then it received a glancing blow from the sledgehammer which produced a very slight bend about midway along the length of the punch. Subsequent hammer blows increased this bend and it became necessary to try to straighten the punch after each subsequent hole was spalled out. The marginal durability of the 3/4" punch could easily be bolstered with a few extra spare punches.

²/ NBSIR 73-101, Penetration Resistance Tests of Reinforced Concrete Barriers, by R. T. Moore, Interim Report for Period October 31 - November 3, 1972, prepared for Defense Nuclear Agency, Washington, D.C. 20305.

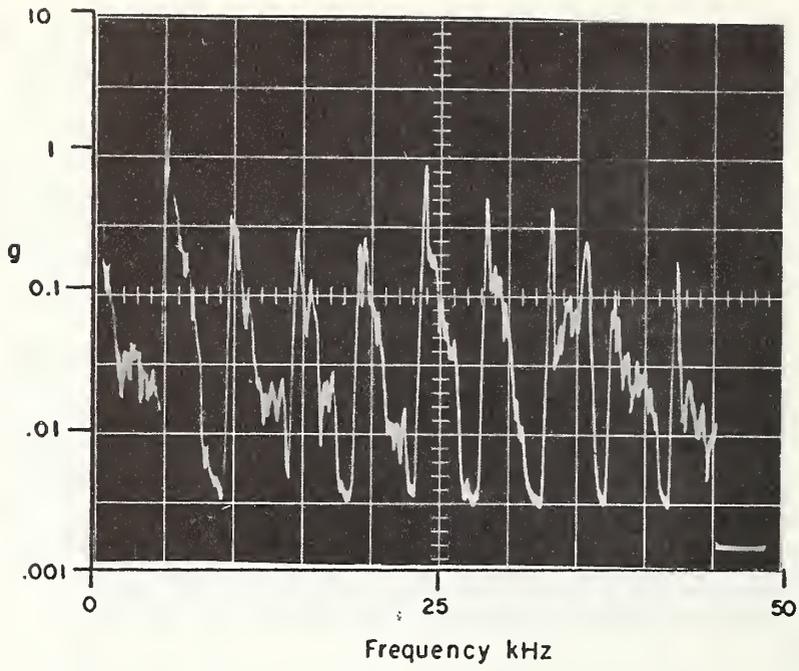


Figure 61. Vibration from Rotohammer

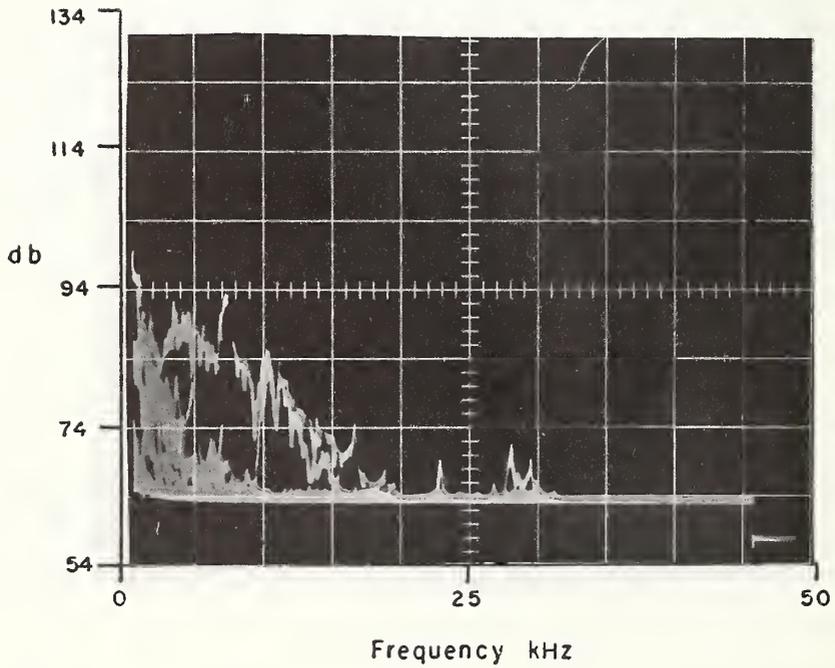


Figure 62. Acoustical Disturbances from Spalling

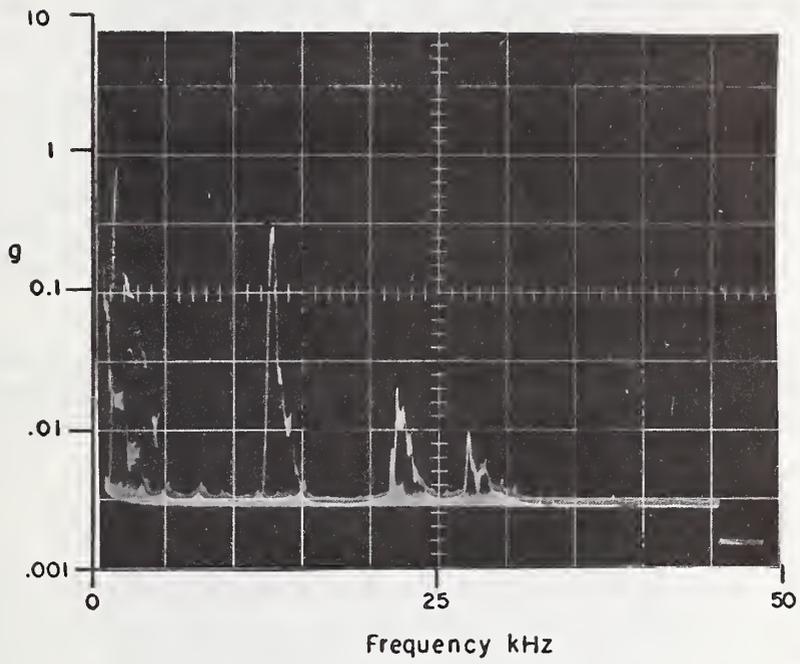


Figure 63. Vibration from Spalling

The remaining plug in the center of the hole was now held in place by a perimeter ring of un-spalled concrete which ranged from 3-1/2" to 5" in thickness and it was expected that this could be rather quickly broken out. This did not prove to be the case. An initial breakthrough was produced in 2.56 minutes with a 20-pound sledgehammer, but, after another 1.07 minutes, it was apparent that the rate of enlargement was not very fast and an alternative strategy was adopted as shown in figure 64. A tapered punch with a maximum diameter of 1-1/4" was driven into each of the 8 perimeter holes. This was quite effective in spalling the remaining concrete between the holes and the broken out center of the plug. It required 1.53 minutes and 66 blows from the 10-pound sledgehammer to complete the spalling from the perimeter holes. This was followed by 0.25 minute with the sledgehammer alone to break off a few remaining projecting points.

A single reinforcing bar was encountered in making this penetration. It was decided to defer cutting this until a later test using the burning bar. At that later time, the bar was cut in two places in 0.40 minute.

The total working time on Attack 24B was 11.31 minutes. The first J-SIIDS alarm occurred 5 seconds after the attack was started.

Although the time here was only about 60 percent of that required for Attack 25D, it could probably be further reduced to about 10 minutes. The 3.63 minutes of sledgehammering the central plug to make initial breakthrough could probably be reduced to about 2.5 minutes by drilling three central holes configured as an equilateral triangle with sides about 5" long. If their depth was 2-1/2", the calculated drilling time would be .51 minute, spalling time with the bull-point punch is estimated to take about 1.0 minute and then probably central breakthrough could have been accomplished with the sledge in about another minute.



Figure 64. Use of Tapered Punch
in Attack 24B

Location 28 was a GSA Class 6 security vault door. Initial plans were to attack this with a burning bar but the plans were changed when the opportunity arose to test a portable rocket-powered cutting torch. Two approaches to making penetrations in this barrier were contemplated. The first involved making a small opening at a point which would permit the bolt-work blocking mechanism to be forced out of the way and permit the bolts to be withdrawn from their locked position by operating the vault door handle. The second involved making a 96 square inch circular cut through the door itself at an area where minimum resistance would be expected to be encountered.

Prior to pursuing either of these approaches, it was necessary to adjust the latch of the inner grilled day-door of the vault. In the process a rattail file was used to enlarge a bolt hole on the latch bracket which was mounted on the inner steel door frame. A vibration transducer had been mounted on the door frame about 20" away from this bracket and the vibrational disturbances produced by the filing are shown in figure 65 .

Next, because drilling could be used to attack the bolt-work blocking mechanism, a sample hole was started in the appropriate area to provide an opportunity to collect acoustical and vibrational disturbance data. A 9/32" high-speed steel bit was used in a 3/8" variable speed electric drill. Multiple sweeps of the resulting acoustical data appear in figure 66 and vibrational data in figure 67 . The vibrational transducer was on the inner frame of the vault door and the microphone was within the vault with the door closed, of course. On the outside, SPL values of 80 dB were observed with the drill running at low speed and 87 to 88 dB at high speed at a distance of 3'.

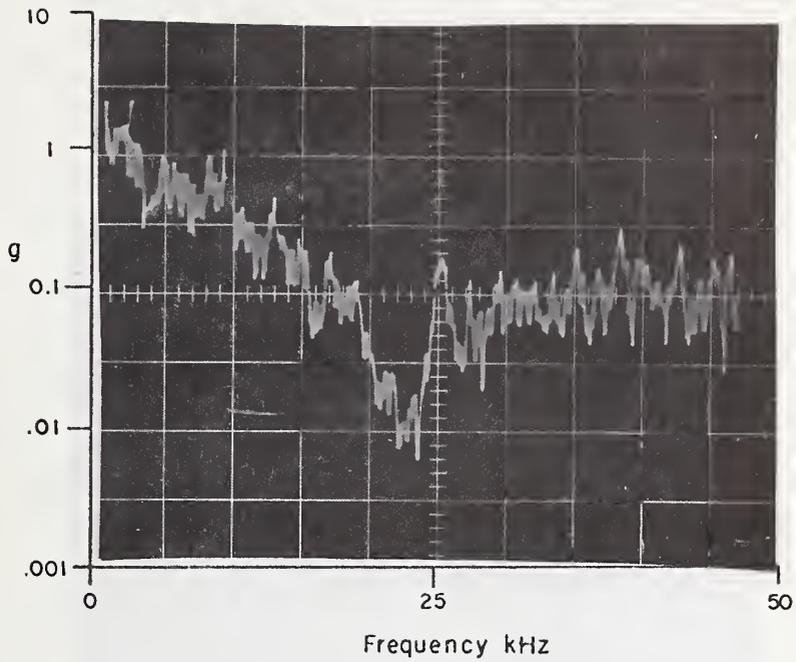


Figure 65. Vibration from File

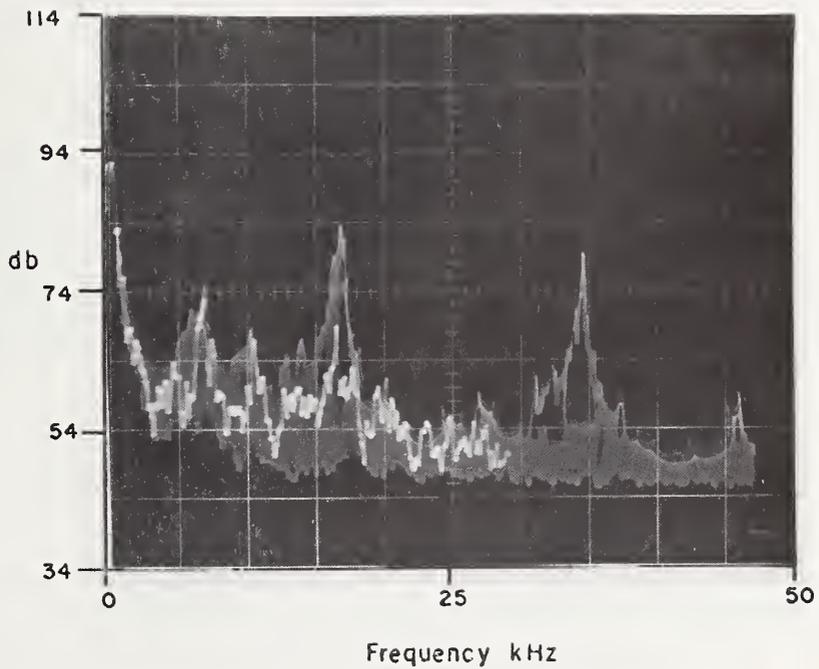


Figure 66. Acoustic Disturbance from Drilling on Vault Door

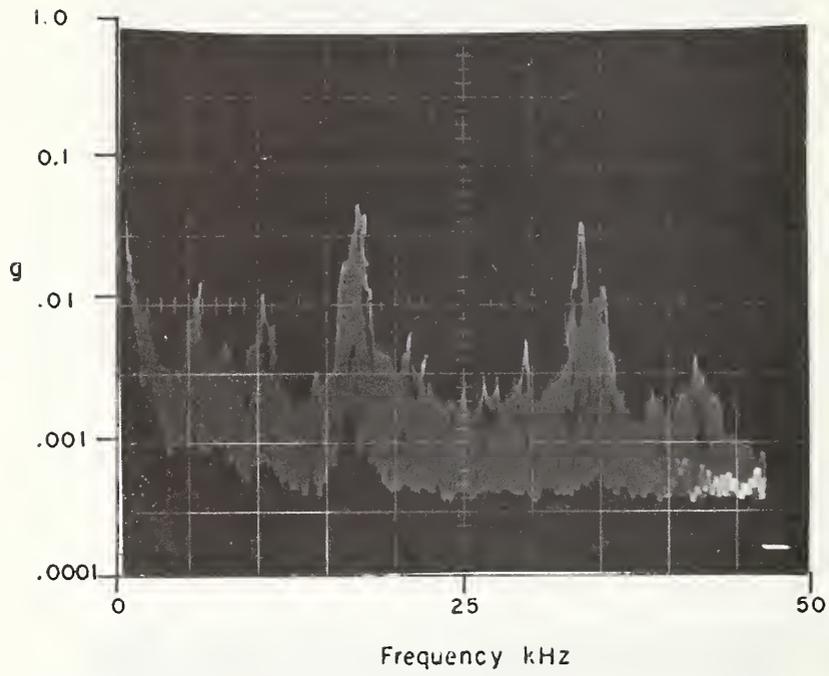


Figure 67. Vibration from Drilling
on Vault Door

Next, the portable cutting torch (rocket) was used to attack the area of the vault door over the bolt-work blocking mechanism. After 74 seconds it appeared unlikely that this attack could be successfully completed with the torch and a circular cut was immediately started in another area of the door. In the remaining 99 seconds, before the torch's fuel was consumed, an 80° arc of an 11.3" diameter circle was cut in the 1/4" thick mild steel plate. The total burning time of the torch was 2.88 minutes. Acoustical disturbances are shown in figure 68 and vibrational disturbances in figure 69 .

The portable rocket torch was judged to be a suboptimal choice for use in an attack against the bolt-work blocking mechanism. The particular area involved is protected by 1/4" of mild steel, 3/8" of hard drill-resistant steel and 1/2" of stainless steel plate. During the 74 seconds that it was used against these, a hole was melted through the mild steel and partially through the drill resistant steel. This attack was abandoned at that point because it appeared likely that it would weld the bolt-work blocking mechanism in place if it were continued. A more concentrated and higher temperature heat source is preferred for this particular type of attack. On the circular cut, the 80° arc represents a cut length of 7.89" in the 1/4" mild steel. This is a cutting rate of 12.5 seconds per inch. This is comparable to the cutting rate of an oxygen-fed electric arc torch on the same material, but at this rate, three of the rocket cartridges would be required to make an opening of the necessary diameter in the 1/4" mild steel outside of the door. This would require an estimated 7.5 minutes of working time and it would still be necessary to penetrate the thinner inside cover of the door. Figure 70 shows cuts made by the rocket torch and by the oxygen-fed electric arc which produced a much narrower cut.

On the assumption that the rocket torch might have annealed the drill-resistant plate, drilling was resumed after the door had cooled off to where it did not represent a burn hazard to the operator. This was continued for 3.55 minutes and then abandoned in favor of an oxygen-fed electric arc torch attack. The electric arc was used for 5.65 minutes to make a hole through which the bolt-work blocking mechanism could be accessed. Multiple sweeps of the acoustical disturbances produced by the arc are shown in figure 71 and the vibrational disturbances in figure 72 .

A 4" long cut was also made in the 1/4" mild steel door cover to establish an estimate of its cutting rate. The 4" cut took 48 seconds for an average rate of 12 seconds per inch.

Finally, the bolt-work blocking mechanism was forced using tooling which was worked through the opening produced by the electric arc. The time required for this activity was 8.0 minutes. The total working time required to release the bolt work was 18.27 minutes.

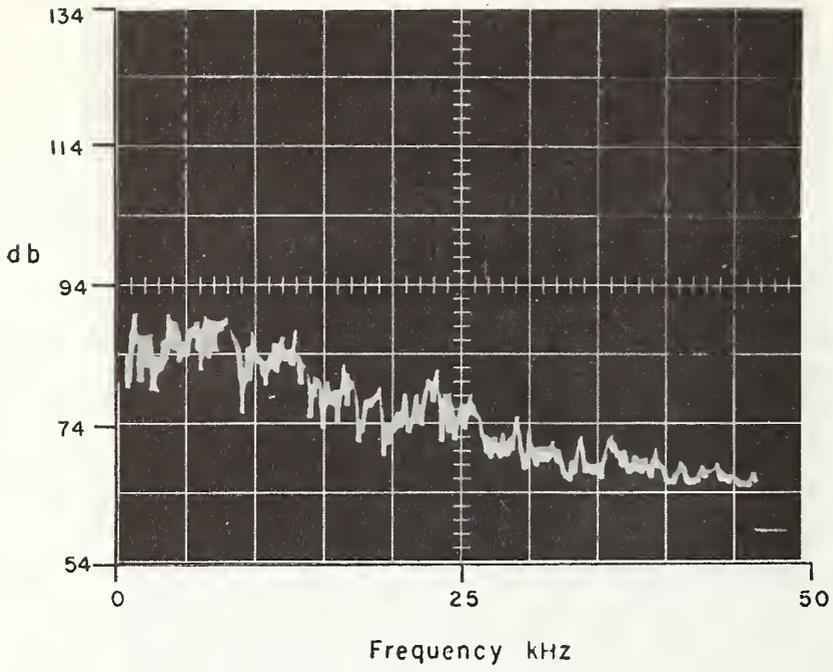


Figure 68. Acoustical Disturbances from Rocket Torch

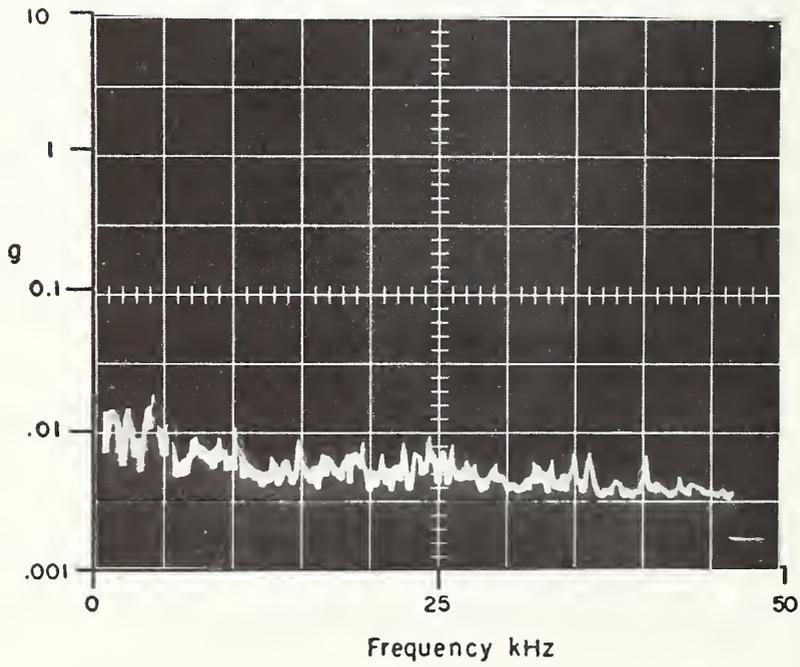


Figure 69. Vibration from Rocket Torch



Figure 70. Comparison of Cuts Made by Rocket Torch (Wide) and Oxygen-fed Electric Arc (Narrow)

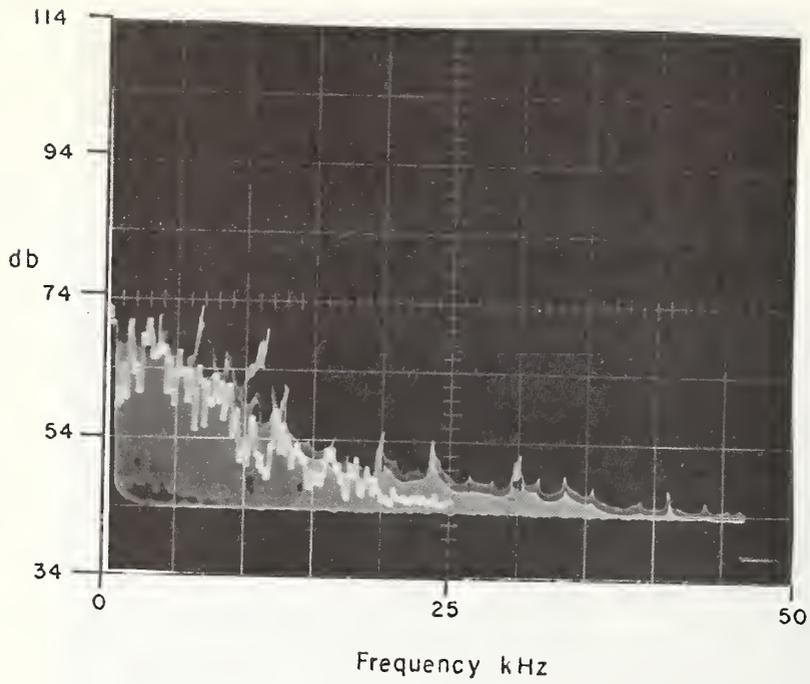


Figure 71. Acoustical Disturbances
from the Electric Arc Torch

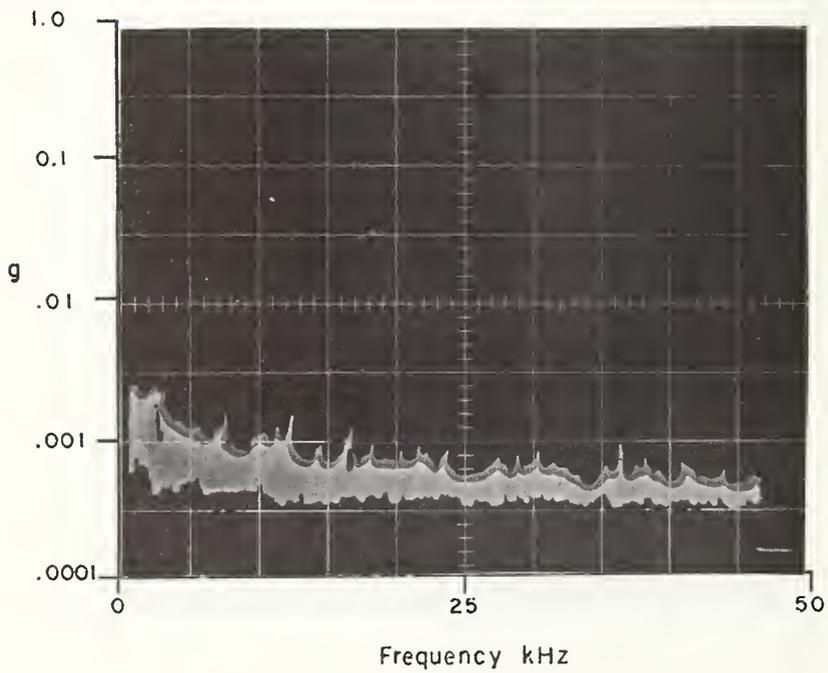


Figure 72. Vibration from the Electric Arc

ATTACK 30D

A burning bar was used to make a single hole in the 8" thick concrete wall of Room 3 as shown in figure 73 . It took .73 minute and used 40" of bar with the oxygen pressure at 160 p.s.i. Acoustical disturbances are shown in figure 74 and vibrational disturbances in figure 75. The vibration transducer was mounted on the inner surface of the wall at a distance of two feet from the attack point.

The first J-SIIDS alarm occurred when the bar penetrated the inner surface of the wall.

As a further demonstration of the burn bar, the aluminum panel covering the opening previously made in Attack 24B was removed and replaced by a 3/16" thick expanded steel grating attached to the outside of the wall. With oxygen pressure at 100 p.s.i., the steel grating was cut along the perimeter of the previously made opening in 1.52 minutes. The reinforcing rod, left intact in the opening until this time, was then cut in 0.4 minute as shown in figure 76 . J-SIIDS alarms were produced by the oxyacetylene torch flame used to ignite the burning bar.

Acoustic disturbances produced by the burning bar are shown in figure 77 and vibrational disturbances in figure 78 . The vibrational transducer was located on the inner wall of Room 3 five feet from the 24B opening.



Figure 73. Burning Bar Melting a Hole through Concrete

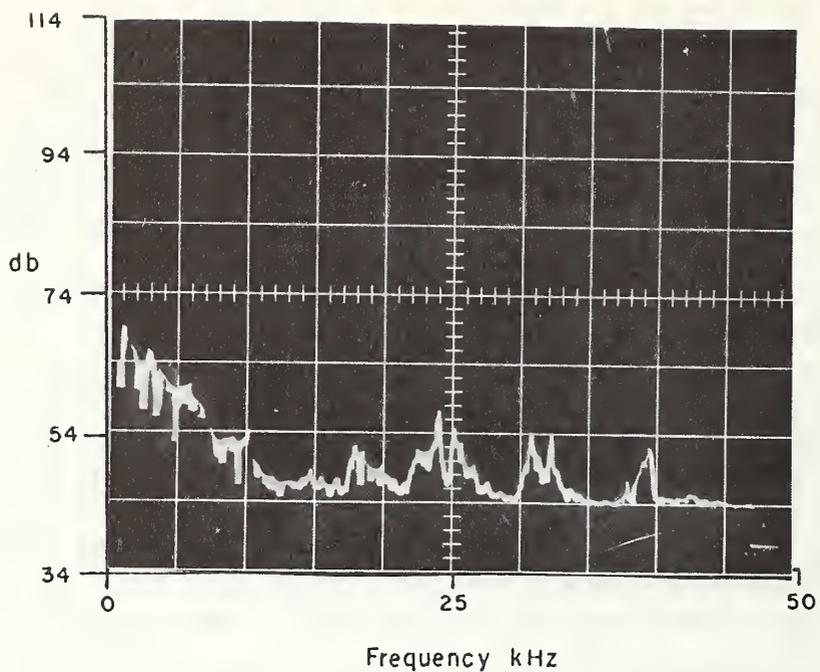


Figure 74. Acoustical Disturbance from Burning Bar Attack on Concrete

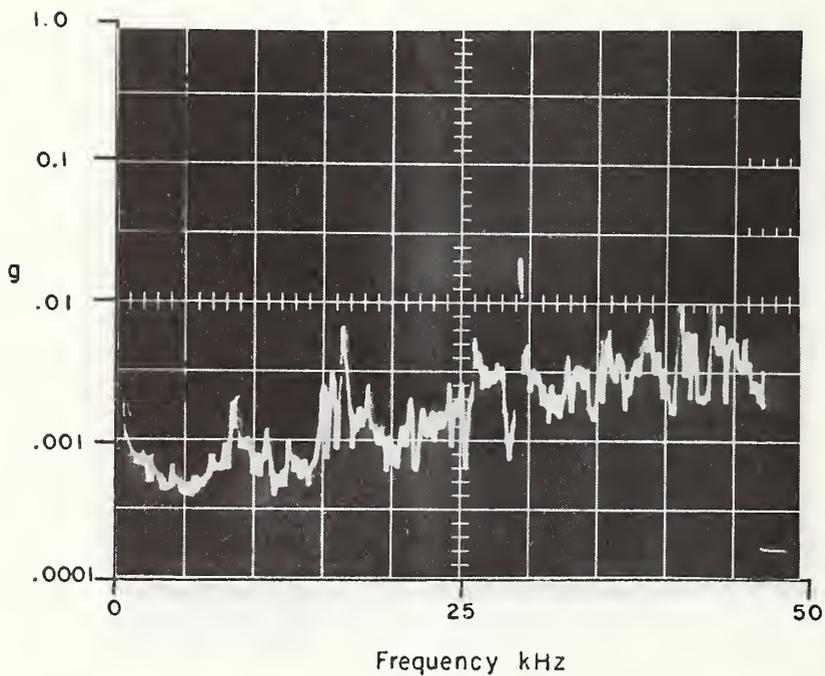


Figure 75. Vibration from Burning Bar Attack on Concrete

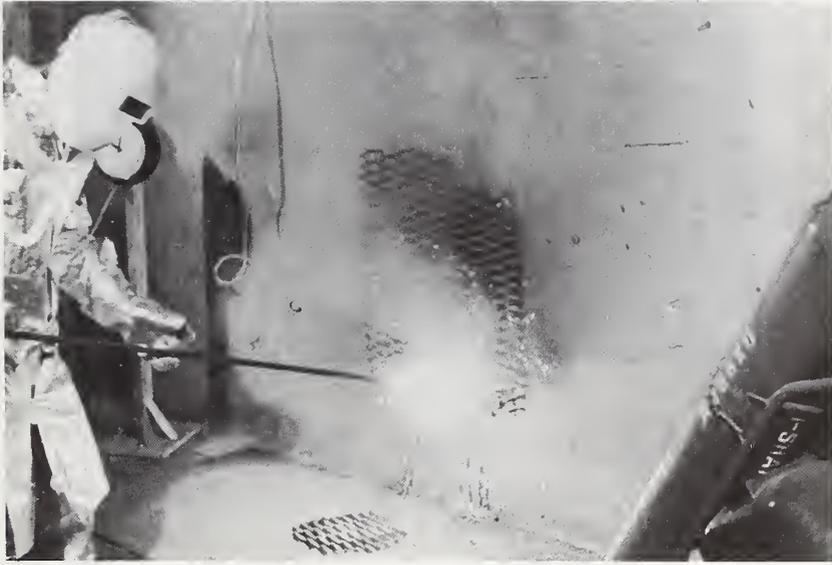


Figure 76. Burning Bar Cutting
Reinforcing Rod at
Location 24B

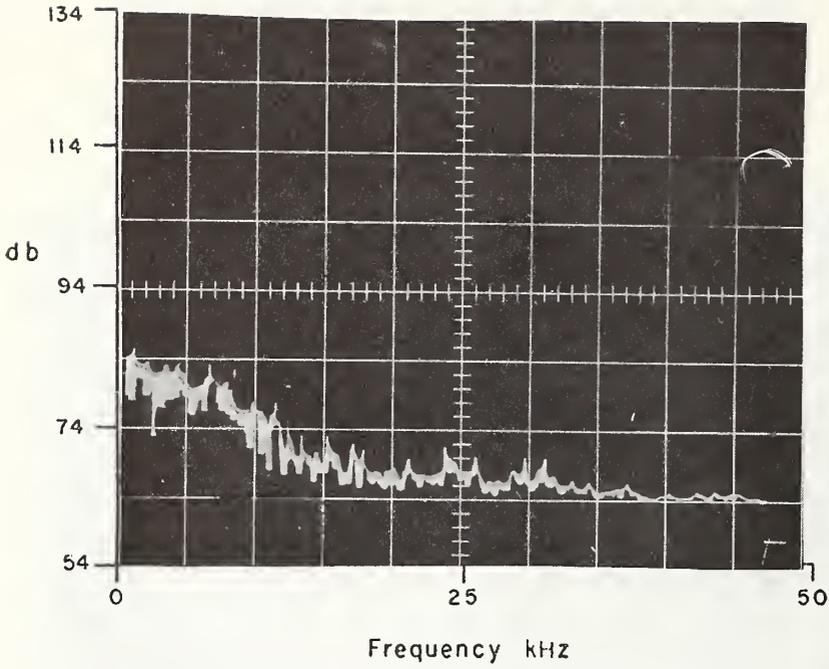


Figure 77. Acoustical Disturbance from Burning Bar Attack on Expanded Metal

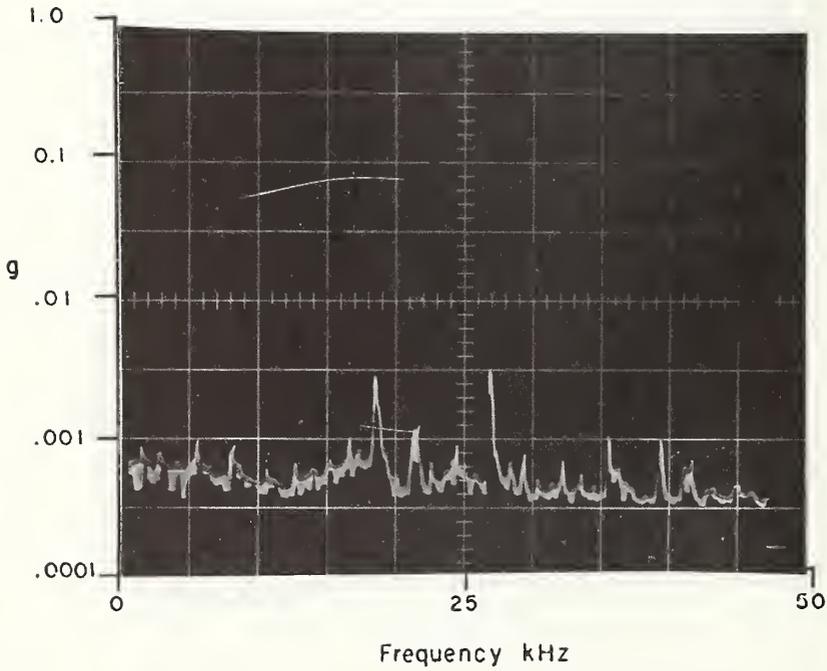


Figure 78. Vibration from Burning Bar Attack on Expanded Metal

CONCLUSIONS

The observed penetration times ranging from 1.3 minutes for a double-planked wooden wall to 18.27 minutes for a GSA Class 6 vault door resulted from the use of portable, readily available tooling, manned by operators who worked willingly and purposefully but who obviously could not be motivated to the same extent as the would-be intruder team who might stand to gain or lose a great deal depending on the speed and vigor with which they pursued their attack. Such a team could probably reduce each of the observed penetration times by at least 10 percent and perhaps in some instances by as much as 50 percent.

All of the attack techniques that were used produced acoustical or vibrational or both types of disturbances which are readily detectable and were, in fact, detected by the J-SIIDS equipment. For adequate safeguarding of any area, the intrusion alarm system must be backed up with guard, police, or other reaction forces having response times which are less than the times required to complete a penetration. This response time should be less than one minute for situations where the barrier structures are similar to those in Rooms 1 and 2, and should be less than 10 minutes in the case of a vault structure similar to Room 3; even shorter response times would be necessary to safeguard against more powerful penetration attacks such as the use of explosives.

APPENDIX

During some of the tests, audio frequency disturbances were picked up using a one-inch microphone located within the room under attack. These data were recorded on magnetic tape and subsequently reduced to 1/3 octave bandwidth sound pressure levels in the 20 to 20,000 Hz frequency bands. The resulting tabulations are presented in this appendix grouped by attack identification designators.

These data should be considered as representative values rather than absolute as there were several uncontrolled variables associated with the data acquisition. These include the unknown acoustical characteristics of the simulated arms rooms and the variations in transmission path lengths between the microphone and the attack points. These factors could have an influence on the order of +6 dB on any of the tabulated values.

ATTACK 20S
One-third octave sound pressure levels, dB

Frequency Band Hz	1	2	3	4				
20	70	40	81	71				
25	61	61	74	79				
31	64	63	75	99				
40	56	56	65	98				
50	53	52	63	84				
63	50	51	58	80				
80	50	49	63	92				
100	56	56	68	94				
125	55	55	73	89				
160	56	56	72	92				
200	55	55	69	92				
250	54	54	69	96				
315	51	51	70	93				
400	55	55	71	88				
500	53	52	71	92				
630	53	53	76	93				
800	56	55	68	93				
1000	53	53	68	92				
1250	54	53	68	91				
1600	54	54	66	91				
2000	57	57	66	90				
2500	56	56	66	91				
3150	54	54	66	87				
4000	51	51	66	85				
5000	49	48	65	85				
6300	47	47	65	83				
8000	43	46	65	80				
10000			65	77				
12500	48	48	63	75				
16000	54	55	65					
20000	68	68	69					

1. Hand brace and 1" wood bit, cutting.
2. Hand brace and 1" wood bit, cutting.
3. Hand brace and 1" wood bit at breakthrough.
4. Electric-powered saber saw.

ATTACK 20M
One-third octave sound pressure levels, dB

Frequency Band Hz	5	6					
20	83	66					
25	84	65					
31	79	66					
40	80	64					
50	65	56					
63	68	56					
80	73	62					
100	85	68					
125	87	61					
160	87	65					
200	83	63					
250	86	64					
315	86	59					
400	86	65					
500	88	68					
630	89	75					
800	90	72					
1000	89	70					
1250	90	68					
1600	90	67					
2000	90	71					
2500	90	70					
3150	89	69					
4000	89	66					
5000	89	69					
6300	89	68					
8000	88	62					
10000	83	51					
12500	82	50					
16000	76	58					
20000	74	72					

5. Electric-powered rotary saw.
6. Electric drill with 3/4" wood bit.

ATTACK 21N

One-third octave bandwidth sound pressure levels, dB

Frequency Band Hz	7	8						
20	69	86						
25	65	84						
31	61	85						
40	69	80						
50	72	80						
63	70	77						
80	73	68						
100	74	70						
125	82	66						
160	77	64						
200	72	61						
250	72	59						
315	78	59						
400	77	65						
500	83	66						
630	84	64						
800	82	61						
1000	89	63						
1250	90	62						
1600	89	62						
2000	90	60						
2500	89	59						
3150	88	59						
4000	87	57						
5000	87	57						
6300	87	57						
8000	88							
10000	84							
12500	83							
16000	80							
20000	78	73						

7. Electric-powered rotary saw.

8. Carpenter's hand saw cutting wooden joist.

OTHER ATTACKS

One-third octave bandwidth sound pressure levels, dB

Frequency Band Hz	9	10						
20	55	93						
25	54	87						
31	56	83						
40	54	80						
50	55	77						
63	57	75						
80	63	80						
100	68	88						
125	62	82						
160	70	85						
200	67	85						
250	73	86						
315	75	95						
400	73	94						
500	76	94						
630	78	92						
800	81	92						
1000	80	92						
1250	79	93						
1600	80	94						
2000	81	95						
2500	81	97						
3150	81	99						
4000	80	101						
5000	80	102						
6300	80	105						
8000	81	105						
10000	82	103						
12500	82	103						
16000	84	101						
20000	84	98						

- 9. Oxyacetylene torch cutting metal grill.
- 10. Breaking window glass.

ATTACK 22A

One-third octave bandwidth sound pressure level, dB

Frequency Band Hz	11	12					
20	85	76					
25	86	87					
31	86	86					
40	76	80					
50	76	78					
63	77	78					
80	75	77					
100	89	86					
125	85	89					
160	93	92					
200	92	93					
250	95	90					
315	96	96					
400	94	94					
500	94	88					
630	91	86					
800	88	87					
1000	87	85					
1250	85	84					
1600	82	83					
2000	81	79					
2500	76	76					
3150	77	77					
4000	72	69					
5000	68	67					
6300	68	66					
8000	65						
10000							
12500	69						
16000	79						
20000	93	84					

11. Twelve-pound sledgehammer attack on brick veneer.
12. Sledgehammer attack on cinder block after penetration of brick veneer.

ATTACK 22B

One-third octave bandwidth sound pressure level, dB

Frequency Band Hz	13	14	15					
20	65	64	78					
25	68	74	75					
31	83	82	69					
40	81	76	62					
50	86	75	59					
63	75	73	60					
80	75	73	52					
100	90	91	62					
125	82	81	58					
160	90	88	66					
200	89	94	71					
250	82	93	72					
315	89	93	69					
400	92	95	71					
500	92	98	72					
630	92	99	71					
800	93	100	73					
1000	91	99	74					
1250	90	96	75					
1600	85	93	77					
2000	87	89	80					
2500	86	86	81					
3150	88	89	82					
4000	85	89	82					
5000	88	93	81					
6300	90	101	81					
8000	83	94	82					
10000	78	90	81					
12500	78	86	79					
16000		82	77					
20000	84	84	83					

13. Rotohammer with 1-1/2" chisel attacking brick veneer.
 14. Rotohammer with chisel attacking cinder block after penetration of brick veneer.
 15. Oxyacetylene torch cutting reinforcing bar.

ATTACK 27T

One-third octave bandwidth sound pressure levels, dB

Frequency Band Hz	16	17					
20	41	93					
25	49	96					
31	70	97					
40	61	96					
50	47	98					
63	47	90					
80	63	94					
100	75	104					
125	67	98					
160	71	101					
200	71	99					
250	71	95					
315	76	98					
400	77	101					
500	71	99					
630	73	95					
800	72	98					
1000	71	98					
1250	74	97					
1600	75	97					
2000	77	97					
2500	82	96					
3150	82	95					
4000	82	94					
5000	79	93					
6300	74	91					
8000	73	88					
10000	71	86					
12500	69	82					
16000	65						
20000	75						

- 16. Bolt cutter clipping expanded metal.
- 17. Sledgehammer attacking metal-clad door.

ATTACK 23B

One-third octave bandwidth sound pressure level, dB

Frequency Band Hz	18	19	20					
20	88	78	70					
25	86	76	72					
31	82	79	71					
40	76	80	71					
50	80	92	75					
63	75	79	71					
80	77	79	66					
100	97	93	82					
125	84	92	74					
160	88	101	79					
200	92	102	82					
250	91	97	79					
315	88	98	82					
400	91	101	80					
500	92	103	83					
630	94	100	87					
800	95	100	84					
1000	93	97	84					
1250	93	98	85					
1600	89	94	91					
2000	86	96	85					
2500	81	96	84					
3150	79	97	89					
4000	86	93	92					
5000	95	90	91					
6300	97	89	86					
8000	88	88	91					
10000	94	86	88					
12500	98	85	83					
16000	91		83					
20000	93	94	93					

18. Rotohammer with 1" drill attacking concrete.
 19. Spalling concrete with 12-pound sledgehammer.
 20. Gasoline-powered abrasive wheel cutoff saw.

U.S. DEPT. OF COMM. BIBLIOGRAPHIC DATA SHEET	1. PUBLICATION OR REPORT NO. NBSIR 73-223	2. Gov't Accession No.	3. Recipient's Accession No.
4. TITLE AND SUBTITLE PENETRATION TESTS ON J-SIIDS BARRIERS		5. Publication Date June 4, 1973	6. Performing Organization Code 650.01
7. AUTHOR(S) R. T. Moore	8. Performing Organization NBSIR 73-223		
9. PERFORMING ORGANIZATION NAME AND ADDRESS NATIONAL BUREAU OF STANDARDS DEPARTMENT OF COMMERCE WASHINGTON, D.C. 20234		10. Project/Task/Work Unit No. Project 6509419	11. Contract/Grant No. IACRO DNA EO 72-201 and 73-406
12. Sponsoring Organization Name and Address Defense Nuclear Agency (DNA) Washington, D. C. 20305		13. Type of Report & Period Covered Interim Report for Period 3/13-16/73	14. Sponsoring Agency Code DNA
15. SUPPLEMENTARY NOTES			
<p>16. ABSTRACT (A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.) A series of penetration tests were made on three simulated arms rooms which incorporated a variety of structural barriers which were intended to be representative of the broad range of construction likely to be encountered in existing arms rooms.</p> <p>The observed penetration times varied from 1.3 minutes for a double-planked wooden wall, 11.31 minutes for an eight-inch thick, reinforced concrete wall and up to 18.27 minutes for a GSA Class 6 vault door. All penetrations were made with portable readily available tooling and produced acoustical or vibrational or both types of disturbances which are readily detectable.</p> <p>The test results provide a basis for estimating the time in which response to an intrusion alarm must occur in order to adequately safeguard an arms room, a computer room or any other sensitive area.</p>			
17. KEY WORDS (Alphabetical order, separated by semicolons) Barrier penetration; intrusion resistance; physical security.			
18. AVAILABILITY STATEMENT <input checked="" type="checkbox"/> UNLIMITED. <input type="checkbox"/> FOR OFFICIAL DISTRIBUTION. DO NOT RELEASE TO NTIS.		19. SECURITY CLASS (THIS REPORT) UNCLASSIFIED	21. NO. OF PAGES
		20. SECURITY CLASS (THIS PAGE) UNCLASSIFIED	22. Price

